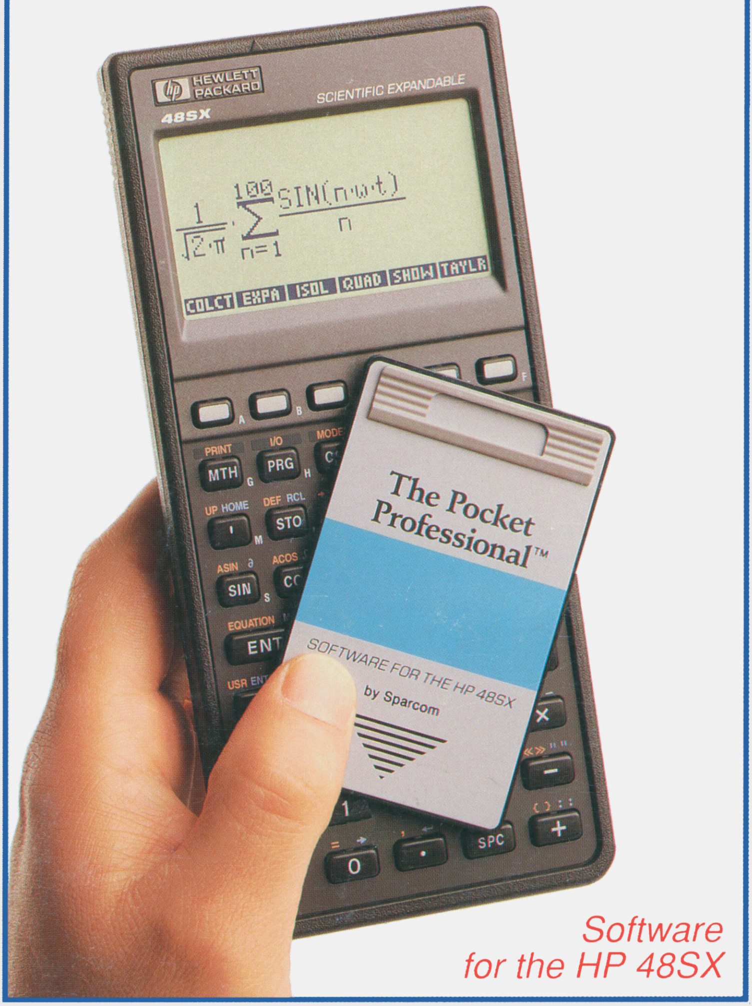
Sparcom

Pocket Professional™

OWNER'S MANUAL



Software
for the HP 48SX

The Pocket Professional™

Celestial Navigation Pac

Owner's Manual

SPARCOM®

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Special thanks to Thomas Metcalf, for developing NAV48 Pac.

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Chapter 1

Getting Started

Sparcom's Pocket Professional software is the first of its kind, developed to provide speed, efficiency and portability to students and professionals in the technical fields. When you slide the Pocket Professional NAV48 Pac into your HP 48SX, your calculator instantly transforms into an invaluable tool, ready to efficiently solve your navigation problems. The NAV48 main menu is organized into 15 separate sections easily accessible by softkeys.

This chapter covers:

- ❑ Sage Advice
- ❑ Installing and Removing An Application Card
- ❑ Starting the NAV48 Pac
- ❑ Overview of NAV48
- ❑ Data Formats
- ❑ Aborting a Routine
- ❑ Text Editing
- ❑ Memory Requirements
- ❑ The 'SPARCOM' Directory

Sage Advice

Navigation is both an art and a science. The programs contained on the HP 48SX Navigation Card are designed to take care of the science so that the navigator can concentrate on the art. By removing the drudgery of sight reduction, the joy of navigating by the stars can be more fully appreciated. These programs can improve your celestial navigation skills by letting you concentrate on the more enjoyable aspects.

Your navigation card incorporates the following features:

- Position fix from two or more celestial observations. The number of observations is essentially unlimited and, when the fix is overdetermined, a least squares fit selects the most likely position.

- Plot lines (circles) of position.

- Estimated position from a single observation combined with a dead reckoning position.

- Running fix accounting for the motion of the observer.

- Course and distance computations for rhumb lines and great circles.

- Accurate and complete astronomical almanac including 268 stars, Sun, Moon, all major planets, and the Messier objects (of interest to amateur astronomers). The almanac is valid from 1900 to at least 2030 and is comparable in accuracy to the "Nautical Almanac".

- Menu driven: celestial navigation can be complicated, and NAV48 has attempted to make the task as simple as possible for the navigator.

The navigation programs will prove to be a valuable tool for your celestial navigation needs, however, you must bear in mind that all electronic navigation aids, including your HP 48SX, will fail; they cannot last forever. The batteries can die, the calculator can be dropped or lost overboard. A person should never rely on an electronic aid unless he/she is prepared to do without it. **As a precaution, it would be wise to carry fresh spare batteries. Also, be careful in the handling of the calculator; do not drop it or let it get wet.**

Throughout this manual, it is assumed that you have a basic understanding of the theory and practice of celestial navigation. This manual is not a celestial navigation tutorial. **If you do not know how to navigate by the stars, we strongly recommend that you learn how to do so before becoming dependent on any electronic navigational aid.** A book that will help measure your ability is "A Star to Steer Her By" by Edward J. Bergin (see bibliography). If you are up to speed with this book then you will be able to understand the concepts put forth in this manual. For suggested readings, see the bibliography.

Another pitfall with a navigation program such as this, is the temptation to unthinkingly read latitude and longitude from the screen. The position fix is, at best, only as good as the data you supply to the calculator. If erroneous data is entered as input, an erroneous fix will be the output. You should always have a good idea of where you are and where you are going so you can check and recheck any position information displayed on the screen.

Any program of the complexity of those included on the navigation card is likely to have a small bug or two in it. The programs described below have been tested on many diverse navigational problems, both real and simulated. However, you should always **think** about the results to insure that they make sense and to beware of undiscovered bugs which may have crept into the programs. The preface to "The American Practical Navigator" Vol. 2, by Nathanial Bowditch, states that "...the [navigational] aids provided by science can be used effectively to improve the art of navigation only if a well informed person of mature judgment and experience is on hand to interpret information as it becomes available."

This manual is not a navigational tutorial, neither is it an HP 48SX tutorial. It is assumed throughout that you have a basic familiarity with the calculator. You may need to consult the HP 48SX Owner's Manual at times to clarify operation of the calculator, particularly with regard to the use of the softkeys and the editing keys.

Installing and Removing an Application Card

The HP 48SX has two ports for installing plug-in cards. You can install your NAV48 Pac in either port.

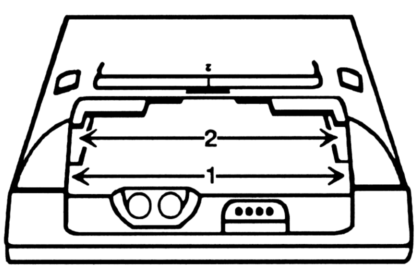
WARNING: Turn off the HP 48SX while installing or removing the card. Otherwise, user memory may be erased.

Installing an Application Card

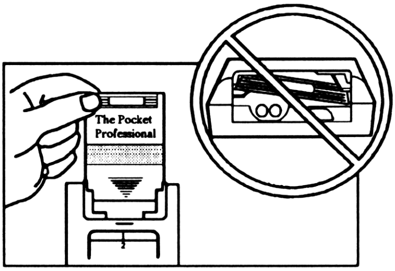
To install an Application card, follow these steps:

❶ Turn the HP 48SX off. Do not press [ON] until you have completed the installation procedure.

❷ Remove the port cover. Press against the grip lines and push forward. Lift the cover to expose the two plug-in ports, as shown below:



❸ Select either empty port for the Pocket Professional™ card, and position the card just outside the slot. Point the triangular arrow on the card toward the HP 48SX port opening, as shown below:



❹ Slide the card firmly into the slot. After you first feel resistance, push the card about 1/4 inch further, until it is fully seated.

❺ Replace the port cover.

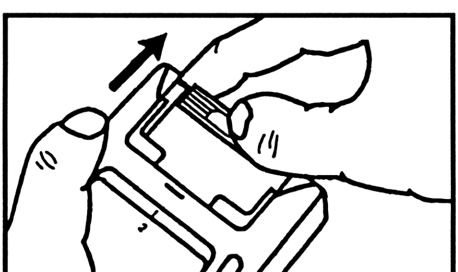
Removing an Application Card

To remove an Application card, follow these steps:

❶ Turn the HP 48SX off. Do not press [ON] until you have completed the removal procedure.

❷ Remove the port cover. Press against the grip lines and push forward. Lift the cover to expose the two plug-in ports, as shown above.

❸ Press against the card's grip and slide the card out of the port, as shown below:

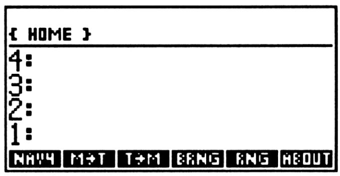


❹ Replace the port cover.

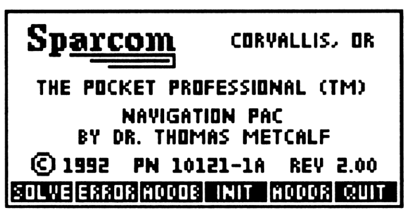
Starting the NAV48 Pac

After you turn on your HP 48SX by pressing [ON], there are three ways to start the Pac.

- ❑ Press [←][LIBRARY] to display all libraries available to the HP 48SX. Find and press NAV4 to enter the NAV48 Pac library directory. The screen displays new menu keys (softkeys) along the bottom, as shown:



  Press NAV4 (the first softkey) to start the application. A message "Checking variables ..." will display. When the variables have been checked the *About* screen will display.



  The About screen contains the revision number and product information concerning the NAV48 Pac. To display the About screen in the future, access the first page of the Nav48 Pac application and press ABOUT (the sixth softkey).

- ❑ Type [α][α] NAV48 then press [ENTER] to start the application.

- ❑ Add the command NAV48 to the CST (custom) menu. (For more information, refer to Chapter 15 of the HP 48SX Owner's Manual, Customizing the Calculator.) After the command has been added to CST, press [CST] NAV48 to start the application.

Overview of NAV48

Each section is briefly described below and is discussed in detail in the remainder of this manual.

NAV48 Page 1:

- SOLVE .... Reduces observations for a fix
- ERROR .... Displays forms of error on a fix
- ADDOB .... Allows input of a celestial observation
- INIT: .... Setup parameters
  - IX/HT .... Sets index correction and height of eye
  - MOTION .... Sets course/speed
  - P/T .... Sets pressure/temperature
  - FORMAT .... Selects format (DMT, DMS, or decimal)
  - ZN/W .... Sets zone description and watch error
  - EXIT .... Exits the INIT program
- ADDDR .... Adds dead reckoning position to celestial observations
- QUIT .... Exits NAV48 program

NAV48 Page 2:

- PLOT .... Plots and displays lines of position
- PILOT: .... Displays various piloting programs
  - DREC .... Sets dead reckoning position
  - VANG Computes distance from an object using a vertical angle
  - DBRG... Computes distance from an object using two bearings
  - ST/DT .... Computes set/drift (current)
  - TIDE .... Interpolates the tide at your location
  - EXIT .... Exits PILOT program
- PILOT Page 2: ....
  - M→T .... Converts your magnetic course to true course
  - T→M .... Converts your true course to magnetic course
  - D=ST .... Calculates distance/speed/time
  - EXIT .... Exits PILOT program
- ADV .... Advances celestial observations
- SAIL: .... Displays various SAIL programs
  - RHUMB .... Computes rhumb line (course and distance)
  - GC .... Computes Great Circle (course and distance)
  - WAY . Computes/displays waypoints along a Great Circle track
  - VERTX .... Displays vertex of a Great Circle
  - COMP .... Computes limiting latitude composite route
  - EXIT .... Exits SAIL program

ALMN: ....Displays various Almanac programs

GHAD...Computes GHA/declination

HORIZ....................... Displays horizon coordinates of a body

RISET...Displays rise/set of a body

ID .... Identifies body from height and azimuth

DTIME.................................. Adjusts almanac date and time

EXIT.. Exits ALMN program

ALMN Page 2: ....

NTWI.................... Displays nautical twilight on date selected

CTWIL.......................Displays civil twilight on date selected

EQT ....Displays equation of time

SD/HP.... Displays semi-diam. of sun/horiz. parallax of moon

GHAγ.................................Displays GHA Aries, LHA Aries

EXIT.. Exits ALMN program

QUIT...Exits NAV48 program

NAV48 Page 3:

WAYP...................................... Displays waypoints (waypoint viewer)

RESET .... Clears out old celestial observations to receive new

DSAVE .... Saves celestial data

DRCL...Recalls celestial data

EDIT: .... Edits celestial data

NEXT... Selects next observation

PREV..Selects previous observation

DEL .... Deletes observation

ADD ....Adds observation

EDIT...Edits observation

EXIT.. Exit EDIT program

QUIT.. Exit NAV48 program

Data Formats

Navigational data is mainly comprised of angles, dates and times. Below is an explanation of the different formats used when entering these types of data.

Entering Angles

Most data in navigation are angles; altitude of a celestial body observed with a sextant, Greenwich hour angle of the observed body, declination of the observed body, etc. You have the choice of three different formats for the input of angular data:

1. **Decimal**
   Decimal format simply uses the angle in degrees.

2. **Degree-minute-second (DMS)**
   Degree-minute-second (DMS) uses the angle in degrees, minutes of a degree, and seconds of a degree.

3. **Degree-minute-tenths (DMT)**
   Degree-minute-tenths (DMT) format uses the angle in degrees, minutes and tenths of a minute. *This format is the most common and will be used in the examples in this manual.*

NOTE: One minute of a degree is 1/60 of a degree while one second of a degree is 1/60 of a minute or 1/3600 of a degree.

The format of angular input is as follows:

Format	Description	Example
Decimal	d.dddd	17.2542 (17.2542 degrees)
DMS	d.mmss	17.1515 (17° 15' 15")
DMT	d.mmt	17.153 (17° 15.3')

Declination and latitude are angular values, but they can be either north or south of the equator. The convention used here is to append the entry with a "N" or "S" (upper case) to indicate north or south latitude. Hence, a north declination of 57°22.2' would be input as 57.222 N in the DMT format, and a south declination of 57°22.2' would be input as 57.222 S. A north latitude of 57°22.2' would be input, in DMT format, as 57.222 N and a south latitude of 57°22.2' would be input as 57.222 S.

Similarly, longitude can be either east or west of the Prime Meridian passing through Greenwich, England. East longitude is indicated by appending an "E" to a number and west longitude by appending a "W" (upper case). A longitude of 157°20.0' west would be input as 157.200 W in DMT format and a longitude of 50°34.6' east would be input as 50.346 E in DMT format.

Entering Time (HMS)
All times are input in the HMS format as hh.mmss (hours-minutes-seconds) where hh is the hour, mm is the minute and ss is the second. A time of 17:01:22 would be input as 17.0122.

IMPORTANT: Use the twenty four hour clock to enter time as the program never uses AM/PM time.

NOTE: Throughout the manual the hours-minutes-seconds format (hh.mmss) will be referred to as HMS. Do not confuse this with DMS (degrees, minutes of a degree, and seconds of a degree).

Entering Dates (YYYY.MMDD)
All dates are input in YYYY.MMDD format (year-month-day) where YYYY is the year, MM is the month number, and DD is the day of month. For example, February 15, 1991 would be input as 1991.0215.

Aborting a Routine

One important key should be remembered: when something goes wrong, you can abort any of the navigation routines described below by pressing the [ON] (or ATTN key) at the lower left corner of the keyboard. At any prompt when inputting data, you may have to press the key twice, once to clear the display, and once to abort.

Text Editing

The softkeys present at the data input screens are command line editing keys. They allow you to edit the search string or input data. Their functions are summarized below. (For more information, refer to Chapter 3 of the HP 48SX Owner's Manual, "The Stack and Command Line.")

Screen	Softkeys
Text Editing	←SKIP SKIP→ ←DEL DEL→ INS■ ↑STK

Key	Action
←SKIP	Moves the cursor to the beginning of the current word.
SKIP→	Moves the cursor to the beginning of the next word.
←DEL	Deletes all characters in the current word prior to the cursor.
DEL→	Deletes all characters in the current word between the cursor's current position and the first character of the next word.
INS■	Toggles between insert and type-over modes.
↑STK	Activates the Interactive Stack, allowing arguments to be copied from the stack to the command line for editing by pressing ECHO.

ATTN — Clears the command line if there is text present, or aborts text entry if the command line is already blank.

ENTER — Accepts the current command line as the entry.

(For more information, refer to Chapter 3 of the HP 48SX Owner's Manual, "The Stack and Command Line.")

Memory Requirements

A minimum of about 1.8K free memory is required for the NAV48 Pac to operate. The precise free memory requirements vary according to the complexity of the sight reductions or the number of computed lines of position. To increase available memory do either:

- ❑ Quit the NAV48 Pac and delete unwanted variables from the {SPARCOM NAV48D DATA} directory. (For more information, refer to Chapter 6 of the HP 48SX Owner's Manual, "Variables and the VAR Menu.")

- ❑ Add additional free memory to your HP 48SX by merging a 32K or 128K RAM card. (For more information, refer to Chapter 5 of the HP 48SX Owner's Manual, "Calculator Memory.")

The 'SPARCOM' Directory

Most Sparcom Pocket Professional™ Pacs create a directory 'SPARCOM' in the HOME directory of your HP 48SX. Inside the 'SPARCOM' directory, each particular Pac creates a specific sub directory. For the NAV48 Pac, the name of that sub directory is 'NAV48D'. All variables and equations for the NAV48 Pac are stored inside 'NAV48D'. so as not to conflict with your global variables in other directories. 'NAV48D' will have two sub directories: 'DATA' and 'VARBLS'. The 'VARBLS' sub directory will be filled with a slew of variables which define the current "NAV48" setup: it should not be necessary to directly access any of these variables, you will change the setup from within the "NAV48" program. To reset "NAV48" to its initial setup, purge the 'VARBLS' directory with the HP48 'PGDIR' command if you desire. The 'DATA' sub directory is used to store user data (see the description of the DSAVE program in Chapter 3, "Storing and Recalling Data"). You may also purge the 'DATA' directory with the HP48 'PGDIR' command if you desire.

If you are extremely low on free memory and do not need to keep any of the NAV48 Pac variables in your HP 48SX, you can purge the 'NAV48D' directory, using the command PGDIR. The next time you execute the NAV48

Pac, the 'NAV48D' directory will automatically be re-created. (For more information, refer to Chapter 7 of the HP 48SX Owner's Manual, "Directories.")

Notes:

Chapter 2

NAV48 Tutorial

In this chapter we go through various navigation examples relating to a voyage from San Diego, California (32°39' N, 117°15' W) to Oahu, Hawaii (21°30' N, 157°30' W).

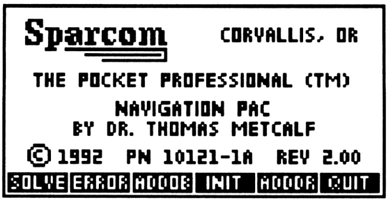
This chapter covers:

- ❑ Starting the Nav48 Tutorial
- ❑ INIT Program
- ❑ Dead Reckoning Position at Beginning of Voyage
- ❑ Route Planning
- ❑ RESET Program
- ❑ Input Celestial Observations
- ❑ Enter Sun Sights
- ❑ Position Fix
- ❑ Margin of Error
- ❑ Plot Lines of Position
- ❑ Compute Running Fix by Advancing Sights
- ❑ Evening Star Sights
- ❑ Estimated Position
- ❑ Moon/Planet Fix
- ❑ Dead Reckoning as Third Observation

Starting the Nav48 Tutorial

To begin the Nav48 Tutorial, follow these steps:

❶ Press [⬅] [LIBRARY] to display all libraries available to your HP 48SX.
❷ Find and press [NAV4] to enter the NAV48 Pac Library directory.
❸ Press the first softkey, [NAV4], to start the NAV48 Pac.



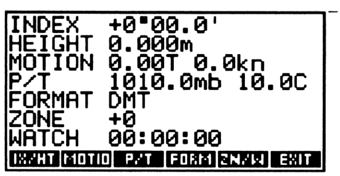
You are now on the first of three pages of the NAV48 Main menu.

NOTE: NAV48 appears as NAV4 since the menu key cannot display all the letters of the name. You may need to press the NXT key on the calculator to find the NAV library if you have several other libraries installed.

INIT Program

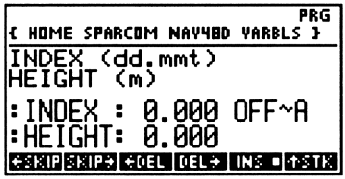
To initialize the Pac, invoke the INIT program, located on the first page of the NAV48 menu. There are several values used in sight reduction which do not change rapidly: sextant index error, height of eye during sextant observations, motion of the vessel, current set and drift, atmospheric conditions, and watch error. These values and a few others are set in the INIT program and remain in effect until you change them by re invoking the INIT program. Since we are at the beginning of our voyage most of our initial values will be default values which are set to zero. When the values are altered, the new input becomes the default. These values will be updated as we get underway.

Press INIT on the first page of the NAV48 menu. This displays the following screen:



Sextant Index Error and Height of Eye

Sextant observations must be corrected for many effects. The first two are the *index error* inherent in the sextant and the error due to the dip of the horizon caused by the *height of eye* above the Earth's surface. The IX/HT program prompts for index error and height of eye data as shown on the screen below.

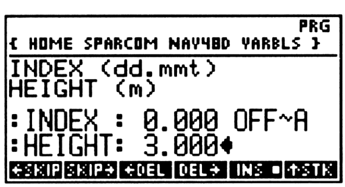


Index error refers to an angle and must be entered in the DMT format described in Chapter 1. Index error "on the arc" must be entered as a number with "ON~A" appended, while index error "off the arc" must be entered as a number with "OFF~A" appended.

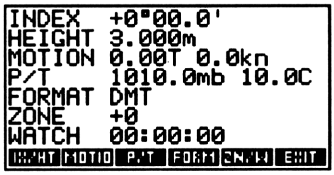
Height of eye is always displayed in meters, but can be entered in any valid unit length such as: ft, km or yd. Whichever unit you chose it will be converted to meters at the INIT screen. As an example, a height of 10 feet can be entered as "10_ft" (i.e. 10 followed by underscore followed by ft in lowercase). For a detailed discussion of units refer to Chapter 13 of the HP 48SX Owner's Manual. If no units are appended to the numbers entered, it is assumed to be in meters.

The calculator must be in alpha-entry mode to enter alpha characters. To enter alpha-entry mode press [α] to enter one alpha character or press [α][α] for multiple alpha character entry. For lower case alpha-entry mode press [α][↰] to enter one alpha character or press [α][α][↰][α] for multiple alpha character entry.

To enter data to the IX/HT program press **IX/HT**. To enter a value for the index error move the blinking cursor using either [←] or [◄] just to the right of **:INDEX:** and type in the value desired. Move to the next line to enter values for the height of eye using the [▼] key. Again use either [←] or [◄] to move the blinking cursor where changes are to be made and enter the appropriate value. For example, leave the index error unchanged from the default of 0.000. Then move the cursor to the **:HEIGHT:** prompt, clear the default value of 0.000, and input 3 (for 3 meters), the result is the screen below:



Press [ENTER] to accept the data. You are now back at the main screen of the INIT program. Height entered as feet has been converted to meters as shown on the screen below:



If a value does not need to be changed, leave it as is, pressing [ENTER] will preserve the displayed default value.

If you erase the prompts, press the [ON] key which aborts the program and returns you to the main menu at which point you can start over. If you erase the "~" it can be recovered by pressing [α][↱][√x].

If you are using a bubble sextant or other type of sextant which does not require a horizon, the height of eye should be set to zero.

Motion of the Vessel and Current

When computing a fix, it is important to account for the motion of the vessel between observations when the observations are not simultaneous. The MOTION program is used to input the course and speed of the vessel as well as the estimated motion due to a current. To enter data to the INIT program press [MOTIO]. You are prompted for two data entries. One for course and the other for speed as shown in the screen below:

The initial default values for both course and speed are 0.000 as shown above. The prompt for course is intended to be a TRUE course, not a magnetic course (for more information on converting true to magnetic as well as magnetic to true see Chapter 7 Piloting, "True Course ↔Magnetic Course"). The prompt for speed is assumed to be in knots although equivalent units such as: mph, m/s or kph are accepted as valid. The data for speed is displayed in knots at the main level of the INIT program.

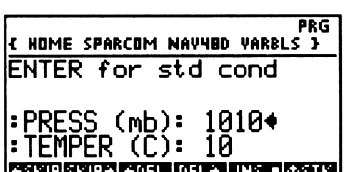
Leave the defaults for course and speed as they are. To accept the data entered at these prompts press ENTER. The following screen appears:

You are now prompted for two more data entries, the set and drift of the current. The initial default values for both set and drift are 0.000 as shown above. The set is again a TRUE course (not magnetic) and the drift is the speed of the current. The drift is assumed to be in knots, but any valid unit can be used, as with the vessel speed above. Leave the defaults as is. To accept the data entered for set and drift press ENTER. You are now back at the main screen of the INIT program.

> **IMPORTANT: At the main level of the INIT program, the displayed values for course and speed are the combined effects of current and motion through the water.**

Atmospheric Conditions

Sextant observations need to be corrected for the effects of refraction. Sextant readings are affected by atmospheric pressure and temperature. The P/T program allows you to set these parameters. To enter information to the P/T program press P/T. The following screen appears:



You are now prompted for two data entries, atmospheric pressure and temperature. The defaults at this screen represent standard conditions. Unless the conditions are quite unusual or your observations are of a body close to the horizon, this is sufficient.

Standard pressure is at 1010 millibars and standard temperature is at 10° Celsius. Although the default unit for atmospheric pressure is millibars, any valid unit such as: atm, bar, Pa, psi, inHg or torr can be used. The default unit for temperature is °C, although any valid unit can be used such as: °F or K.

Press ENTER to accept the standard default conditions for each. You are now back at the main screen of the INIT program.

IMPORTANT: When the INIT program is invoked any previous non-standard conditions input to the P/T program will be set back to default conditions when P/T then ENTER are pressed.

Format

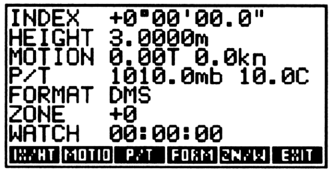
As discussed earlier in Chapter 1 there is a choice of data formats for angular data. They are Decimal, DMS, and DMT. The main screen of the INIT program displays the type of format currently invoked.. For example, in the screen below we observe that FORMAT is set to DMT.

```
INDEX   +0°00.0'
HEIGHT  3.000m
MOTION  0.00T 0.0kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:00
IX/HT MOTIO P/T FORM ZN/W EXIT
```

To change to the Decimal format press FORM. The screen repaints as shown below:

```
INDEX   +0.0000°
HEIGHT  3.0000m
MOTION  0.00T 0.0kn
P/T     1010.0mb 10.0C
FORMAT  Decimal
ZONE    +0
WATCH   00:00:00
IX/HT MOTIO P/T FORM ZN/W EXIT
```

To change to the DMS format press FORM. The screen repaints as shown below:



Press FORM one more time so that DMT is displayed.

IMPORTANT: All examples in this manual use the DMT format. Please leave the format at DMT for the remainder of the manual. The other two formats are provided for more advanced users.

Time Zone and Watch Error

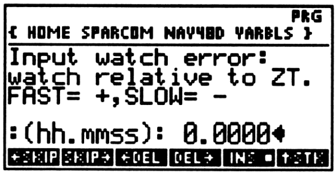
ZN/W in the INIT program is used to set the time zone and the watch error. The time zone is your zone description. Zone description is the number of whole hours from your current time zone *to* UT. Hence, on the East Coast of the United States which is 5 hours behind UT (Universal Time), the zone description is +5. It is important to understand that the zone description is only used as a convenience to the navigator. Hence, if you choose to always use UT (or GMT as it was formerly known), simply set the zone description to zero and don't change it.

NOTE: When the zone description is set to zero most of the screen displays involving time display UT. When the zone description is set to something other than zero, most of the screen displays involving *time* are listed in zone time. Zone time is abbreviated by ZT in many NAV48 displays: "ZT" *always* means "zone time" and *never* means "zulu time".

To enter data to the ZN/W program press ZN/W. The following screen appears:

The initial default value for zone is zero (UT). This allows you to input time as UT. But, if you are in Hawaii (10 hours behind UT), your zone description would be +10. Input as *10*. If you are in Japan (9 hours ahead of UT), your zone description would be -9. Input as *-9* (use the +/- key to make the entry negative). Changes for zone are complete when a new value has been input, but for the upcoming examples we will require the zone be set to zero (UT).

Press ENTER to accept zero as the zone. The calculator now prompts for the watch error as shown in the screen below:

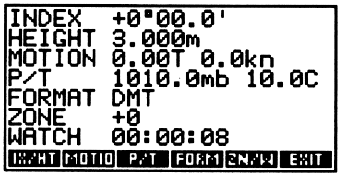


Watch error is a correction which is applied to all the observation times input. This is a convenience to the navigator. If your watch is off by a known amount, you can set the watch error equal to this amount and all observation times will be corrected. If you keep your watch set accurately, you can leave the watch error set to zero. The initial watch error is 0.0000. We will now change the watch error to an error of eight seconds fast. At the **:(hh.mmss):** prompt press ← 8.

If your watch were 2 seconds slow, the input would look like: *-0.0002* (use the +/- key to make the entry negative). Press ENTER to accept the eight second fast value.

IMPORTANT: The watch error must be input in HMS (hour-minute-second) format, hh.mmss, where hh represents hours, mm minutes and ss seconds.

You are now back at the main screen of the INIT program. Your INIT screen should resemble the following:



Exit

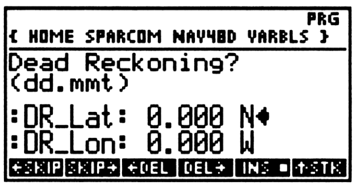
Press EXIT to quit the INIT program and to return to the main NAV48 menu.

Dead Reckoning Position at Beginning of Voyage

We are now ready to set the dead reckoning position for San Diego, California as we begin our Voyage. To do this we need to access the DREC program.

This program is a sub-program of the PILOT program. To begin, press [NXT] [PILOT]. The following screen appears:

The PILOT program menu displays softkeys for each of the available programs. Press [DREC]. The following screen appears:



You are prompted for your dead reckoning latitude and longitude (32°39' N by 117°15' W). Clear the first line by pressing [←DEL] enough times to erase the default value but not the prompt. Prompting for latitude is the line **:DR_Lat:**. At this prompt press 32 [.]39 [SPC][α]N to enter the latitude. Press [▼] to access the second line. Clear the line being careful not to erase the prompt.. Prompting for longitude is the line **:DR_Lon:**. At this prompt press 117 [.]15 [SPC][α]W to enter the longitude. Your screen should resemble the following:

Press [ENTER] to accept these values. The following screen will display:

```
Dead Reckoning:

  Lat:   32°39.0' N
  Lon:   117°15.0' W

DREC VANG DBRG ST/DT TIDE EXIT
```

Press EXIT to quit the DREC program.

Route Planning

To plan our route we compute the course and distance from San Diego, California to Oahu, Hawaii via rhumb and great circle routes. We will use the SAIL program to compute this information. To access the SAIL program press NXT SAIL. You will be prompted for the 'from' and 'to' positions (San Diego and Oahu, respectively). First you are prompted for the 'from' position.

```
                                   PRG
{ HOME SPARCOM NAV48D VARBLS }
From? (dd.mmt)

:Lat: 32.390 N◆
:Lon: 117.150 W
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

The default 'from' position should look familiar as this data was just input using the DREC program. In the SAIL program, your last dead reckoning position will always be your default 'from' position. Press ENTER to accept this data. Now you are prompted for the 'to' position.

```
                                   PRG
{ HOME SPARCOM NAV48D VARBLS }
To? (dd.mmt)

:Lat: 0.000 N◆
:Lon: 0.000 W
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

Set the 'to' position to Oahu, Hawaii (21°30' N, 157°30' W). Clear the first line by pressing ←DEL enough times to erase the default value but not the prompt. At the **:Lat:** prompt press 21 · 300 SPC α N to enter the latitude. Clear the line being careful not erase the prompts.. At the **:Lon:** prompt press 157 · 300 SPC α W to enter the longitude.

```
Command?
From:
  Lat:   32°39.0' N
  Lon:   117°15.0' W
To:
  Lat:   21°30.0' N
  Lon:   157°30.0' W
RHUM | GC | WAY | VERTX | COMP | EXIT
```

Press ENTER to accept this data. You will now see the SAIL program menu where you can select any of the programs by pressing the softkeys provided. We need to compute the TRUE course and distance from San Diego to Oahu. To do this press RHUM.

```
Command?

Course:   252°40.8' T
Dist: 2247.07_nmi


RHUM | GC | WAY | VERTX | COMP | EXIT
```

To compute the great circle distance and initial TRUE course press GC.

```
Command?

Course:   262°56.0' T
Dist: 2237.04_nmi


RHUM | GC | WAY | VERTX | COMP | EXIT
```

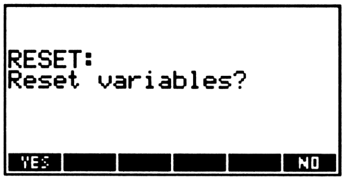
Since the great circle route is only 10 miles shorter than the rhumb line, there is little point in following a great circle route. Hence we take the rhumb line and set our course at 253 True (252° 40.8' T rounded up = 253). Had we wanted to take the great circle route, we would run the WAY program to compute waypoints along the great circle route. For more information on the WAY program and the SAIL program see Chapter 6, "The Sailings".

Press EXIT to quit the SAIL program.

RESET Program

Your next task will be to input a group of celestial observations. First a few words on how the observations are stored. When you input an observation, the calculator will compute Greenwich Hour Angle (GHA), declination and corrected altitude for the observed body. These values are stored in a variable called 'OBS' in the {HOME SPARCOM NAV48D VARBLS} directory. *Do not tamper with the 'OBS' variable* but, be aware of its existence. All observations are saved in 'OBS' and all are used in the sight reduction process until you clear the 'OBS' variable by running the RESET program. This has an advantage and a disadvantage. The advantage is that, *at any time*, you can add observations, advance or retard them, or compute a fix. The disadvantage is that you must remember to reset the 'OBS' variable whenever starting a *new* set of observations. Procedures for saving and recalling observations are described later on in this manual.

To run the RESET program press NXT NXT to display the third page of the NAV48 menu. Press RESET. The following screen will appear:



Press YES to reset the 'OBS' variable. If you press NO then the reset command is ignored and any observation(s) currently residing in the 'OBS' variable remain current. When the program is finished the first page of the Main menu appears.

CAUTION: If you do not reset the 'OBS' variable before inputting a new set of observations, the new observations will be combined with obsolete observations, during the sight reduction, yielding a bad fix.

IMPORTANT: The RESET program has no effect on the INIT program. Any values entered into the INIT program remain as defaults until they are altered within the INIT program itself.

Input Celestial Observations

Once the initial dead reckoning position and the values in the INIT program are set, you are ready to key in sextant observations.

To start entering an observation you will need to run the ADDOB program (ADDOB stands for add observation). This program is located on the first page of the main NAV48 menu. The first value you are prompted for is the date of the observation. Dates must be entered in the YYYY.MMDD format where YYYY is the year, MM is the month number, and DD is the day. Any date from October 15, 1582 on is valid.

IMPORTANT: The date is zone time...For example, if you have set the zone description to zero (UT), the date must be the date in Greenwich, England!

You are next prompted for the time of the observation and the uncorrected altitude of the celestial body you have observed. As always, the time is input in HMS format (hh.mmss). The default time displayed is the last time input, if any, which can be edited to the desired value. The altitude, being an angle, is input in the current format (Decimal, DMS or DMT). No default altitude is used, so it must be keyed in from "scratch". When this information is entered you are then prompted to identify the celestial body that you observed. It could be the sun, the moon, a planet or a star.

If you have selected the Sun or the Moon, you will be asked what limb you observed. There are three options: lower limb, upper limb or disk center.

If you observed a planet, you will be asked which planet you observed. There are five planets to choose from Mercury, Venus, Mars, Jupiter and Saturn.

If you have observed a star, a list of the 57 navigational stars is available to make your selection from. To select the star from this list you need to input the proper name of the star, Arcturus, for example. See Appendix B for details.

There is also a separate list of 268 stars stored using their "scientific" name. For example, to select Arcturus (designated "Alpha Bootis") input "ALP BOO". See Appendix B for details.

A list of Messier objects is also provided. This list is comprised of a catalog of interesting astronomical objects, many of which can be observed with a good pair of binoculars. The objects are numbered sequentially 1 through 109. **These are NOT for navigation and are only provided for people with an interest in amateur astronomy.** The Messier objects are stored by number with an "M" in front. For example, "M 1" or "M 109" (if the "M" is included, the space between the "M" and the number is required, however, the "M" is optional). For information on Messier Objects refer to the "Catalogue of the Universe", by Paul Murdin and David Allen. For further information on this book see the bibliography.

Once the celestial body has been entered the program will offer to compute the body's position with the program's internal almanac. You do not have to use the internal almanac if you do not want to, you may compute the observation yourself by entering specific information that you will be prompted for. If this were the case, you would be prompted for values out of the "Nautical Almanac" which would then be used to linearly interpolate the GHA and declination of the body. You will have a chance to practice this later.

When the computation is finished the program will display a screen with the corrected observation of the observed body. At this point additional observations can be entered. When entering observations, it is not necessary to enter the observations in the order they were observed.

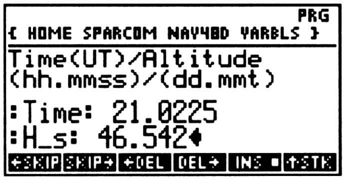
IMPORTANT: Altitude corrections will be automatically applied to the observation, so it is important that you input the uncorrected (observed) altitude. The corrections include; refraction, dip, semi-diameter (Sun and Moon only), parallax (Sun, Moon, Venus, Mars only), lunar augmentation (Moon only), and phase (Mercury, Venus, and Mars only).

Enter Sun Sights

Continuing with our voyage; on February 12, 1991, when roughly half way to Oahu, we obtain some sun sights around Local Apparent Noon (LAN). At the time the sights are taken, the wind has died and our speed is zero (speed is already at zero in the INIT program).

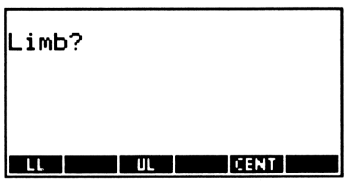
We are now ready to input the observational data with the ADDOB program. Press [ADDOB]. You are first prompted for the date. The date is February 12, 1991 and must be input using the YYYY.MMDD format. At the **:Date:** prompt clear the default and input 1991[•]0212.

Press [ENTER]. The next prompt is for the time of the observation and the uncorrected altitude. The time must be zone time (which in this example is set to UT and our watch is 8 seconds fast already input in INIT) and must be input in the HMS format (hh.mmss). The time is 21:02:25 UT. At the **:Time:** prompt press 21[•]0225. The sextant altitude is 46° 54.2'. At the **:H_s:** prompt press 46[•]542. The screen should read as follows:



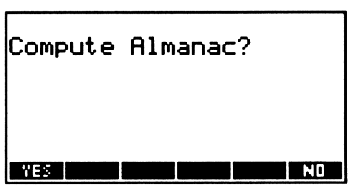
Press ENTER. After inputting the observation, you are prompted for the body you have observed.

Since the sun was the body we observed press SUN.



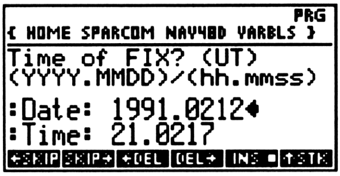
Since the lower limb was observed press LL.

You will next be asked whether you want the HP 48SX to **Compute Almanac?**.

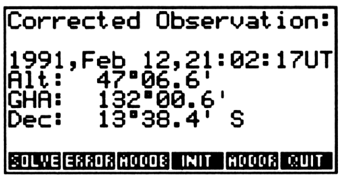


Press YES. The calculator will think for a bit.

Next you are prompted for the time of the fix, both the date and the time are required and must be input in YYYY.MMDD and hh.mmss format respectively. When the almanac has been computed, or the GHA/declination from the "Nautical Almanac" has been input, you will be prompted for the time at which the computed fix is to be valid. This is necessary to correct for any motion of the vessel between sights. If the vessel is moving, the fix you derive from the observations will only be valid at one time and this time must be specified. All the observations you input are advanced or retarded such that they are all valid at this specified time. You will only be prompted for the time of fix for the first observation you input. The others will automatically use the same time of fix. In this case, the default values for the time of fix are the date and time you input with the previous sun sight.



Press ENTER to accept the defaults. If you wish to change the time of fix, use ADV program described in Chapter 4, "The running Fix". Finally, after the ADDOB program is finished, the corrected observation is displayed.



This display gives the time (UT) of the observation corrected for watch error, the corrected altitude, and the computed GHA and declination. The GHA and declination displayed are not corrected for the motion of the vessel. You will learn about the EDIT program in Chapter 3 where you can see the corrected GHA and declination, if you need this information.

The correction to the Greenwich hour angle and the declination due to the motion of the vessel depends somewhat on the vessel's position. *If the speed in the INIT program is anything but zero, you will be prompted for the dead reckoning position.* The default is the current DR position. The position need not be very accurate, an accuracy of 60 miles or so will suffice. If you change the default, you will change the current dead reckoning position. If you wish to change the time of fix, use the ADV program described in Chapter 4, "The Running Fix".

IMPORTANT: ADDOB will not advance observations properly unless you have correctly input the motion of the vessel in the INIT program. Be certain that the average speed and course from the time of the fix to the time of the new observations are properly entered in INIT. Even if your vessel is not moving, you must still input a time of fix. Although the fix is valid at any time in this case, the calculator must know a time of fix in case you start moving again at a later time. Later observations could not be advanced or retarded if the time of fix of the previous observations was unknown.

Run the ADDOB program as before until you have input all the observations below. When prompted for **Compute Almanac?** Press YES and remember the date is February 12, 1991.

Body	Time (UT)	Hs
Sun (LL)	21:07:40	47:00.4
Sun (LL)	21:15:09	47:06.3
Sun (LL)	21:31:05	47:03.1
Sun (LL)	21:42:26	46:48.1

Once you have run the ADDOB program for each observation, you are ready to solve for the position fix. We will use the SOLVE program to get the fix.

NOTE: You can run the SOLVE program at any time and continue inputting more observations later if you prefer.

Position Fix

When you have input at least three observations you can run the SOLVE program. The SOLVE program will compute the position fix and display the result. At the same time you will be asked whether to update the dead reckoning position. Taking the fix as your new dead reckoning position is useful if you are using the HP 48SX to keep track of your progress on a voyage. If you are not using the calculator to keep track of your dead reckoning position or are not happy with the fix, you do not have to accept it when prompted to do so. The time at which the fix is valid is also displayed along with the fix.

With all the observations input, press SOLVE to get a position fix.

```
COMPUTED POSITION
Update DR?

LAT:   29°02.0' N
LON:   136°31.2' W

1991,Feb 12,21:02:17UT
 YES |     |     |     |     | NO
```

The computed position and time of fix are displayed and you are asked whether you want to update your dead reckoning position to reflect the fix. In this case, press YES to accept. This final screen displays

```
COMPUTED POSITION

LAT:   29°02.0' N
LON:   136°31.2' W

1991,Feb 12,21:02:17UT
SOLVE|ERROR|MODOB|INIT|MODOR|QUIT
```

Margin of Error

To get an idea of the accuracy of the fix, press ERROR . (Read more about the margin of error in Chapter 5 Accuracy of the Fix, "Formal Error")

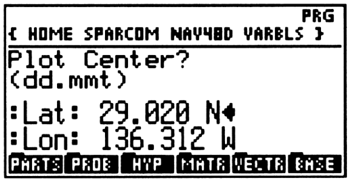
```


±NS_Err: 0.01_nmi
±EW_Err: 0.06_nmi

SOLVE|ERROR|MODOB|INIT|MODOR|QUIT
```

In this example the North-South error is less than the East-West error. This is because the observations were obtained when the Sun was near transit and hence lay in a southerly direction. The lines of position are thus in a generally East-West direction.

Plot Lines of Position

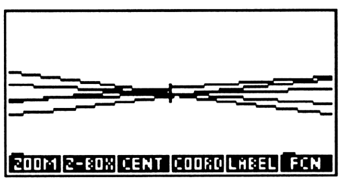
A line of position can be plotted for each of the five observations you input.

To see the lines of position, press NXT PLOT (read more about PLOT in Chapter 5 Accuracy of the Fix, "Plotting Lines of Position"). You are first prompted for the position of center of the plot window.



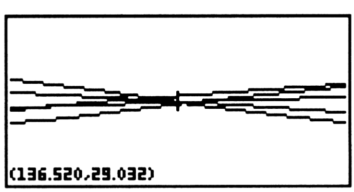
The plot will be made in a region about this point. The default plot center is the last position fix. At the **Plot Center?** screen press ENTER to accept the default. You are next prompted for the scale of the plot.

This is the size of the window in nautical miles; the plot will extend for the specified number of nautical miles in the north-south direction. The default is 9 miles which is adequate for this example: At the **Scale?** screen press ENTER to accept the default value.



All the lines more or less come together near the center of the plot where a cross-hair is drawn to indicate the position of the fix. One would not normally rely on a fix obtained with lines of position which cross at such shallow angles, however we will advance these lines of position to a later time and use them to obtain an afternoon running fix.

To set the scale, the lines on the cross-hair are one nautical mile in length from tip to tip. After the lines of position have been drawn, the HP 48SX Graphics Environment is started. This allows you to do two things. First, press COORD.



The position of the graphics environment cursor is displayed (lon, lat in decimal degrees-which is: 136.520, 29.032). The cross-hair indicating the fix resembles the HP 48SX Graphics Environment cross-hair, and there is some chance that you can be confused as to which is which. To resolve this, use the arrow keys to move the cursor cross-hair around. Practice this, then return the cursor to its original position. This feature allows you to disagree with the information suggested by the computer. You can move the cursor to a position you trust and press [ENTER] to accept it as your present fix. But for now make sure that the cursor is in its original position (136.520, 29.032).

Second, to record this position press [ENTER] while still in the Graphics Environment . This position will become your present fix. Press [ON] to quit the Graphics Environment. The last position indicated by pressing [ENTER] is displayed and you are prompted to update the dead reckoning position.

```
Update DR?

Last position entered
in GRAPH utility:

  Lat:   29°01.9' N
  Lon:   136°31.2' W
 YES                     NO
```

Press [YES] to accept this position. The following screen will display:

```
Last position entered
in GRAPH utility:

  Lat:   29°01.9' N
  Lon:   136°31.2' W
SOLVE ERROR MODOB INIT MODOR QUIT
```

If you are happy with the fix suggested by the computer, you need not press [ENTER] before exiting the graph. If this is the case you will not be prompted to update the dead reckoning position.

No position fix is complete without an estimate of the reliability of the fix. Read Chapter 5, "Accuracy of the Fix" carefully. Running the ERROR program and particularly the PLOT program will give you a feel for the accuracy you have achieved. Remember: the computed fix is, at best, only as accurate as the data you have supplied. Do not be fooled by the fact that the fix is displayed to a precision of a tenth of an arc minute or so; celestial fixes are rarely that accurate.

CAUTION: It is difficult to observe bodies close to 90 degrees. The SOLVE program deals with this problem by weighting this type of data less: Any observations with Ho greater than 86 degrees will automatically be weighted significantly less in the fix than data with Ho under 86 degrees (weight=cos^2 (Ho) for Ho>86). Since observations of bodies near the zenith are generally difficult, and hence less accurate than sights of bodies closer to the horizon, this weighting scheme is quite useful in sight reduction. If, however, you have data above 86 degrees and you want to include it with equal weight, use SOLVE to get a weighted fix and then use PLOT to refine this fix. (From PLOT, move the graphics cursor to some position which you like better than the fix from SOLVE. Press ENTER to mark this spot, and when you exit PLOT the latitude and longitude of the selected point will be displayed.)

Compute Running Fix by Advancing Sights

Soon after the noon fix, the wind picks up and we follow a course of 248 True at 4.5 knots from 22:00 UT to 01:20 UT. Notice that, because we are using UT, 01:20 is on the next day. We obtain another observation of the Sun and can now compute a running fix by advancing the earlier noon sights to 01:20. To achieve this, we will use the ADV program [ADV stands for advance observation(s)].

Do not run the RESET program as we need the earlier noon sights to obtain our current fix. However, press INIT to update the course and speed. Press MOTIO. You are prompted for the new course and speed. At the **:COURSE:** prompt clear the default and input 248. At the **:SPEED:** prompt clear the default and input 4 . 5.

Press ENTER. You are next prompted for current set and drift. Let us assume that there is no appreciable current. Press ENTER to accept the defaults then press EXIT to quit the INIT program.

```
INDEX  +0°00.0'
HEIGHT 3.000m
MOTION 248.00T 4.5kn
P/T    1010.0mb 10.0C
FORMAT DMT
ZONE   +0
WATCH  00:00:08
IX/HT MOTIO  P/T  FORM ZN/W EXIT
```

IMPORTANT: Set the motion correctly. These values (course and speed) are used in ADDOB to advance or retard all sights to the same time of fix. IF THE COURSE AND SPEED ARE NOT CORRECTLY SET when you run ADDOB, YOU WILL GET A BAD FIX.

Since we sat becalmed from the last time of fix (21:02:17 UT) until 22:00 UT, but then began to move, we will have to update the observations in two steps. First we will update from 21:02:17 UT to 22:00 UT when the average speed was zero. Then we will advance from 22:00 UT to 01:20 UT during which the average speed was 4.5 knots.

To advance the sights press [NXT] [ADV]. You are first prompted for your dead reckoning position.

```
                                PRG
{ HOME SPARCOM NAV48D VARBLS }
Input DR (dd.mmt) at
1991,Feb 12,21:02:17UT
:DR_Lat: 29.019 N◆
:DR_Lon: 136.312 W
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

The ADV program does not require that the dead reckoning position be very accurate (within 60 nautical miles or so) since only the vessel's approximate position is needed in the computation of the advanced observations. The dead reckoning position must represent the vessel's position at the *initial time of fix* not at the time the observations are being advanced to. In this example, the dead reckoning position is already set to the position of the noon sight fix and we need not alter it. Press [ENTER] at the prompt to accept the default value.

You are next prompted for distance run, true course, and average speed.

```
                                PRG
{ HOME SPARCOM NAV48D VARBLS }
Motion? (nmi,true,knt)
:DISTANCE: ◆
:COURSE: 248.000
:SPEED: 4.500
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

In this case, instead of entering a distance at the first prompt, we will input a time by appending "_h" to the input. This will be for the first leg of the run when the speed was zero and the length of time was 57 minutes 43 sec.

To advance the time 57 minutes 43 seconds, at the **:DISTANCE:** prompt press 0[.]5743[→][×][α][←]H (make sure "_h" appears). The course should already be set to 248, leave this value alone. Clear the default at the **:SPEED:** prompt and input zero.

```
                          ALG PRG
{ HOME SPARCOM NAV48D VARBLS }
Motion? (nmi,true,knt)
:DISTANCE: 0.5743_h
:COURSE: 248.000
:SPEED: 0◆
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

Press [ENTER]. You are then prompted for the set and drift of the current.

```
                              PRG
{ HOME SPARCOM NAV48D VARBLS }
Current set/drift?
(True course / Knots)
  :Set: 0.000◆
:Drift: 0.000
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

The default values are those we specified in INIT. Press [ENTER] at this prompt to accept the default values. The time of fix is updated from 21:02:17 UT to 22:00 UT and the old and new dead reckoning positions are displayed:

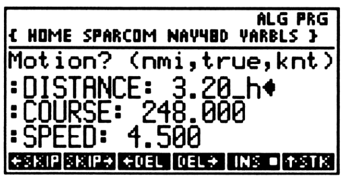
```
Old DR:
  Lat:  29°01.9' N
  Lon:  136°31.2' W
New DR:
  Lat:  29°01.9' N
  Lon:  136°31.2' W
SOLVE ERROR ADDDB INIT ADDDR QUIT
```

We can proceed to advance the second leg. Press [NXT] ADV. Again the program prompts you for the dead reckoning position.

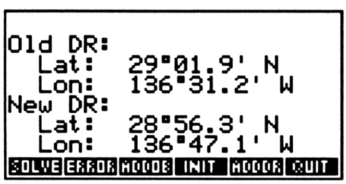
```
                              PRG
{ HOME SPARCOM NAV48D VARBLS }
Input DR (dd.mmt) at
1991,Feb 12,22:00:00UT
:DR_Lat: 29.019 N◆
:DR_Lon: 136.312 W
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

This position is the one from the noon sight fix. Press ENTER to accept this default DR position. You are next prompted for distance run, true course, and average speed.

Again input a time rather than a distance by appending "_h" to the input of the first prompt. To advance the time 3 hours 20 minutes, at the **:DISTANCE:** prompt press 3[.]20[→][×][α][←]H (make sure "_h" appears). The course and speed are the defaults from the INIT program and already set to 248 and 4.5 respectively. Press ENTER when finished.



You are then prompted for the set and drift of the current.
Press ENTER at this prompt to accept the default values.



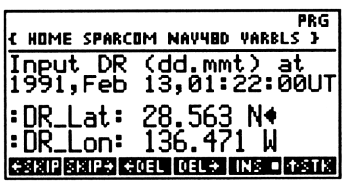
The observations are updated and the old and new dead reckoning positions are displayed. The observations have now been advanced to 01:20 UT (because we are using UT, it is now the next day). Input the new observation using the ADDOB program. The new observation is described below.

Body	Time (UT)	Hs (deg:min)
Sun (LL)	01:22:08	17:54.7

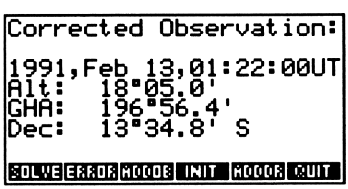
Press ADDOB to input the new observation. The date is now February 13, 1991. Press [←]3 to change it. Your screen should resemble the one below:

Press [ENTER]. Now input the time and sextant angle. At the **:Time:** prompt clear the default and input 01[·]2208. At the **:Hs:** prompt press 17[·]547. Your screen should resemble the one below:

Press [ENTER]. When prompted for the body press [SUN]. When prompted for the Limb press [LL]. When prompted to Compute Almanac press [YES]. After the almanac is computed, another prompt will be presented: *since the vessel is now moving you will be prompted for your dead reckoning position.*



The dead reckoning position need not be very accurate and the one we obtained by running ADV is fine. This is the default, so just press [ENTER] at this prompt. The corrected observation will be displayed when ADDOB completes its calculations.



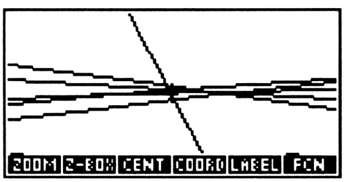
The running fix has now been input and you can run the SOLVE program to get the fix. Press [SOLVE].

```
COMPUTED POSITION
Update DR?

LAT:   28°56.3' N
LON:   136°49.9' W

1991,Feb 13,01:20:00UT
 YES                      NO
```

As before you are asked whether you want to update the dead reckoning position. Notice that the time the fix is valid is also displayed. Press **YES** to accept this position. The computed position will display. To get an indication of the accuracy of the fix press **ERROR**. The following screen appears:

```
±NS_Err:  0.06_nmi
±EW_Err:  0.19_nmi

SOLVE ERROR MODOB INIT MODOR QUIT
```

To see the lines of position press [NXT] **PLOT**. Press [ENTER] to accept the default plot center. Press [ENTER] to accept the default scale.



You can see that there is a lot of uncertainty since the lines do not intersect in anything like a point. A running fix is inherently inaccurate since the observations must be advanced along the dead reckoning track. Press **ON** to quit the graph.

So, what is the course and distance from the running fix to our destination? Since we accepted the dead reckoning position from the SOLVE program, this calculation is quite easy. We will use the SAIL program to acquire this information. Press [NXT] **SAIL**. Accept the default 'from' position (our dead reckoning position) by pressing [ENTER]. Accept the default 'to' position (our destination, set previously) by pressing [ENTER]. The following screen will display:

```
Command?
From:
  Lat:   28°56.3' N
  Lon:   136°49.9' W
To:
  Lat:   21°30.0' N
  Lon:   157°30.0' W
RHUM  GC  WAY  VERTX COMP EXIT
```

Now press RHUM to check that we can continue on the same course.

```
Command?

Course:   248°17.2' T
Dist: 1206.35_nmi



RHUM  GC  WAY  VERTX COMP EXIT
```

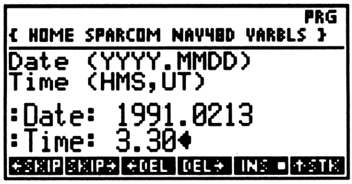
We can confirm from this information that we should maintain our course of 248 True and that we have another 1206 miles to go. Press EXIT to quit the SAIL program. For further information on computing a running fix see Chapter 4, "The Running Fix".

Evening Star Sights

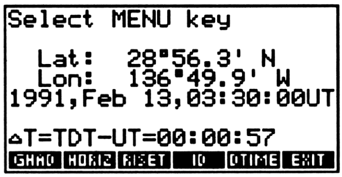
To take an evening star sight we first precompute the star sights we wish to obtain. To do this we will use the ALMN (Almanac) program. Press NXT ALMN. The following screen appears:

```
                                  PRG
{ HOME SPARCOM NAV48D VARBLS }
Position? (dd.mmt)

:Lat: 28.563 N◆
:Lon: 136.499 W
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

You are prompted for your position. The default position is the dead reckoning position. This position is adequate, press ENTER at this prompt. Next you are prompted for the date and time. To enter the date of February 13, 1991 clear the default at the **:Date:** prompt and input 1991[·]0213. Next clear the default at the **:Time:** prompt and input 3[·]30 (to enter a time of 3:30 UT).

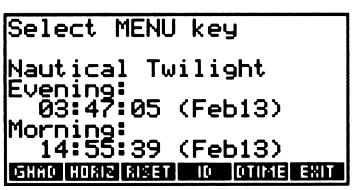


Press [ENTER].



You will now see the ALMN program menu where you can select any of the almanac programs by pressing the softkeys provided. To continue, we will need to know the window of time in which to make our star observations. To do this we need to determine when civil and nautical twilight will occur. First, civil twilight. Press [NXT] [CTWIL]. This will compute the times of civil twilight (this will take a little time):

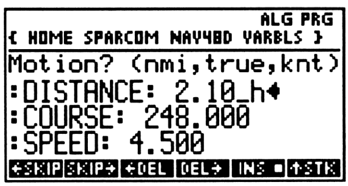
Now press [NXT] [NTWIL], to compute the time of Nautical twilight.



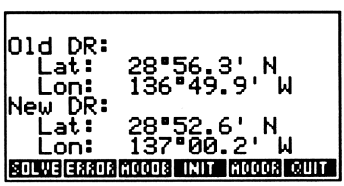
Civil twilight (evening) is at 03:19 and nautical twilight (evening) is at 03:47. Between these two times will be an excellent time for our star sights. Since the vessel is not moving rapidly we could now proceed to precompute star sights, however, for practice let us first compute our dead reckoning position at 03:30, rather than relying on our dead reckoning position at 01:20.

Press EXIT to quit the ALMN program. We will run the ADV program to advance our dead reckoning position. First though, clear out any old observations. Press NXT NXT RESET YES. This deletes our previous observations which we will no longer need. Had we run ADV without first running RESET, the old observations would have been updated and this is time consuming. By erasing them first, the ADV program will only update the DR position, which is much faster.

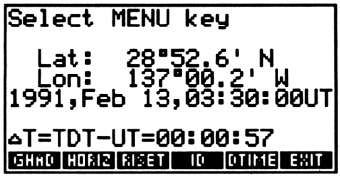
To continue, press NXT ADV. You are prompted for your dead reckoning position. Press ENTER to accept the default dead reckoning position. Next, you are prompted for the distance, course and speed at which you traveled. We have continued at 4.5 knots on a course of 248 True until 03:30, 2 hours and 10 minutes after the last valid time of fix. At the **:DISTANCE:** prompt press 2 · 10 ⮫ × α ⮪ H (to advance 2 hours 10 minutes). The course and speed are already set to 248 and 4.5 respectively.



Press ENTER when finished. A prompt for the set and drift appears. Assume there is still no appreciable current. To accept the defaults press ENTER. Your old and new dead reckoning position will be displayed.



Now that we have updated our dead reckoning position, we can precompute the star sights. Press NXT ALMN again. At the dead reckoning prompt press ENTER to accept the new position displayed. As before, you are prompted for the date and time. The date is February 13, 1991 and the time is 03:30 UT. Clear the default at the **:Date:** prompt and input 1991 · 0213. Clear the default at the **:Time:** prompt and input 3 · 30. Press ENTER. The ALMN program menu displays as seen below:



Now we can begin to precompute the sights of 4 stars: Rigel, Sirius, Dubhe, and Alpheratz. We start with Rigel. Press HORIZ. You are prompted for the body as seen below:

Press STAR when prompted for the body.

When prompted to enter star name type RIGEL. The alpha-entry mode is already on, so just key in the name.

Press ENTER when finished. After a moment the position of the star relative to the horizon will be displayed:

The altitude of Rigel will therefore be about 48 degrees. The value displayed is not corrected for refraction, dip, etc., so the actual observed altitude will be slightly different. Enter the three stars below in the same way:

Sirius	(when finished Alt: 28°18.9' will display)
Dubhe	(when finished Alt: 17°28.0' will display)
Alpheratz	(when finished Alt: 41°19.9' will display)

Press EXIT to quit the ALMN program and return to the NAV48 menu. We are approaching the predetermined time for our star sights and around 03:30 we obtain the following sight:

Body	Time (UT)	Hs
Rigel	03:31:18	48° 12.7'

Press ADDOB to enter the sight above. Remember, the date is now February 13, 1991. When prompted for the date, clear the default and input 1991[·]0213. Press ENTER. Next you are prompted for the time and sextant angle. At the **:Time:** prompt clear the default and input 3[·]3118. At the **:H_s:** prompt press 48[·]127. Press ENTER. When prompted for the body press STAR. When prompted to compute the Almanac press YES. The following screen will appear:

When prompted for the star name type in RIGEL (the program is already in alpha-entry mode).

Press ENTER. Next you will be prompted for the time of fix. The date is correct, but we will change the time of fix to 03:35 UT. At the **:Time:** prompt clear the default and input 3[·]35. Press ENTER. Then press ENTER again to accept the default dead reckoning position which was just computed with ADV. The screen displays the corrected observation.

Enter the following sights as you did for Rigel. The process is the same except you will not be prompted for the time of fix.

Body	Time (UT)	Hs
Dubhe	03:33:58	17° 57.3'
Alpheratz	03:35:20	40° 19.6'

In order to practice entering stars using their scientific names, we will use our observation of Sirius. Do not be concerned that the observation of Sirius occurred between our sights of Rigel and Dubhe. The order in which you enter sights does not matter.

Body	Time (UT)	Hs
Sirius	03:32:50	28° 48.6'

Press ADDOB as before. The date is correct press ENTER. The procedure to enter the time and sextant angle are also the same as before. At the **:Time:** prompt clear the default and input 3[•]3250. At the **:H_s:** prompt press 28[•]486. Press ENTER. Now when prompted for the body press LSTAR instead of STAR. When prompted to compute the Almanac press YES. The following screen will appear:

If you know that Sirius is the brightest star in the constellation Canis Majoris then you know that the scientific abbreviation for Sirius is: α CMa. To enter the scientific name of Sirius into the calculator type ALP[SPC]CMA (the program is already in alpha-entry mode). "ALP" represents the character α and "CMA" represents CMa. Also, case does not matter when inputting the scientific abbreviation, upper or lowercase is fine.

Press [ENTER]. Press [ENTER] again to accept the dead reckoning position. The calculator will think for a bit then display the corrected observation.

> **IMPORTANT: Do not be concerned that you need to know the scientific names of all the stars. This information is provided for individuals who are particularly interested in astronomy. The list of 57 navigational stars, accessed by pressing [STAR], will be more than enough for your sight reductions. For a complete list of stars refer to Appendix B.**

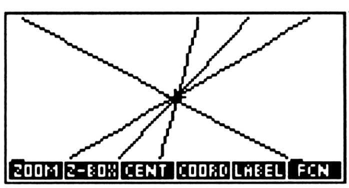
Now that all four observations have been input press [SOLVE] to get the fix:

```
COMPUTED POSITION
Update DR?

LAT:    28°52.8' N
LON:    137°02.3' W

1991,Feb 13,03:35:00UT
 YES                        NO
```

Press [YES] to accept the fix as the new dead reckoning position. To get an estimate of the accuracy of the fix press [ERROR].

```
±NS_Err:  0.07_nmi
±EW_Err:  0.06_nmi

SOLVE ERROR HOOOB INIT HOOOR QUIT
```

Now, plot the lines of position. Press [NXT] [PLOT]. Accept the default plot center by pressing [ENTER]. Accept the scale by pressing [ENTER].



This is an excellent fix. Press [ON] to quit the plot. With this fix we can accurately determine the true course and distance to Oahu. Press [NXT] [SAIL]. Since we accepted the fix as our new dead reckoning position, press [ENTER] to accept the default 'from' position. Press [ENTER] to accept the default 'to' position. Now, press [RHUM] to compute the rhumb line to Oahu:

```
Command?

Course:   248°14.9' T
Dist: 1194.91_nmi



RHUM  GC  WAY VERTX COMP EXIT
```

Our current course of 248 True is still correct. Press EXIT to quit the SAIL program.

Estimated Position

There is a second way to use the SOLVE program. If have you input *one* celestial observation with the ADDOB program and input your dead reckoning position with the ADDDR program, you can find your *Estimated Position.* This is simply the point on the celestial circle of position which is closest to your dead reckoning position. With the single celestial observation and the dead reckoning position input, you use the SOLVE program to get the estimated position. Follow the example below.

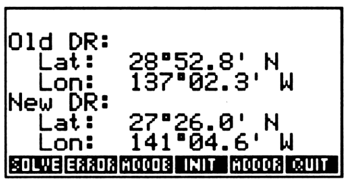
After our evening star sights, clouds roll in. We do not obtain any sights for about 41 hours. At about 21:18 UT on February 14, we get a single sun sight before clouds move in again. By combining our dead reckoning position with the line of position from the sun sight, we can determine our estimated position (that point on the LOP which is closest to the dead reckoning position).

First we compute our dead reckoning position by advancing our last fix. We will use the ADV program. First, press [NXT] [NXT] RESET YES to clear the old observations. Since our last fix at 03:35 UT on February 13, the log shows that we have traveled 231 nautical miles in 42 hours at a speed of 5.5 knots on an average course of 248 True. Once again we assume there is no appreciable current. Press INIT MOTIO the course should already be set to 248. At the **:SPEED:** prompt clear the default and input 5[·]5. Press [ENTER]. Leave set and drift at zero and press [ENTER]. Be sure your screen matches the one below:

```
INDEX   +0°00.0'
HEIGHT  3.000m
MOTION  248.00T 5.5kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:08
IX/HT MOTIO P/T FORM ZN/W EXIT
```

Press EXIT to quit the INIT program. Now press NXT ADV. Press ENTER to accept the default dead reckoning position (this is the initial position). You are prompted for the distance, course and speed. At the **:DISTANCE:** prompt press 231 (to advance 231 nautical miles). The course should already be set to 248 and the speed should already be set to 5.5.

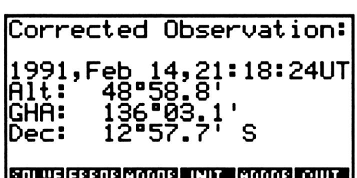
Press ENTER. Leave the set and drift at zero and press ENTER again. The old and new dead reckoning positions will be displayed.



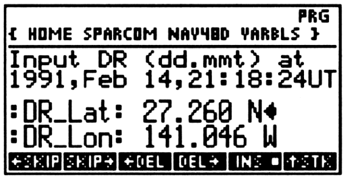
Now input the Sun observation below.

Body	Time (UT)	Hs
Sun (LL)	21:18:32	48°:46.4′

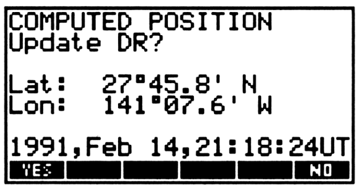
Press ADDOB. Remember the date is February 14, 1991. At the **:Date:** prompt clear the default and input 1991 . 0214. Press ENTER. At the **:Time:** prompt input 21 . 1832. At the **:H_s:** prompt clear the default and input 48 . 464. Press ENTER When prompted for the body press SUN. When prompted for the limb press LL. When asked to compute the almanac press YES. Press ENTER to accept the default time of fix. Press ENTER to accept the default dead reckoning position. The corrected observation is displayed.



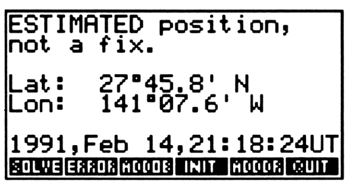
With the observation input, we next input the estimated dead reckoning position as an observation. To do this, press ADDDR . You are prompted for the dead reckoning position as seen below:



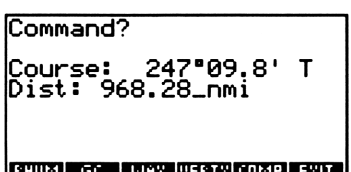
Since we have updated the dead reckoning position with the ADV program, we can accept the default position. Press ENTER. The screen will display the added dead reckoning position. To find the estimated position press SOLVE.



This is **NOT** a fix and has the potential to be very far from the correct position! To accept the estimated position as the new dead reckoning position press YES. The screen will display the following:



Now we need to compute the true course and distance to Oahu. Press NXT SAIL. Press ENTER to accept the default values for the 'from' position. Press ENTER to accept the default values for the 'to' position. Press RHUM to compute the rhumb line.



We should now steer 247 True. Press EXIT to quit the SAIL program.

WARNING: This estimated position is NOT a fix and should not be construed as one. It may in fact be very far from your true position but in some circumstances can be better than the dead reckoning position alone.

Moon/Planet Fix

As a last example of our voyage from San Diego to Oahu, we will obtain a fix from two sights, one of the Moon and the other of the planet Jupiter. We observe these bodies as we are nearing Oahu in the evening of February 22, 1991 (February 23 in Greenwich). First, press [NXT] [NXT] RESET YES to clear the old observations.

As some time has passed we will need to reassign the values in the INIT program to represent any changes that we would have made between our last fix and this example. Next press INIT MOTIO and change the course to 247 (247 degrees True) and the speed to 4 (for 4 knots). Press [ENTER]. There is no set or drift, leave these at zero. Press [ENTER]. Make sure your screen matches the one below:

```
INDEX   +0°00.0'
HEIGHT  3.000m
MOTION  247.00T 4.0kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:08
IX/HT MOTIO P/T FORM ZN/W EXIT
```

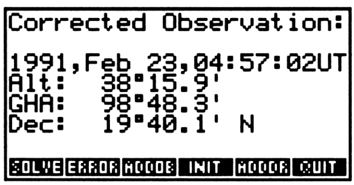
Press EXIT to quit the INIT program. Since we have been traveling for a few days the dead reckoning position in the calculator is no longer valid. To continue with this example we will need to reassign it. Press [NXT] PILOT DREC. At the **:DR_Lat:** prompt clear the default and input 22[·]25[SPC][α]N. At the **:DR_Lon:** prompt clear the default and input 154[·]45[SPC][α]W. Press [ENTER]. Press EXIT to quit the PILOT program. Now, input the Jupiter observation.

Body	Time (UT)	Hs
Jupiter	04:57:10	38°20.2'

IMPORTANT: Since the observation times are after 2400 UT, the UT date of the observation is February 23 not February 22!

Press ADDOB. At the **:Date:** prompt clear the default and input 1991[·]0223. Press ENTER. At the **:Time:** prompt input 4[·]5710. At the **:H_s:** prompt input 38[·]202. Press ENTER. When prompted for the body press PLAN. The following screen appears:

When prompted for the planet press JUPIT (Jupiter). When asked to compute the almanac press YES. Press ENTER to accept the time of fix. Press ENTER to accept dead reckoning position you just input with DREC.



Since we are nearing landfall, we wish to make the fix as accurate as possible. We decide to use the Greenwich Hour Angle (GHA) and declination of the Moon from the U.S. Naval Observatory "Nautical Almanac" rather than relying on the program's internal almanac. Generally this only matters for the Moon since the computation of the Lunar ephemeris is somewhat less accurate than for the other bodies (see Appendix A). The calculator will interpolate the hourly "Nautical Almanac" values to find the GHA and declination at the time of the observation.

Now enter the observation of the moon.

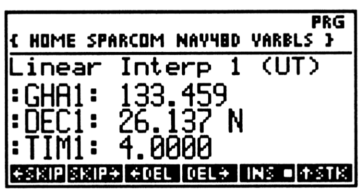
Body	Time (UT)	Hs
Moon (LL)	04:55:08	81°52.2'

Press ADDOB. The date should already be set to 1991.0223 so just press ENTER at this screen. At the **:Time:** prompt clear the default and input 4[·]5508. At the **:H_s:** prompt press 81[·]522. Press ENTER. When prompted for the body press MOON. When prompted for the limb press LL. When asked to compute the almanac press NO. You are first prompted for the horizontal parallax (H.P. on the daily pages of the U.S. Naval Observatory "Nautical Almanac"). A default value is computed and, while you should check it, it will usually be good enough. Make sure the default value matches the one on the screen below.

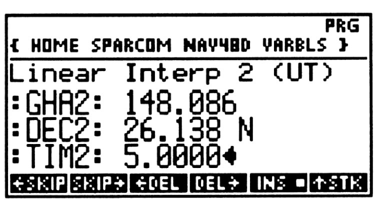
Press [ENTER] to accept the value. Next, you are prompted for the first GHA, declination and time set (time must be input in UT!). The information needed for the screen below is listed in the U.S. Naval Observatory "Nautical Almanac", although it is given below for your convenience.

Time	GHA	declination	HP
04:00	133° 45.9'	N26° 13.7'	59.4'
05:00	148° 08.6'	N26° 13.8'	59.4'

At the **:GHA1:** prompt press 133[·]459 (for a GHA of 133°45.9'). At the **:DEC1:** prompt press 26[·]137[SPC][α]N (for a declination of 26°13.7'N). At the **:TIM1:** prompt press 4[·]0000 (for a GHA/Declination at 04:00:00 UT).



Press [ENTER]. Then you are prompted for the second GHA and declination set. At the **:GHA2:** prompt press 148[·]086 (for a GHA of 148°08.6'). At the **:DEC2:** prompt press 26[·]138[SPC][α]N (for a declination of 26°13.8'N). At the **:TIM2:** prompt press 5[·]0000 (for a GHA/Declination at 05:00:00 UT).



Press [ENTER]. The "Nautical Almanac" data has now been entered and you are prompted for the dead reckoning position. Press [ENTER] to accept this position.

Important: Read Chapter 8, "The Almanac" for further information on inputting data from the "National Almanac".

We now have both observations input and are almost ready to solve for the fix. To obtain a fix requires at least 3 observations. The reason for this is that each observation yields a *circle of position*, but you do not know exactly where on the circle you are located. With two observations, you have two circles of position and can almost fix your position. Not quite, however, since the two circles will generally intersect at two positions; you are at one of these intersections. To completely fix your position, you need a third observation to select between the two intersection points. We could enter another observation, or use the dead reckoning position as a third observation. This is discussed in the following section.

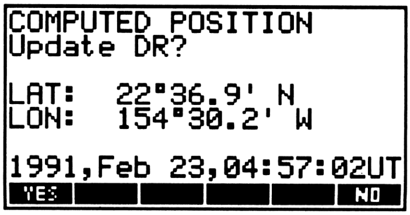
Dead Reckoning as Third Observation

When a third observation is required to get a fix, this third observation can be of a celestial body or it can simply be a reasonably accurate dead reckoning position. The dead reckoning position should be as accurate as possible but need not be exact, say within 10 or 20 miles. We will use the ADDDR program to add the dead reckoning position to the moon and planet fix we just obtained. The default values are the last dead reckoning position you input, if any.

NOTE: If you have three or more celestial observations, no dead reckoning information is required. You can always include it if you wish, but it is not necessary for isolating the fix. Press ADDDR.

```
                                 PRG
{ HOME SPARCOM NAV48D VARBLS }
Input DR (dd.mmt) at
1991,Feb 23,04:57:02UT
:DR_Lat: 22.250 N◆
:DR_Lon: 154.450 W
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

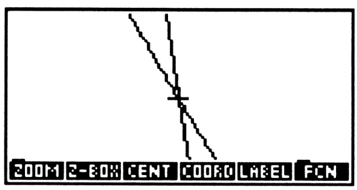
To accept the default dead reckoning position press ENTER. The dead reckoning position can now be used as a third observation. Press SOLVE to get the fix:



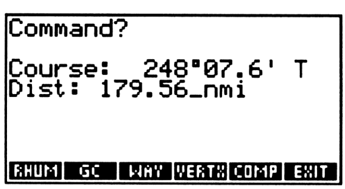
You are prompted to update the position. Press YES to accept the fix as the new dead reckoning position.

IMPORTANT: ERROR will not return meaningful information on the accuracy of the fix when only two sights are used. With two sights the lines of position cross at a single point and it is not possible to analyze the accuracy by determining how far the lines of position are from the fix.

Press NXT PLOT to see the lines of position. Press ENTER to accept the default plot center. Press ENTER again to accept the scale.



You will see that the lines of position cross at a fairly shallow angle. This fix is not as accurate as one in which the lines cross at a right angle. Since the shallow angle opens generally north-south, the east-west position (longitude) will be more accurate than the north-south position (latitude). Press ON to quit the plot. Finally, compute the course and distance to our destination. Press NXT SAIL. Press ENTER to accept the 'from' position. Press ENTER to accept the 'to' position. Press RHUM.



Press EXIT to leave the SAIL menu. You have completed the tutorial.

Notes:

Chapter 3

Saving and Recalling Data

Before continuing with navigation, we will discuss the ability to save and recall data. This chapter provides you with information for saving your observations, recalling them and deleting them if they are no longer needed. A simple data editor is also provided. This information will be used in upcoming chapters.

This chapter covers:

- ❑ Save Data
- ❑ Recall Data
- ❑ Data Editor
- ❑ Remove Data

Save Data

Data is saved in the {HOME SPARCOM NAV48D DATA} directory which is created when you first run the NAV48 program. The example below will show you how to save data with the DSAVE program.

First, clear out any old observations by pressing NXT NXT RESET YES. Second, press INIT IX/HT. There is no index error but, at the **:HEIGHT:** prompt input 2 (for 2 meters). Press ENTER. Next, press MOTIO. and set the course and speed to zero. Press ENTER. Leave set and drift at zero. Press ENTER. Your screen should read as the following: (Set the watch error is set to zero.)

```
INDEX   +0°00.0'
HEIGHT  2.000m
MOTION  0.00T 0.0kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:00
IX/HT MOTIO P/T FORM ZN/W EXIT
```

Press EXIT to quit the INIT program. As this is a new example we will need to reset the dead reckoning position. Press NXT PILOT DREC. At the

:DR_Lat: prompt input 21[•]451[SPC][α]N. At the **:DR_Lon:** prompt input 156[•]095[SPC][α]W. Press [ENTER] then [EXIT]. The two planet observations below we be used in our example.

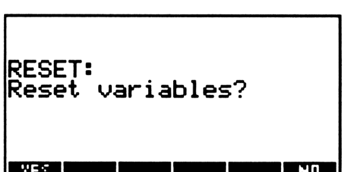
Body	**Time**	**Hs**
Venus	16:15:00 UT	14° 26.5'
Jupiter	16:16:32 UT	26° 19.6'

To add the observation of Venus press [ADDOB] and input the date as 1992[•]0210. Press [ENTER]. At the **:Time:** prompt input 16[•]1500. At the **:H_s:** prompt input 14[•]265. Press [ENTER] when finished. When prompted for the body press [PLAN] and when prompted for the planet press [VENU]. When prompted to compute the almanac press [YES]. Accept the date and time of fix by pressing [ENTER].

Press [ADDOB] again and add the observation of Jupiter above. Remember, since you have already entered the time of fix with the Venus observation you will not be prompted for it.

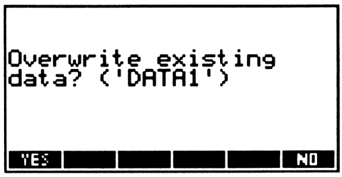
Now we will save these two observations with the DSAVE program (DSAVE stands for *data save*). The DSAVE program's softkey looks like: [DSAVE]. To access the DSAVE program press [NXT][NXT][DSAVE]. You are prompted for a variable name in which to store the data you just entered. In this case, the two planet observations from above. Save the data as variable DATA1. Input DATA1. The alpha-entry mode is automatically turned on so that you can simply key in the name.

Press [ENTER]. The two planet observations are now saved under the variable name DATA1. Next, you will be prompted to reset the variables. The following screen will appear:



What the DSAVE program can do is execute the RESET program *after* it has saved the data. You have a choice of whether you want to do this or not. If you press yes, upon exiting the DSAVE program, you will be able to input a new set of data without any old observations interfering. If you press no, upon exiting the DSAVE program, you will be able to add more observations to the observations just saved and thus continue with your sight reduction. In this case, when asked whether you wish to reset the data variables press YES.

In the future if you attempt to save data in a variable which already exists, you will be given a choice of whether *to overwrite* or *not to overwrite* the existing data. If this is the case, the following screen will appear:

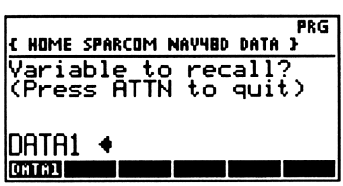


To overwrite press YES and continue with your calculations. To *not* overwrite press NO. The program will then abort the command and you will placed on the first page of the main menu. You can then restart the saving process and choose a different variable name.

Recall Data

To recall data which has been saved with the DSAVE program NAV48 provides the DRCL program (DRCL stands for *data recall*). The DRCL program's softkey looks like: DRCL. The softkeys display the names of the variables you have created with the DSAVE program and the WAY program (information on the WAY program is included in Chapter 6 The Sailings, "Waypoints").

To access the DRCL program press NXT NXT DRCL. You will be prompted for the variable name. You will see the variable DATA1 appear at the bottom of the screen as a softkey. Press DATA1.



NOTE: If you have a long list of variable names in your softkey menu, and you cannot find DATA1, you can type in the variable name DATA1 instead.

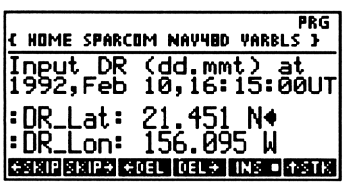
Alternatively, use the NXT key to move through the softkey menu until you find DATA1. Be sure your screen matches the one above.

Press ENTER.

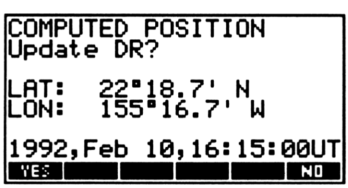
If recalling data would overwrite existing observations a message "Overwrite existing observations (OBS)?" will appear. If this is the case, the following screen will appear:

You will have the choice *to overwrite* or *not to overwrite*. To overwrite press YES and continue with your calculations. To *not* overwrite press NO. The program will then abort the command and you will be placed on the first page of the main menu. Once the data has been recalled, you can incorporate it into your fix.

Since only two observations were saved we will need to add our dead reckoning position to the planet observations that we just recalled. Press ADDDR to add the dead reckoning position.



Press ENTER to accept. Finally, press SOLVE. The result is:



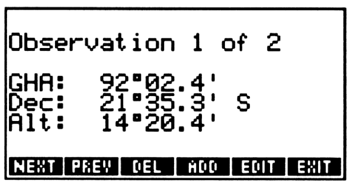
Press YES to accept this position.

NOTE: In the example above you saved two observations in the variable DATA1. Then used the dead reckoning position to get a fix. As long as you have at least three observations saved in a *recalled* variable , you can act on it directly with the SOLVE program. You can then run ERROR and/or PLOT.

Data Editor

A simple editor is provided to allow you to examine the observations you have entered, or to add, delete or change them.

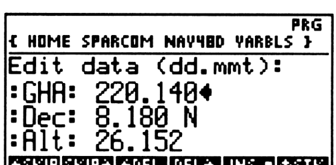
To delete or edit an observation(s) you have just entered you may run the EDIT program directly. To delete or edit an observation that you have saved with the DSAVE program, you must first select the observation using DRCL program. Press NXT NXT DRCL. You will see the variable DATA1 appear at the bottom of the screen as a softkey. Press DATA1 then ENTER. When asked to overwrite the existing observations, press YES. Now press NXT NXT EDIT to see the following screen.



There are six softkeys activated when you run the EDIT program:

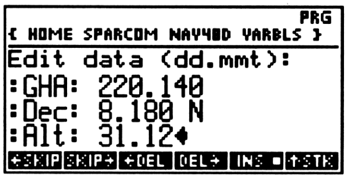
NEXT: Moves to the next observation
PREV: Moves to the previous observation
DEL: Deletes an observation
ADD: Adds a new observation
EDIT: Edits an observation
EXIT: Exits back to the main NAV48 menu

The observation(s) are selected with the NEXT and PREV keys. Press NEXT to access the second observation. When the observation is displayed press EDIT to edit it.



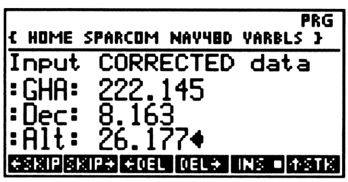
To edit the observation, you are prompted for the three observational values: GHA, declination, and altitude. The default values are the old values and you can change these in any way you wish. In the example above the GHA is 220° 14', declination is 8°18' N, and altitude is 26°15.2'.

If you now wish to change the altitude to 31°12', edit the display to:

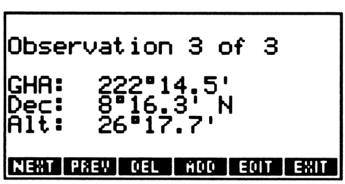


Press [ENTER].

An observation can be added at any time, you need not select any particular observation in the display. As with the EDIT key, you will be prompted for the GHA, declination, and the altitude, although in the ADD routine, no default values are given. Press [ADD]. Input data so that it matches the screen below:



Press [ENTER]. You will be prompted for the date and time of the observation . Input a date of 1992[.]0210 and a time 16[.]1700. Press [ENTER]. It will now appear as observation 3 of 3 on the screen.



NOTE: You must key in all data before pressing [ENTER]

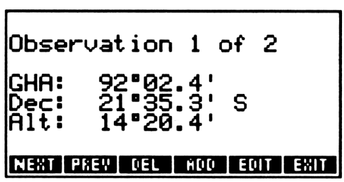
WARNING: Any observations you add or change with the editor are used "as is"; they are not corrected in any way for any effects such as refraction, semi-diameter, parallax, index error, dip etc. You should always enter observations with the ADDOB program to apply these corrections. The observation will, however, be corrected for the motion of the observer.

The ADD program (but not the EDIT program) does correct the input data for the motion of the vessel. Hence, as in the ADDOB program, you will be prompted for a time of fix (if one has not been input previously) and for your dead reckoning position at the time of the observation (if the speed set in INIT is not zero).

As in the ADDOB program, it is very important to check that the course and speed set in INIT are correct before running ADD since these values will be used to advance or retard the observation.

See Chapter 2 NAV48 Tutorial, "Inputting Celestial Observations".

Deleting an observation is very easy. Select observation 3 of 3 using NEXT or PREV. Press DEL and the observation is gone. This puts you back to observation 1 of 2.

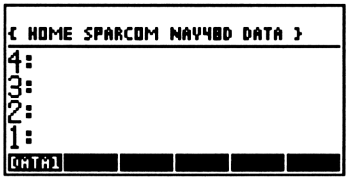


Press EXIT when finished.

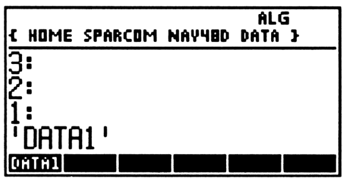
Remove Data

Exit NAV48 and enter the 'DATA' sub directory of the 'NAV48D' directory.

Press QUIT VAR ⮫ ' SPARC NAV4 DATA



Once inside the DATA directory press ' then either press the softkey that corresponds to the variable you wish to remove or type in the variable name. In this case, press DATA1.



Then press ENTER ⮪ DEL (PURGE). The variable's softkey will disappear from the display. When finished press ⮫ ' ⮪ ▲ (LIBRARY) NAV4 NAV4 to return to the NAV48 program.

Chapter 4

The Running Fix

There are two methods to obtain a running fix with NAV48. The *first* is with the ADDOB program. The *second* is with the ADV program. In this chapter you will be given an example of this second method along with specific information exclusive to the ADV program.

This chapter covers:

- ❑ Running Fix Using ADV Program

Running Fix Using ADV Program

A running fix is a fix computed from observations widely separated in time, obtained when the vessel is moving. In order to compute the fix, a time at which the fix is valid is chosen. All the lines of position are advanced or retarded to this time. The accuracy of a running fix is thus much less than the accuracy of a fix computed from simultaneous sights. The reason being, that the lines of position must be advanced using the vessels estimated course and speed. Including the dead reckoning information compromises the accuracy; the longer the time span between the observations, the less accurate the fix will be.

There are two ways to obtain a running fix. The first is with the ADDOB program. By selecting a time when the fix is valid, the ADDOB program will automatically advance or retarded all observations to this time yielding a running fix.

> **CAUTION: ADDOB will not advance observations correctly unless you have correctly input the motion of the vessel in the INIT program. Be certain that the average speed and course from the time of the fix to the time of the new observations are properly entered in INIT. Make sure that the speed and course are correct every time you run ADDOB.**

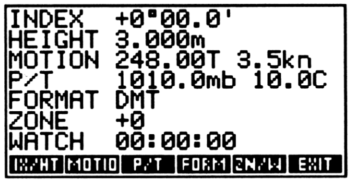
The second way to get a running fix is to use the ADV program. This program will advance or retard all observations previously input, as long as you specify the distance traveled and the course followed since the observations were taken. In other words, the ADV program advances a set of observations which are all valid at the same time *to a new time*. Since ADDOB automatically adjusts your sights to the same time, any observations you have input with ADDOB will generally all be valid at the same time and hence suitable for use with ADV.

For example, suppose you take a set of morning star observations, reduce these with the ADDOB program and run SOLVE to get a fix. Late in the morning you then obtain a single observation of the Sun. With only one observation of the Sun, you cannot get a fix. But, using the ADV program you can advance your morning star sights to the time of the Sun sight. You then enter the Sun sight with ADDOB and obtain a running fix with SOLVE.

The ADV program updates your dead reckoning position automatically and does not require that you keep the vessel's motion and the time of fix updated with INIT.

IMPORTANT: The ADV program advances the observations by correcting the Greenwich Hour Angle and the declination of the observed body. This correction depends somewhat on position and hence the current dead reckoning position is used in the correction. You must set the dead reckoning position when prompted in the ADV program to your initial position (at the time the old observations are valid), not your position at the time the observations are being advanced to. If the DR position is within 60 nautical miles or so of your true position, ADV will be sufficiently accurate.

The following example will use the ADV program to advance a single sun sight. This single sun sight will be combined with a later sun sight then combined further with the new dead reckoning position to obtain a fix. To get started clear out all old observations. From the first page of the main menu press NXT NXT RESET YES. Press INIT IX/HT. There is no index error, but at the **:HEIGHT:** prompt input 3 (for height of eye at 3 meters). Press ENTER then MOTIO. At the **:COURSE:** prompt input 248 and at the **:SPEED:** prompt input 3.5 (for a course of 248 True at a speed of 3.5 knots). Press ENTER and make sure that set and drift are at zero. Press ENTER. Make sure your screen matches the one below:



Press EXIT when finished. Now reset the dead reckoning position. Press NXT PILOT DREC. At the **:DR_Lat:** prompt input 28 . 565 SPC α N and at the **:DR_Lon:** prompt input 136 . 468 SPC α W.

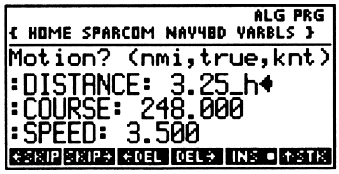
Press ENTER then EXIT when finished.

Next, press ADDOB and input the sun sight below. The date is July 27, 1992.

Body	Time (UT)	Hs
SUN (LL)	20:20:39	74°:22.6′

At the :Date: prompt input 1992 . 0727. Press ENTER. At the **:Time:** prompt input 20 . 2039 and at the **:H_s:** prompt input 74 . 226. Press ENTER. When prompted for the body press SUN, when prompted for the limb press LL and when asked to compute the almanac press YES. When prompted for the time of fix, press ENTER to accept. At the Input DR screen press ENTER to accept the dead reckoning position of 28°56.5' N by 136°46.8'W. Press ENTER.

A little over three hours later we get another sun sight. Run the ADV program to advance the observation and dead reckoning position Press NXT ADV. ADV will prompt you for the dead reckoning position, press ENTER to accept this position. Next you will be prompted for the distance traveled. At the **:DISTANCE:** prompt input 3 . 25 ↱ * α ↰ H. Make sure your screen matches the one below:



NOTE: This is the vessel's motion through the water, current will be dealt with later.

The default unit for distance is nautical miles and the default for speed is knots. Any valid unit may be specified by appending an underscore ("_") and the unit name, i.e. 3_m/s would be 3 meters per second. At the distance prompt above you have specified the distance in time with the HMS format (3 hours 25 minutes). To indicate that the input is a time, "_h" was appended to the value. In this case, the distance traveled will be taken as the time multiplied by the speed (3.25 x 3.5 = 11.375_nmi).

> **IMPORTANT: The "h" must be in LOWER CASE or it will be ignored and the number treated as a distance in nmi. "_h" is keyed in by pressing [→][×][α][←]H.**

You are also prompted for the true course steered (not the magnetic course!), and the average speed over the run. The default values for course and speed are the vessels course and speed which were set in the INIT program. These values already appear at the course and speed prompts as 248.000 and 3.500 respectively. Press [ENTER] to accept the defaults. The program next prompts you for current set and drift, with default values equal to the values input in the INIT program. Press [ENTER] to accept these values. The observations are then advanced along with the dead reckoning position. A counter is displayed in the upper left corner of the screen to indicate which observation is currently being updated. The calculator will then display the new dead reckoning position as follows:

```
Old DR:
   Lat:   28°56.5' N
   Lon:   136°46.8' W
New DR:
   Lat:   28°52.0' N
   Lon:   136°59.4' W
SOLVE ERROR ADDOB INIT ADDOR QUIT
```

Now, press [ADDOB] and input the sun sight below. The date is still July 27, 1992.

Body	Time (UT)	Hs
SUN (LL)	23:45:22	54°:05.5′

Press [ENTER] to accept the date. At the **:Time:** prompt input 23[·]4522 and at the **:H_s:** prompt input 54[·]055. Press [ENTER]. When prompted for the body press [SUN], when prompted for the limb press [LL] and when asked to compute the almanac press [YES]. Since we advanced our last observation using the

ADV program you will not be prompted for the time of fix. At the Input DR screen press ENTER to accept the dead reckoning position of 28°52.0' N by 136° 59.4'W.

Now add the dead reckoning position to the sight reduction. Press ADDDR and press ENTER to accept this position. Then press SOLVE to get the fix:

```
COMPUTED POSITION
Update DR?

LAT:    28°33.3' N
LON:    136°57.4' W

1992,Jul 27,23:45:39UT
 YES                  NO
```

Press YES to update the dead reckoning position.

There are two special cases which you will need to keep in mind when using the ADV program. Both when you input the speed to ADV as zero (including the drift due to a current). In the first case, the speed is zero and the distance run is input as a distance, not a time. The observations and the dead reckoning position are advanced, but the time of fix is not changed. The other case is when the speed is input as zero and the distance is input as a time. In this case, the observations and the dead reckoning position are not changed, but the time of fix is incremented by the time input to the ADV program. These special cases can be useful if you wish to advance the time of fix or the observations independently.

NOTE: You can use the ADV program to update your dead reckoning position for distance run, even if you do not currently have any observations entered.

NOTE: If you want to undo the action of ADV, input the same course and speed, but input the distance as the negative of the distance you input previously.

NOTE: If you input the vessel's speed as zero and the distance run as a distance rather than a time, the program cannot compute the distance you have drifted in a current and you will be prompted for time spent in the current, if the drift is not zero. This is simply the time interval over which you wish to advance your observations.

NOTE: The ADV program includes a small correction for the non-spherical shape of the Earth.

Notes:

Chapter 5

Accuracy of the Fix

In a sense, this is the most important chapter in this manual. A position fix, from any source, is essentially useless without an estimate of the accuracy. For example, there is a very large difference between two position fixes which yield the exact same position if one has an error of 100 meters and the other an error of 50 nautical miles! If you were approaching landfall on an unfamiliar coast after an ocean crossing, it would be very important to know how accurate your fix was; not allowing for the uncertainty could easily be disastrous. Error estimates can be difficult, and in any event, can never be more than estimates; the final judge of the fix accuracy must be the navigator him or herself. This chapter describes several programs which assist the navigator in estimating accuracy.

This chapter covers:

- ❑ Random and Systematic Error
- ❑ Formal Error
- ❑ Plotting Lines of Position
- ❑ Navigate with PLOT Only

Random and Systematic Error

There are two kinds of error encountered in navigation: random and systematic. Random error is an error which varies from observation to observation; if you made exactly the same observation many times, the random error is the scatter in the measurements. Systematic error, on the other hand, is a constant error which is the same for all observations. An example of random error would be the variation in an observed altitude from one sight to the next due to the motion of the vessel in the waves and the fact that you cannot hold your sextant perfectly steady. An example of a systematic error is misalignment of the sextant optics, which affects each observation in the same way (i.e. index error).

Of the two types of error, systematic errors are more insidious. The problem is that it is difficult to detect the presence of systematic error unless you already know exactly where you are. If it is present when you are relying exclusively on celestial navigation, you may not be aware of it. Systematic errors must be eliminated before you start your voyage by taking observations from a known location and comparing your celestial results with your true position. The book "Celestial for the Cruising Navigator" by Merle Turner has a very good description of systematic errors and how to detect and eliminate them (see the bibliography).

Random errors are treated differently. With random errors, there is often very little you can do to eliminate them except practice your observing technique. However, if you are plagued by random error, chances are that you will know it and be able to quantify the effect. When you take multiple observations, in theory all the lines of position will intersect at a single point. In practice, this never happens and the distance by which the LOPs (lines of position) miss one another gives you an idea of what the random errors are. You must have at least 3 LOPs for this to work: two LOPs always intersect in a point even when random error is at work.

Another feature of random errors is that, on the average, they tend to cancel each other out. Hence the more observations you take, the less you will be affected by random error. The SOLVE program described above is ideally suited for this, since it will accept any number of observations and eliminates the drudgery of reducing a large number of sights.

The two programs described below, ERROR and PLOT will help you estimate the accuracy of your position fix. The sight reduction in SOLVE is performed by a least squares fit to the altitude of the bodies in time. Associated with this fit is a formal error which is computed with the ERROR program. This formal error is a measure of the internal consistency of your data. The PLOT program gives you a visual indication of the accuracy of the fix by plotting the lines of position from your observations. The accuracy is then indicated by how close the LOPs come to meeting at a single point.

Formal Error

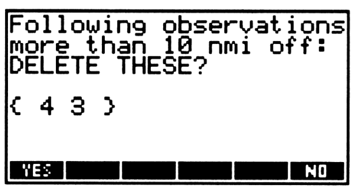
The formal error on the least squares fit computed with the SOLVE program is calculated with the ERROR program. The program assumes that all errors are random, it cannot determine systematic error. However, *if there are no systematic errors*, the displayed uncertainty is such that there is somewhere around a 60 to 70 percent chance that the true position is within the given uncertainty range and somewhere around a 90 percent chance that it lies within twice the indicated range.

NOTE: There is a chance (roughly 1 in 10) that the true position lies outside even twice the displayed uncertainty.

As mentioned above, you must have at least 3 observations, excluding dead reckoning data, to get an indication of the random error in your observations, and the ERROR program will abort if you have less than 3 observations.

IMPORTANT: The ERROR program uses the fix computed by SOLVE and, hence, SOLVE must be run first. If you run ERROR before SOLVE you will get an incorrect error estimate.

If any of the observations are more than 10 nautical miles from the position fix, this will be reported and you will be asked whether you want to delete the indicated observations. Press the YES or NO menu key to indicate your choice. The numbers displayed in between the { } are the observation numbers assigned in order of entry. They correspond to the numbers displayed when you run the EDIT program. To examine the bad observations, note down the numbers, press NO, run the EDIT program, and move to the observation indicated by the observation number. For example, if observation numbers 3 and 4 are off by more that 10 nautical miles, the display would be as follows:



If all the observations are within 10 nautical miles of the fix, you will not be prompted for any input. The program will display two numbers: the East-West error and the North-South error (both in nautical miles). For example, if the program displays:

EW_Err: 0.25_nmi
NS_Err: 0.57_nmi

then, *if there are no systematic errors*, there is a roughly 60 to 70 percent chance that the true position is within 0.57 nautical miles north or south of the fix and 0.25 nautical miles east or west of the fix. There is a roughly 90 percent chance that the true position is within twice this range, 0.5 nautical miles east or west and 1.14 nautical miles north or south. There is roughly 10 percent chance that the position is outside even twice the displayed range.

Plotting Lines of Position

A visual and, hence, probably a better estimate of the error is provided with the PLOT program. PLOT plots the lines of position from each of the observations you have input, and the accuracy of the fix is determined by the extent to which these LOPs intersect in a single point. Of course, two LOPs will always intersect in a point, so the program is only useful if you have three or more observations.

As you saw in the San Diego to Oahu voyage the PLOT program will first prompt for the position of the center of the plot. The default is the latest position fix from the SOLVE program and normally you would simply press [ENTER] at this prompt. If you wish to move the plot window around, you can center it at positions other than the fix by editing the displayed latitude and longitude.

> **IMPORTANT: As with the ERROR program, you must run SOLVE before running PLOT.**

You are next prompted for the scale of the plot. The default is 9 nautical miles. For example, if you accept the default value of 9 miles, each vertical side of the plot will be roughly 9 miles in length. When the plot is finished a cross hair is drawn to indicate the position fix, and each of the two line segments of the crosshair is one nautical mile in length, tip to tip. This gives the scale of the plot.

As an example, if all the LOPs fall within the cross hairs, then all are within +/- 0.5_nmi of the fix position and the true position is likely (but not guaranteed) to be within +/- 0.5_nmi of the fix (unless there are systematic errors). If the LOPs fall outside the crosshairs, the accuracy is worse than one nautical mile. You will have to be the judge of how accurate the fix is by looking at the scatter in the LOPs. Does one LOP fall much further from the fix than the others? Perhaps the data input for that observation is bad and you may be better off removing this observation with the editor. The LOPs are plotted in the order they were entered so you can count the LOPs as they are plotted to determine the observation number.

After the plot is drawn, you are put into the HP 48SX Graphics Environment included in the HP 48SX. Refer to the HP 48SX Owner's Manual for use of the Graphics Environment. For our purposes, the primary use of the Graphics Environment is to use the arrow keys to move the graphics cursor around the plot. When you arrive at an interesting position, press [ENTER] and exit the program by pressing [ON]. As mentioned in the San Diego to Oahu voyage, the position of the cursor when you pressed [ENTER] will be displayed and stored as the new fix. Hence, if, for some reason, you do not like the position fix computed by the SOLVE program, you can select a better one by moving the graphics cursor to the better position. If you select a new fix with PLOT, you will be asked whether you want to update the dead reckoning position when you exit the program. Typically you would answer yes to this question.

The cross-hair indicating the fix resembles the HP 48SX Graphics Environment cross-hair, and there is some chance that you can be confused as to which is which. To resolve this, use the arrow keys to move the Grapgics Environment cursor around.

Navigate with PLOT Only

It is possible to navigate with PLOT only: Select a plot center near your dead reckoning position, plot the lines of position, and select the best fix with the graphics cursor. Press [ENTER] to select the position under the graphics cursor and exit PLOT. The position you select will be displayed and the fix will be updated to this position (you will also be asked whether you want to update your dead reckoning position). Finally, run ERROR to check the consistency of the data.

If you use PLOT to navigate, you must be careful in your selection of the scale of the plot. For example, suppose you accept the default scale of 9 nmi (this gives the size of the plot from top to bottom). Since there are 64 pixels from the top of the screen to the bottom of the screen, this gives the scale of each individual pixel as

(9 nmi)/(64 pixels)=0.14_nmi/pixel

Hence, you cannot resolve any distance smaller than 0.14_nmi on the plot and your fix cannot be determined to better than 0.14_nmi. As another example, suppose you set the scale to 50_nmi. Then the size of one pixel is 0.78_nmi and you cannot determine your position to an accuracy better than this. Bear this in mind as you use PLOT and, if you use PLOT to get a fix, do not set the scale larger than 10_nmi or so.

Since the PLOT program does not enter an equation into the Graphics Environment, some of the graph keys will not work, and some may even cause an error. This is harmless, but you may be kicked out of PLOT if you press a key which requires an equation. You can reenter by running PLOT again or by exiting NAV48 and pressing [⬅][GRAPH] (GRAPH) on the calculator from the {HOME SPARCOM NAV48D VARBLS} directory.

A "line of position" is only an approximation to the true "circle of position": The PLOT program plots the true circle of position rather than the approximate line of position. Hence, you can specify a very large scale (try 10000_nmi) to see the circles of position. This is not very useful navigationally, but it is fun (though somewhat time consuming). The plot is made on a uniform grid of latitude and longitude (simple cylindrical equidistant projection), and the circles of position may therefore appear distorted. The "circles" will be drawn over the correct positions, however. Obviously, the PLOT program is not an electronic chart. It draws lines of position but not land masses.

When you are prompted for the center of the plot window, the default fix position is displayed in the current format (DMT, DMS, or decimal) which has a fixed number of decimal places. For example, if you are using DMT format, the default center is only listed to the nearest 0.1 minutes of arc. Hence, if you use a very small plot scale (like 0.1 nmi), the crosshair will not fall exactly on the fix position. It would instead fall on the fix position rounded to the nearest 0.1 nmi. If you switch to decimal format before running PLOT, you get more accuracy: 0.0001 degrees or 0.006 nmi.

Chapter 6

The Sailings

Our discussion of celestial navigation is now complete and we turn to route planning. This chapter will discuss the use of the SAIL program. This program will compute course and distance from one place to another using a Great Circle, Rhumb Line, or Composite route. The example input at the beginning of this chapter will be used throughout this chapter to further explain the SAIL program.

Note: The SAIL program merely computes course and distance. It is the navigator's responsibility to check that the route is a safe one.

This chapter covers:

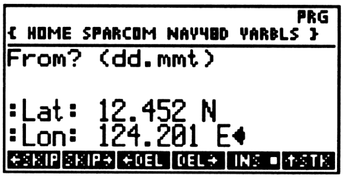
- ❑ Rhumb Lines
- ❑ Great Circles
- ❑ Waypoints
- ❑ Vertex of a Great Circle
- ❑ Composite Routes

Rhumb Lines

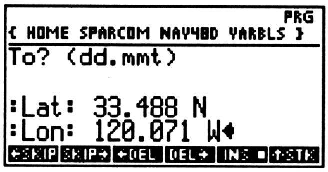
On the second page of the main NAV48 menu, is the SAIL program. When you enter the SAIL program you are prompted for the latitude and longitude of the *'from'* and *'to'* positions. These values must be input in the format you chose in the INIT program, usually DMT. The default *'from'* position is the current dead reckoning position as set previously by either the DREC or SOLVE programs. The default *'to'* position is the last 'to' position input, if any.

Taking an example from "The American Practical Navigator" Vol. 2 by Nathanial Bowditch, suppose you wish to sail from Manila (12°45.2' North, 124°20.1' East) to Los Angeles (33°48.8' North, 120°07.1' West). Manila is the 'from' position, and Los Angeles is the 'to' position. Press [NXT] [SAIL] to start the SAIL program. Enter the 'from' and 'to' values for Manila and Los

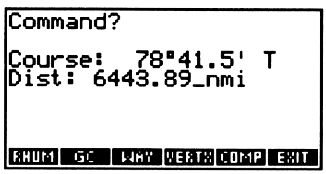
Angeles so they match the screens below (you may have to edit some default values that might appear):



Be sure to enter East not West for the last longitude. Press ENTER.



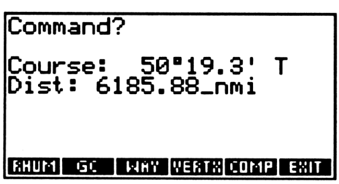
Press ENTER. What is the true course and distance from Manila to Los Angeles along a rhumb line (steering a constant course)? Press RHUM to get the answer:



The course is rounded to 79 T and the distance is 6443.89_nmi.

Great Circles

What is the course and distance from Manila to Los Angeles along a Great Circle? Press GC to compute this:



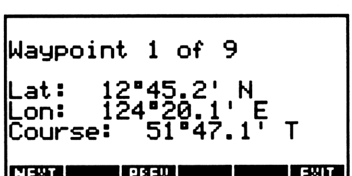
A Great circle route does not follow a constant course. The course displayed is the *initial* course you would have to steer. Also, the courses are *true*, not magnetic. When following a rhumb line, you move along a constant true course, however, since the magnetic variation may change along the route, you may *not* in fact be following a constant *magnetic* course. Don't forget to apply the magnetic variation! For more information see Chapter 7 Piloting, "True Course ↔ Magnetic Course".

Waypoints

Since the Great Circle route does not follow a constant course, course changes are required. However, it is much more convenient to approximate the Great Circle route by a series of short rhumb lines. While sailing each rhumb line, you are moving along a constant course and need not be constantly recomputing the course you are required to steer (though you still have to keep checking the magnetic variation). To compute this approximation to the Great Circle, use the WAY program in the SAIL menu. This will compute several waypoints along the route with the course to steer between them.

To begin press WAY. You are prompted for a scale. This is the distance you want to travel between waypoints. The distance between waypoints is not necessarily exactly equal to the scale you set; the last leg of the route is as short as it has to be to get from the last waypoint to the final destination. The default unit is nautical miles. As an example, let us compute waypoints for the trip from Manila to Los Angeles. If we wish to change course only once every four days and plan on moving roughly 200 miles per day, a scale of 800 miles would be required (4 days x 200_nmi/day = 800). Input 800.

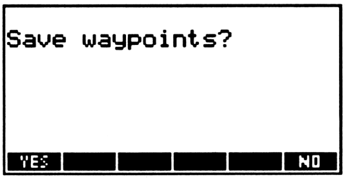
Press ENTER to get into the waypoint viewer. The waypoints are computed. In this case it requires nine of them to get from Manila to Los Angeles. We know this because the first of nine appears (as in the screen below). The course is the TRUE course from the displayed waypoint to the next waypoint.



The softkey menu displays 3 keys:

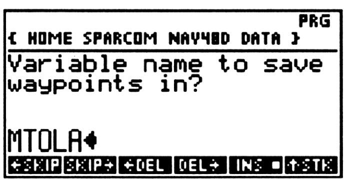
NEXT: Displays the next waypoint
PREV: Displays the previous waypoint
EXIT: Exits the waypoint viewer

Press NEXT until you are finished viewing the waypoints. Press EXIT, you will be asked if you want to save the waypoints.

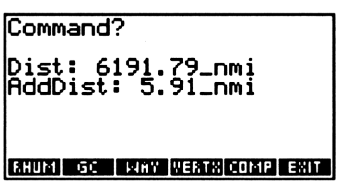


Press YES to save the waypoints. If you pressed NO the waypoints would have been discarded. Next you will be prompted for the name of the variable to save the waypoints in. The data is stored in the same 'DATA' sub directory of the 'NAV48D' directory in which celestial observations are stored. *Do not use the same names you have stored celestial data in when using the DSAVE program.*

Input MTOLA to store the data under the name MTOLA (calculator is already in alpha-entry mode).

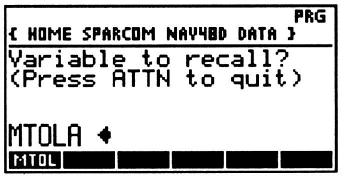


Press ENTER. Having left the waypoint viewer, the final display gives the total distance traveled along the sequence of rhumb lines and the additional distance traveled beyond the distance you would have traveled on a perfect Great Circle. In our example, this is



Hence, in this example, we would travel about six nautical miles further by approximating the Great Circle by a sequence of rhumb lines, an insignificant addition.

To recall the waypoints you saved in the variable MTOLA press [EXIT] to quit the SAIL program and then press [NXT] [NXT] [WAYP]. You are then prompted for a variable name. The list of variables you have previously saved is displayed in the softkeys (variables containing both waypoints and celestial data are displayed). Press [MTOLA] to enter the variable name:

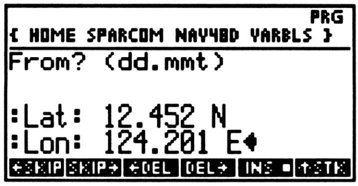


Press [ENTER]. You are then returned to the waypoint viewer described above. Press [EXIT] when finished viewing the waypoints.

Since the default 'from' and 'to' positions are your dead reckoning position and the last 'to' position entered, you can easily use the SAIL program to navigate to your next waypoint. The first time you run the SAIL program on your way to the waypoint, enter the 'to' position as the next waypoint. This position will be saved so that you need only press [ENTER] to accept the default 'to' position the next time you run the SAIL program. By keeping track of your dead reckoning position with SOLVE and ADV, your default 'from' position can also be accepted by pressing [ENTER] at the 'from' prompt. Thus, running the SAIL program to compute the course from your dead reckoning position to the next waypoint is as easy as pressing [ENTER] at each of the prompts and using the RHUM program to compute the true course you should be following.

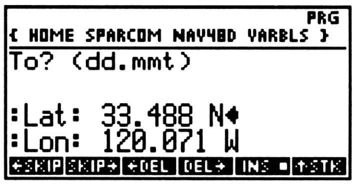
Vertex of a Great Circle

The VERTX (vertex) program computes the position of the point on the great circle which is at the highest latitude. Press [NXT] [SAIL] to start the program. As before, when entering the SAIL program you are prompted for the 'from' and 'to' positions. Enter these values as follows so they match the screens below (you will have to edit some default values which appear). At the 'from' screen input a latitude of 12°45.2' N and a longitude of 124°20.1' E.



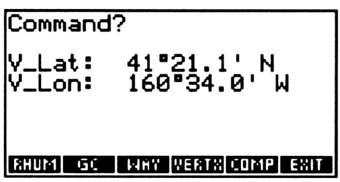
NOTE: Be sure to enter East not West for the last longitude.

Press ENTER. At the 'to' screen the latitude of 33°48.8' N and a longitude of 120° 07.1' W exists as the default.



Press ENTER to accept this default value.

Press VERTX to find the vertex of the great circle between Manila and Los Angeles:



The vertex is defined for the entire great circle, not necessarily just for the portion you are traversing. In this case, however, our path does bring us through the vertex if we follow a great circle route. Hence our highest latitude would be 41° 21.1' N.

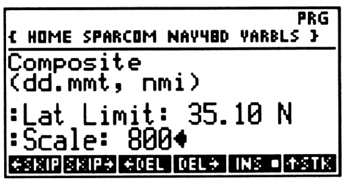
Composite Routes

Suppose that for some reason we did not want to travel this far to the north. You can then use the COMP program to compute a *composite route* which takes us up to some limiting latitude on a great circle, then moves due east or west along the limiting latitude until we can safely move along a great circle again to our final destination. All this is accomplished without ever crossing the limiting latitude we have set. For example, suppose that we do not want to go above 35° 10' N on our voyage from Manila to Los Angeles.

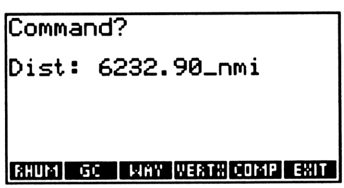
Press COMP to start the program. You are prompted for two numbers. The latitude limit discussed above and a scale. The COMP program outputs a sequence of waypoints just as the WAY program did and the scale sets the distance between waypoints on the great circle portion of the route. As with the WAY program, the distance between waypoints may not be exactly equal to the scale value.

The *last leg before the limiting latitude is reached* as well as the *last leg before the final destination is reached* may be shorter. They are whatever distance they need to be to get from the previous waypoint to the required position.

At the **:Lat Limit:** prompt input 35[•]10[SPC][α]N. At the **:Scale:** prompt input 800.



Press ENTER. Once the waypoints are computed, they will be displayed exactly as they were with the WAY program (remember that the computed course is true, not magnetic, and you must apply magnetic variation). Press EXIT. As with the WAY program, you can store the waypoints if you like. For this example press NO. The final display gives the total distance traveled during the composite voyage.



If the great circle from your starting to your ending position does not take you above the limiting latitude, the message "GC is OK: Press Enter" is displayed on the screen. If the limiting latitude is between the starting and ending positions, you must cross this latitude and the message "No sol'n: Press Enter" is displayed. Press EXIT to quit the SAIL program.

Notes:

Chapter 7

Piloting

This chapter discusses the various options available in the PILOT program. The example input at the beginning of this chapter will be used throughout this chapter to further explain the PILOT program.

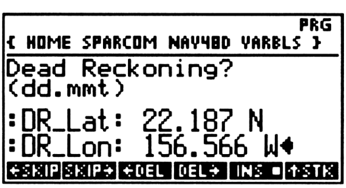
This chapter covers:

- ❑ Dead Reckoning
- ❑ Distance Off by Vertical Angle
- ❑ Distance Off by Two Bearings
- ❑ Current Set and Drift
- ❑ Tide Interpolator
- ❑ True Course↔Magnetic Course
- ❑ Distance/Speed/Time Calculator

Dead Reckoning

As you saw earlier the DREC program in the PILOT menu is used to set your dead reckoning position. From the first page of the main menu press [NXT] [PILOT] followed by [DREC]. You will be prompted for your dead reckoning position with the default equal to your previous dead reckoning position (or 0 N, 0 W if you have not previously entered a dead reckoning position).

Enter a dead reckoning position of 22° 18.7' N latitude and 156° 56.6' W longitude so that it matches the screen below.



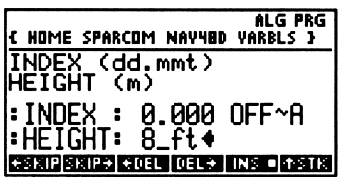
Press [ENTER]. The dead reckoning position is now set to 22° 18.7' N and 156° 56.6' W.

Distance Off by Vertical Angle

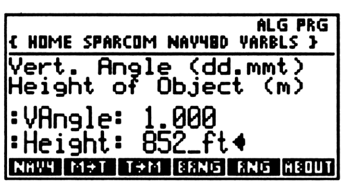
The VANG program in the PILOT menu computes your distance from an object using a sextant observation of the angle between the top of the object (mountain etc.) and the horizon (or shoreline of the object if the horizon is not between you and the base of the object).

This computation depends on both the height of eye of the observer and the sextant index error. The first step would be to run the INIT program and set these values. Once they are properly set you would run the VANG program where you would be prompted for two values. The first would be the vertical angle between the top of the object and the horizon or shoreline of the object (if it is visible). The vertical angle should be input in the current angular format (DMT for this example) and will be corrected for index error and dip. So, you must input the uncorrected angle between the top of the object and the horizon (or shoreline) of the observed object. Secondly, you are prompted for the height of the top of the object above sea level. The default units on the height are meters, but you may specify any valid unit.

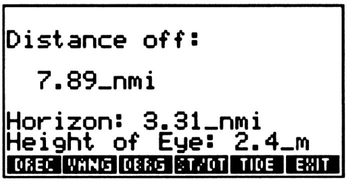
For example, suppose your height of eye is 8 feet. Press [EXIT] to quit the PILOT program. Press [INIT] [IX/HT]. Leave the index error at zero and set the height of eye to 8 feet by inputting 8[→][*][α][α][←][α]FT.



Press [ENTER] then [EXIT]. Then press [NXT] [PILOT] [VANG]. You observe a hilltop which your chart shows to have an elevation of 852 feet The angle you have measured between the top of the hill and the horizon is 1° 00.0'. At the **:VAngle:** prompt input 1[.]0000 and at the **:Height:** prompt input 852[→][*][α][α][←][α]FT.



Press [ENTER]. The output is:



The output informs you that you are 7.89_nmi from the hill, the visible horizon is 3.3_nmi from you, and you have set the height of eye to 2.4 meters (8 feet).

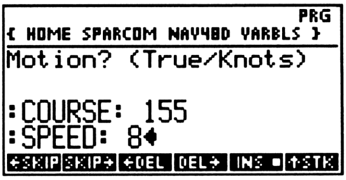
Distance Off by Two Bearings

As you move past an object, its apparent bearing changes. If you also know how far and in what direction you have moved between bearings, you can compute the distance of the observed object. The DBRG program can do this by computing a moving vessel's distance off from an object using two bearings of the object obtained at separate times.

To use the program, take a bearing on the object, wait a while and take another bearing. Be sure to note the times at which the bearings were obtained. For example, suppose you are moving at 8 knots on a course of 155 true and obtain a bearing of 35 true at 12:00:00 on April 15, 1992 and a bearing of 15 true at 12:20:00.

Important: You must set the motion of the vessel in INIT to the average course and speed of the vessel between bearings *before* running DBRG.

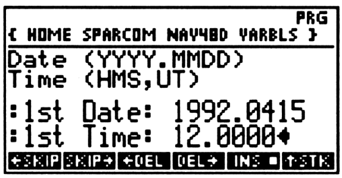
First, press EXIT to quit the PILOT program. Press INIT MOTIO. At the **:COURSE:** prompt input 155 (155 degrees True) and at the **:SPEED:** prompt input 8 (8 knots).



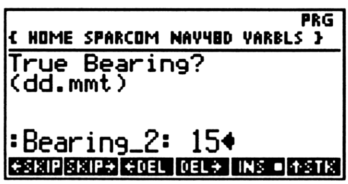
Press ENTER. Leave the set and drift at zero. Press ENTER again then EXIT. No need to change the other INIT values. These values just entered are used to compute the distance run and course steered between bearings, so you must make sure these are correctly set before running DBRG.

To compute the distance of the observed object press [NXT] [PILOT] [DBRG]. You will be prompted for the two bearings and for the times the bearings are valid. At the **:Bearing_1:** prompt input 35.

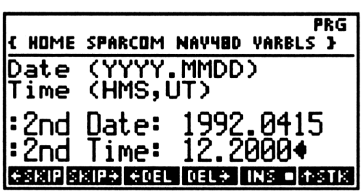
Press [ENTER]. At the **:1st Date:** prompt input 1992[.]0415. At the **:1st Time:** prompt input 12[.]0000.



Press [ENTER]. At the **:Bearing_2:** prompt input 15.



Press [ENTER]. At the **:2nd Date:** prompt input 1992[.]0415. At the **:2nd Time:** prompt input 12[.]2000.



Press [ENTER]. The output is:

```
Distance off:
  6.75_nmi
Dist. Run: 2.67_nmi
Course: 155.000 T
1992,Apr 15,12:20:00UT
DREC VANG DBRG ST/DT TIDE EXIT
```

Thus, the vessel is 6.75_nmi away from the observed object *at the time of the second bearing*, and the vessel moved 2.7_nmi between the bearings. Press **EXIT** to quit the PILOT program.

NOTE: See Chapter 9, "Algebraic Input" in if you prefer to input the bearings using a magnetic course rather than a true course.

Mathematically, the accuracy of the distance off improves with longer distances run between bearings. However, the longer the distance run, the less accurate your average course and speed will be and the less accurate the distance off will be. Hence, the navigator must balance these two effects when deciding how long to wait between bearings. As a general rule of thumb: The distance run between bearings should be comparable to the distance off.

The accuracy is best when at least one of the bearings is close to 90 degrees from the course you are steering. In fact, if you are steering directly towards or away from the object (bearings 0 or 180 degrees from your course) the distance cannot be computed at all.

CAUTION: Do not use DBRG if your course is within 20 degrees or so of being directly towards or away from the object.

The formula used to compute the distance off is found by solving the plane triangle between the observer's first position, the object, and the observer's second position. Since plane geometry is used, the formula will not be accurate for observations of an object far from the observer. The computation will be sufficiently accurate for visual observations, *but the DBRG program should not be used with radio bearings of distant radio sources.*

Current Set and Drift

If you carefully keep track of your course and speed but find that your position computed by advancing a previous fix does not agree with an up-to-date position fix, you may be drifting in a current. This section describes the ST/DT program which computes the set and drift of a current from the difference in position between an advanced fix and a new fix. Following is an example to demonstrate the use of ST/DT.

First press [NXT] [NXT] RESET YES to clear away any old observations. Press INIT IX/HT. There is no index error. At the **:HEIGHT:** prompt input 2 (2 meters). Press [ENTER]. Press MOTIO. At the **:COURSE:** prompt input 50 (50 degrees True) and at the **:SPEED:** prompt input 5 (5 knots). Press [ENTER]. Leave set and drift a zero. Press [ENTER].

```
INDEX   +0°00.0'
HEIGHT  2.000m
MOTION  50.00T 5.0kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:00
IX/HT MOTIO P/T FORM ZN/W EXIT
```

Press EXIT. Press ADDOB and input the date as 1992[.]0210. On this date we obtain the following evening star sights:

Star	Time	Hs
Polaris	04:40:00 UT	22° 33.6'
Sirius	04:41:00 UT	29° 38.3'
Aldebaran	04:42:30 UT	75° 03.1'

Input the above sight for Polaris. Press [ENTER] when finished. When prompted for the body press STAR. When prompted to compute the almanac press YES. Input the star name and press [ENTER]. Accept the date and time of fix by pressing [ENTER]. At the **:DR_Lat:** prompt input 21[.]45[SPC][α]N and at the **:DR_Lon:** prompt input 156[.]05[SPC][α]W. Press [ENTER]. Input the rest of the observations above (since you have already entered the time of fix you will not be prompted for it). Press SOLVE. The result is:

```
COMPUTED POSITION
Update DR?

LAT:   21°45.1' N
LON:   156°09.5' W

1992,Feb 10,04:40:00UT
YES                    NO
```

Press YES to accept the dead reckoning position. We continue along the same course at the same speed until dawn when we obtain two morning planet sights.

Press[NXT] [NXT] RESET YES. Press ADDOB and input the date as 1992[.]0210. Press [ENTER]. On this date we obtain the following morning observations:

Body	Time	Hs
Venus	16:15:00 UT	14° 26.5'
Jupiter	16:16:32 UT	26° 19.6'

Input the above sight for Venus. Press [ENTER] when finished. When prompted for the body press [PLAN] and when prompted for the planet press [VENU]. When prompted to compute the almanac press [YES]. Accept the date and time of fix by pressing [ENTER]. At the **:DR_Lat:** prompt input 22[•]225[SPC][α]N and at the **:DR_Lon:** prompt input 155[•]216[SPC][α]W. Press [ENTER].

Input the observation of Jupiter above (since you have already entered the time of fix you will not be prompted for it).

When finished press [ADDDR] to add the dead reckoning position to our planet observations. Press [ENTER] to accept the default lattitude and longitude values. Finally, press [SOLVE]. The result is:

```
COMPUTED POSITION
Update DR?

LAT:   22°18.5' N
LON:   155°16.8' W

1992,Feb 10,16:15:00UT
 YES                     NO
```

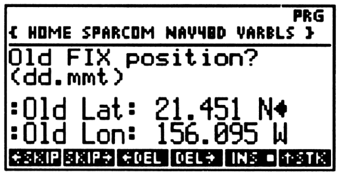
Press [YES] to accept this position.

Assuming that the difference between the computed dead reckoning position and the morning fix is due entirely to the action of a current, we can compute the set and drift of the current with the ST/DT program. Of course, there are other reasons the positions may not agree; when you use this procedure, at the very least, make sure that the difference in the positions is substantially larger than the uncertainty in the positions. Also watch out for compass errors, log errors, and leeway. Also, for this routine to be accurate, the two fixes should be far apart in time. "Far" in this case means as far apart as possible without compromising your ability to compute the average course and speed from the old to the new fix.

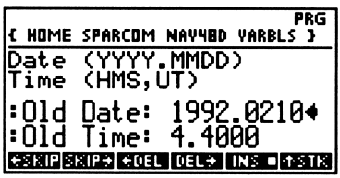
CAUTION: Make sure that the course and speed set in the INIT program represent the average course and speed of the vessel between the old and new fix. If it is not, ST/DT will advance the old fix incorrectly and will give an erroneous result.

To compute the set and drift of the current we can compare the dead reckoning position (obtained by advancing the evening fix) with the fix from the morning sights. The evening fix will be automatically advanced by the ST/DT program. Press [NXT] [PILOT] [ST/DT]. You will be prompted for the fix position and time for both the old and the new fix. If you have followed this example, the default values should be correct and you can press [ENTER] at each prompt.

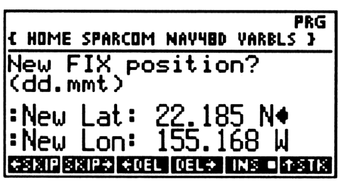
You are first prompted for the old fix position,



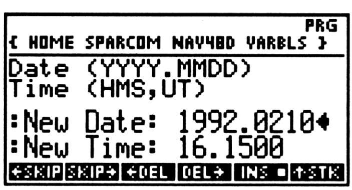
Press [ENTER]. You are then prompted for the old time of fix:



Press [ENTER]. Finally, you are prompted for the position and time of the new fix (again the default valued should be correct).



Press [ENTER].



Press [ENTER]. The output is the average set and drift of the current between the time of the old fix and the new fix.

```
Update Current?

Set: 130°55.9' T
Drift: 0.52 knots

 YES |    |    |    |    | NO
```

Finally, you are asked whether you want to update the current. Press YES to include the computed current in your motion. This will be reflected in the INIT program. To see this press EXIT INIT MOTIO. Then press ENTER at the course and speed prompts. You will see that the set and drift have been automatically altered to reflect the values set in the ST/DT program. They are no longer set to zero. Press ENTER EXIT NXT PILOT to return to the PILOT program.

Tide Interpolator

The program TIDE in the PILOT menu interpolates the height of the tide from adjacent high/low tide heights you input. The interpolation is done on a sine curve which can be plotted on the HP48 screen.

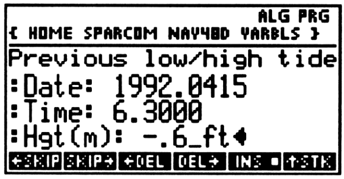
To interpolate the tide requires that you have the time and height of the high and low tides *at your location* which bound the time you are interested in. Normally this information would come from a set of tide tables which you adjust suitably for your particular position (see "The American Practical Navigator" Vol. 2, by Nathaniel Bowditch). With this information in hand, run TIDE. You will be prompted for the date, time and height of the high and low tide.

You must input the high and low tide which bound the time for which you need to compute the height of the tide. Do not input two high tides, two low tides or skip a high or low tide. The height of the tide is a very complicated phenomenon and the interpolation on a sine curve will quickly lose accuracy if you attempt to interpolate over more than one transition from low to high tide or high to low tide.

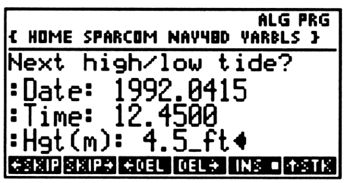
NOTE: It does not matter whether the tide before the time you are interested in is high or low, it only matters that the second tide you input be the opposite of the first (first high, second low or first low, second high).

Press TIDE. You are prompted for the low/high tide before the time you are interested in and then the high/low tide after the time you are interested in. For example suppose you want to compute the tide at 12:00:00 on April 15, 1992. You look in your tide tables and find the tide just before 12:00:00 (low) is at 06:30:00 with a height of -0.6 feet. The next tide (high) is at 12:45:00 with a height of 4.5 feet. The default units on the height are meters, but as usual you can specify feet by appending "_ft" to the number.

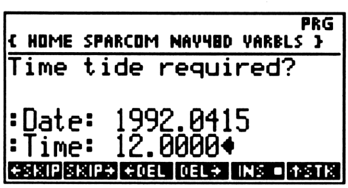
At the **:Date:** prompt input 1992[·]0415. At the **:Time:** prompt input 6[·]3000. At the **:Hgt(m):** prompt input .[·]6[+/-][↱][*][α][α][↰][α]FT.



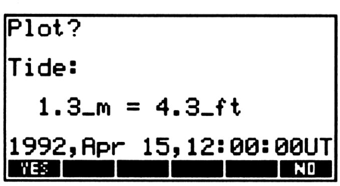
Press [ENTER]. On the next screen the date is already set. At the **:Time:** prompt input 12[·]4500. At the **:Hgt(m):** prompt input .4[·]5[↱][*][α][α][↰][α]FT.



Press [ENTER]. You are next prompted for the time for which you require the height of the tide. This time must be between the times of low/high tide input above. The date is already set. At the **:Time:** prompt input 12[·]0000.



Press [ENTER]. The output looks like:



The height of the tide at 12:00:00 is 4.3 feet. The depth of the water is the charted depth plus the height of the tide.

At this point you are asked whether you want to plot the sine curve used to interpolate the tide.

If you press NO the programs ends. If you press YES the sine curve is plotted and you are put into the HP 48SX Graphics Environment (for more information on the Graphics Environment see Chapter 18 of the HP 48SX Owner's Manual, "Basic Plotting and Function Analysis").

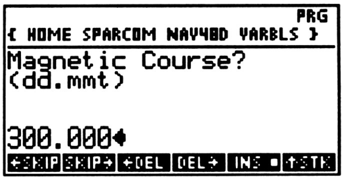
If you plot the tide, you can press COORD and move the graphics cursor around the screen and select other times at which you want to know the height of the tide. On the graph, the horizontal axis is the time in decimal hours and the vertical axis is the height of the tide in meters. When you find the time you want, make sure the cursor is sitting on top of the sine curve and press ENTER. When you exit (by pressing ON) the point you selected will be displayed.

CAUTION: Do not use the HP48 ZOOM features with GRAPH. The interpolation is only valid between the times you entered for the low/high tides. This is exactly the range of times which is plotted, and, if you display more of the sine curve, the additional sections will NOT show the true tide.

True Course ↔ Magnetic Course

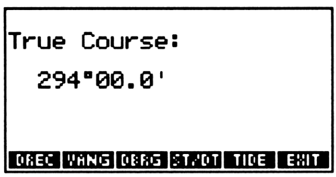
On the second page of the PILOT menu are the two programs M→T and T→M. These programs convert a course from magnetic to true and from true to magnetic. When run, you are prompted for the magnetic or true course and the magnetic variation. The output is the converted course. Both the inputs (course and variation) must be in the current angular format (DMT for this example). The variation can be either east or west, and this is indicated by appending a "E" or "W" to the variation on input.

For example, suppose you are sailing on a magnetic course of 300 degrees and wish to convert this to a true course. Assume the magnetic variation is 6 degrees west. Since we want to convert from magnetic to true we press NXT M→T. You are first prompted for the magnetic course. Input 300 · 000.



Press [ENTER]. You are then prompted for the magnetic variation. Erase the default input and key in 6[.]000[SPC][α]W.

Press [ENTER]. The output is:



This indicates that the true course is 294 degrees.

Distance/Speed/Time Calculator

The D=ST program on the second page of the PILOT menu is a distance/time/speed calculator. Given two of the three values (distance, speed, and time), the third can be computed. When you run D=ST you get a new menu. Pressing the appropriate menu key sets the distance, speed, or time (DIST, SPD, TIME). The default units on distance are _nmi, but any valid unit can be used by appending and underscore and the unit. Similarly, the default units for speed are knots, but any valid unit can be used. The time is input in HMS format (hh.mmss).

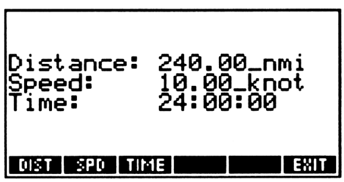
Once you have input two of the three values, you can solve for the third by pressing [←] followed by the appropriate menu key.

CAUTION: There is no solution for time if the speed is set to zero and no solution for the speed if the time is set to zero. In these cases the distance, speed, and time are left unchanged.

As an example, suppose you are sailing at a speed of 10.0 knots and wish to know how far you would travel in 24 hours. Press NXT D=ST. Press SPD. Input 10 as the speed.

Press ENTER. Now press TIME. Input 24 · 0000 as the time:

Press ENTER. To solve for the distance traveled in 24 hours, press ⬅ followed by the DIST menu key. The display indicates that you would travel 240 nmi.



Press EXIT to quit the distance/speed/time calculator. Then press EXIT again to quit the PILOT program.

Notes:

Chapter 8

The Almanac

The "perpetual" almanac used to compute Greenwich Hour Angle (GHA) and declination when inputting observations with the ADDOB program, can be accessed directly. It can compute most of the values which are printed in the "Nautical Almanac" to a sufficient accuracy. The accuracy of the almanac program is discussed in detail in Appendix A.

This chapter covers:

- ❑ Almanac Computed in ADDOB
- ❑ Almanac Not Computed in ADDOB
- ❑ Stars Not Computed by Almanac in ADDOB
- ❑ Body Not Computed by Almanac in ADDOB
- ❑ Starting the Program
- ❑ GHA and Declination
- ❑ Precomputing Sights
- ❑ Rise and Set
- ❑ Identify Unknown Stars
- ❑ Change Date and Time of Computed Almanac Values
- ❑ Twilight
- ❑ Equation of Time
- ❑ Semi Diameter of Sun / Horizontal Parallax of Moon
- ❑ Greenwich Hour Angle of Aries
- ❑ Add Your Favorite Objects

Normally, you will want the ADDOB to compute the almanac since it saves time and avoids the potential for error inherent in copying numbers from the "Nautical Almanac". However, there are two instances in which you may want to avoid the computed almanac. First, the computed almanac is not quite as accurate for the Moon as the "Nautical Almanac" (see Appendix A). In cases where very high accuracy is required in lunar observations, you may wish to use the "Nautical Almanac". The second case is for rapid observations of a single body. In this case, rather than compute the GHA and declination for times which are quite close together, it is faster to use the interpolator which is invoked when the almanac is not computed. For example, if you obtain 20 observations of the Sun in 30 minutes of time, you can avoid the lengthy almanac computations by interpolating the GHA and declination over this short time span.

Almanac Computed in ADDOB

In ADDOB unless you are working with an observation of a star, once you press YES to indicate that you want the almanac computed, the computation proceeds and, when complete, a description of the observation is displayed (you may be prompted for a time of fix and dead reckoning position before the ADDOB program finishes, see Chapter 2, "Time of Fix"). At this point, you are returned to the main NAV48 menu and are ready to proceed (unless the vessel is moving, see Chapter 2, "Time of Fix").

If you are working with an observation of a star, there is one more step before the almanac can be computed and the observation displayed. The program will prompt you for the name of the star. If you are using the short list of the 57 navigational stars (plus Polaris), type in the proper name of the star (the alpha-entry mode on the calculator is automatically turned on so that you can just type). You do not have to input the entire name of the star, only the first few letters, but make sure that you input enough letters to uniquely specify the name of the star. Case is not important when entering a star name, all upper case is fine. See Appendix B for a list of the star names.

If the name is not found, you will be prompted for the name again, if it is found, the name of the star will be displayed. If the name displayed is not the star you intended, press [ON] to terminate the program. In this case, you must run the ADDOB program again to input the correct observation and star name. If the program finishes, and you realize that a mistake was made, use the observation editor (EDIT) to delete the observation and start over with the ADDOB program. The editor is described in Chapter 3, "Data Editor".

Almanac Not Computed in ADDOB

If you are working with an observation of the Sun, you will first be prompted for the Sun's semi-diameter. This can be found on the daily pages in the "Nautical Almanac" and is given in minutes of a degree. It is very helpful to be using the DMT format for angular input when entering the semi-diameter; since semi-diameter is an angle, it must be input in the current format (decimal, DMS, or DMT). The default value is computed from the internal almanac and should be sufficiently accurate.

If you are working with an observation of the Moon, you will first be prompted for the Horizontal Parallax (HP) which can be found from the daily pages of the "Nautical Almanac". This value is an angle given in the "Nautical Almanac" in minutes of arc. It must be input in the current format (decimal, DMS, or DMT). The default value is computed with the internal almanac and should be accurate enough.

If you are working with an observation of Venus or Mars, you will also be prompted for the Horizontal parallax. No default value is computed, but the value can be found in a small table in the explanation section of the "Nautical Almanac" (the value of "p" is required and the table is under the heading "Composition of the Corrections"). Since the parallax is an angle, it must be input in the current format.

Once these preliminaries are out of the way you are prompted for the GHA and declination of the body. You are prompted for slightly different values in the case of a star than for the other bodies. Since the input for a star is simpler, this case is treated first.

Stars Not Computed by Almanac in ADDOB

If you choose not to use the almanac to compute a star you will be prompted for four values, the Greenwich Hour Angle of Aries near the observation time (the default value is computed from the internal almanac at the time of the observation), the Sidereal Hour Angle of the star, the declination of the star, and the time (in HMS format: hh.mmss) at which the GHA-Aries is valid. All these values are contained in the "Nautical Almanac". Since the actual value of the GHA and declination will be interpolated from the values input, you need not input values exactly at the time of the observation. Hence it is simplest to input values at the whole hour nearest to the observation time since this does not require you to interpolate from the values given in the "Nautical Almanac".

NOTE: The time MUST be UT, not zone time. The reason for this restriction is that GHA-Aries is listed in the "Nautical Almanac" in UT and forcing the time to be UT eliminates any errors which may occur when attempting to convert from UT to zone time.

Remember: the time must be UT regardless of what value you have set for the zone description. Now for a bit of confusion: Since the time must be UT, be sure that you look up GHA-Aries for the right date! For example, if you have the zone description set to +10 (Hawaii Standard Time) and your observation is at 18:20:50 on February 14, 1991 Zone Time, that corresponds to 04:20:50 UT on February 15, 1991. So, to get the GHA-Aries at a nearby time, you would select 04:00 on February 15, 1991 in the "Nautical Almanac" (204° 40.0').

There is yet another, subtler, complication. If your observation is near the end of a UT day, do not input the time at which the GHA-Aries value is valid as 00:00 UT since this will confuse the interpolation. For example, if your observation occurred at 23:50:00 UT, you must not enter the time of GHA-Aries as 00:00:00 UT. The interpolation will consider these two times to be 23 hours 50 minutes apart when in fact you only intended them to be 10 minutes apart! Instead you should input the time and GHA-Aries for 24:00:00 UT (since 24:00:00 is equivalent to 00:00:00 on the next day). Similarly, if the observation is at 00:10:00 UT, do not input the GHA-Aries time as 24:00:00 but as 00:00:00 UT since the interpolator considers 24:00:00 UT to be 23 hours 50 minutes after 00:10:00 UT when you intended it to be 10 minutes before the observation time.

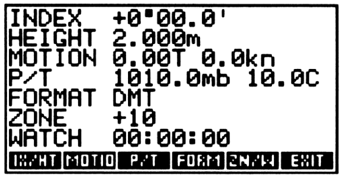
These subtleties can be understood by remembering that
THE CALCULATOR ALWAYS ASSUMES THAT THE TIME YOU INPUT TO THE INTERPOLATOR (THE TIME AT WHICH GHA-ARIES IS VALID) IS ON THE SAME DATE (UT) AS THE OBSERVATION TIME.

Body Not Computed by Almanac in ADDOB

The input for non-stellar bodies like the moon is slightly different. Again an interpolation is performed from entries in the "Nautical Almanac". Since stars move at a very regular rate, it was only necessary to input stellar data at a single time and interpolate from there. However, all the other bodies move at irregular rates and the GHA and declination must be interpolated from two sets of data spanning the observation.

You are prompted for the GHA, declination and time twice. The first entry should be the whole hour before the observation and the second entry should be the whole hour after the observation. **As with the stellar data, the times must be UT, not zone time and must be in HMS (hh.mmss) format.** If the two entries are not on either side of the observation time you will be asked to reenter the data.

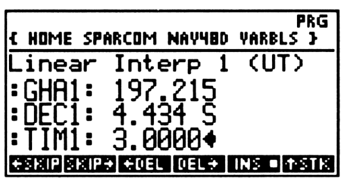
Suppose you observed Venus at 17:10:00 zone time on February 14, 1991 with a sextant reading of 30°20.2' and a zone description of +10 (Hawaii Standard Time). First clear any old observations. From the first page of the main menu press [NXT] [NXT] [RESET] [YES]. Then press [INIT] [ZN/W]. At the **:ZONE:** prompt input 10. Press [ENTER]. There is no watch error so press [ENTER] at this prompt. HEIGHT should be at 2 meters. All values in MOTION should be at zero.



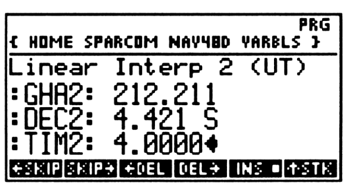
Press [EXIT] when finished. Press [ADDOB] and begin to enter the observation. In UT, the observation is 17:10:00 plus 10 hours equals 03:10:00 UT on February 15, 1991. The two entries used in the interpolation will then be at 03:00 UT and 04:00 UT on February 15, 1991. However, at the **:Date:** prompt input 1991[•]0214 since the date and time should input in zero time. Press [ENTER]. At the **:Time:** prompt input 17[•]1000. At the **:H_s:** prompt input 30[•]202. Press [ENTER]. When prompted for the body press [PLAN]. When prompted for the planet press [VENU] (Venus). When asked to compute the almanac press [NO]. Input the parallax as 0.001. Press [ENTER].

You are prompted for the first GHA and declination set. At the **:GHA1:** prompt input 197[•]215. At the **:DEC1**: prompt input 4[•]434[SPC][α] S. At the **:TIM1:** prompt input 3[•]0000.

NOTE: Even though the zone is set to +10 in the INIT program the almanac asks for UT time.



Press [ENTER]. You are prompted for the second GHA and declination set. At the **:GHA2:** prompt input 212[•]211. At the **:DEC2:** prompt in put 4[•]421[SPC][α]S. At the **:TIM2:** prompt input 4[•]0000.



Press [ENTER]. Then press [ENTER] again to accept the time of fix.

```
Corrected Observation:

1991,Feb 15,03:10:00UT
Alt:   30°16.1'
GHA:   199°51.4'
Dec:   4°43.2' S

SOLVE ERROR HOOOB INIT HOOOR QUIT
```

The same subtleties apply to these interpolations as applied to the stellar interpolation. The times must be UT so make sure you look up data for the correct date. Also make sure that the times do not cross from 24:00 to 00:00 or from 00:00 to 24:00. For example, if the observation is at 23:50:00 UT on February 14, 1991, the two times on either side of the observation time would be 23:00 UT and 24:00 UT since 24:00 UT on February 14 is equivalent to 00:00 UT on February 15, 1991. If you input 00:00 instead of 24:00, the program would consider this time 23 hours 50 minutes before the observation time when you intended it to be 10 minutes after.

These subtleties can be understood by remembering that **THE CALCULATOR ALWAYS ASSUMES THAT THE TIME YOU INPUT TO THE INTERPOLATOR (THE TIME AT WHICH THE GHA AND DECLINATION ARE VALID) IS ON THE SAME DATE (UT) AS THE OBSERVATION TIME.**

As mentioned above, the bodies other than stars move at irregular rates, and hence the GHA and declination are interpolated from the two entries described in the previous example. Just like the time entries which could not cross from 24:00 to 00:00, the GHA must not cross from 360 degrees to 0 degrees. If the first GHA entry is 350 degrees in the "Nautical Almanac", and the second is 5 degrees, the second would be input as 365 degrees. If the second GHA is less than the first, you will be asked to reenter the data and it may be necessary to add 360 degrees to the second value.

Starting the Program

We now turn our attention to the ALMN program which allows direct access to the internal almanac. When you start the almanac program you will be prompted for your current position and the date and time. The defaults are the current dead reckoning position and the current date and time from the calculator's clock. You can accept the defaults, or you can edit the values before accepting them. The date must be input in the YYYY.MMDD format and the time in hh.mmss format. The entries must be in Zone Time, unless you have your zone description set to zero in the INIT program. Since the default date and time are the current date and time from the calculator's clock, you may have to edit the displayed numbers.

After the position, date and time are input you will enter the ALMN program. Initially, the data you just entered will be displayed, along with the value of the time difference between Terrestrial Dynamical Time (TDT) and Universal Time (UT) used in the computations (See Appendix A.).

GHA and Declination

The Almanac program offers many options that you can choose from. Press [INIT] [ZN/W] and set the zone back to zero and leave the watch error at zero.

```
INDEX   +0°00.0'
HEIGHT  2.000m
MOTION  0.00T 0.0kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:00
IX/HT MOTIO P/T FORM ZN/W EXIT
```

Press [EXIT] when finished.

The GHAD program computes the GHA and declination of a body at the current time input when you started ALMN or ran DTIME (for more information on DTIME see "Change Date and Time of Computed Almanac Values" in this chapter).

To access the GHAD program press [NXT] [ALMN]. At the **:Lat:** prompt input 27[.]06[SPC][α]N. At the **:Lon:** prompt input 149[.]11[SPC][α]W. Press [ENTER]. At the **:Date:** prompt input 1991[.]0804. At the **:Time:** prompt input 21[.]5658. Press [ENTER].

The GHAD program will prompt you for the body you wish to use, and after selecting the appropriate softkey(s), the GHA and declination are computed. The following values will be output for the various bodies.

Object	**Output**
Sun	GHA, Dec
Moon	GHA, Dec
Mercury	Phase, GHA, Dec, Mag
Venus	Phase, GHA, Dec, Mag
Mars	Phase, GHA, Dec, Mag
Jupiter	GHA, Dec, Mag
Saturn	GHA, Dec, Mag
Star	SHA, GHA, Dec, Mag

where, GHA = Greenwich Hour Angle
Dec = Declination
SHA = Sidereal Hour Angle
Phase = Fraction of planet illuminated (1.00 = 100%, 0.00 = 0%)
Mag = Approximate Visual Magnitude

NOTE: The phase of the Moon is computed in a separate program SD/HP described below.

Press GHAD. When prompted for the body press STAR. Enter the star name PROCYON. Press ENTER. The calculator will think for a bit then display the following:

```
Select MENU key

Procyon
SHA:   245°17.1'
GHA:   167°29.5'
Dec:   5°14.9' N
:Mag: 0.380
GHAD HORIZ RESET  ID  DTIME EXIT
```

Precomputing Sights

To precompute a sight, use the HORIZ program. It will prompt you for the body you wish to use, and compute the altitude and azimuth of the body for the position you input when starting the ALMN program, and for the date and time you input initially (or with the DTIME program which is explained in detail in this chapter under the heading, "Change Date and Time of Completed Almanac Values"). The azimuth is the true azimuth. The altitude is the true, corrected altitude since effects of refraction, dip of the horizon, etc. will affect your observation of the body, the computed altitude is close to the altitude you would observe, but not exact. Press HORIZ. When prompted for the body press SUN. The output is:

```
Select MENU key

Sun
Alt:   79°59.9'
Azim:   171°57.4'


GHAD HORIZ RESET  ID  DTIME EXIT
```

Rise and Set

To compute times and azimuths of the rising, setting and upper transit of a body, run the RISET program. You will be prompted for the body, and the time and azimuth of the rise and set will be computed for the position and time entered into the ALMN program.. Press **RISET**. When prompted for the body press **PLAN**. When prompted for the planet press **MARS**. The output is:

```
Select MENU key

Rise: 17:41:12 (Aug4)
Rise Azm: 81°01.2'
Set: 06:21:04 (Aug4)
Set Azim: 279°06.7'
Tran: 00:03:47 (Aug4)
GHAD HORIZ RISET  ID  DTIME EXIT
```

Since the times of the rising and setting are given in Zone Time but computed in UT, the date of the computed rise/set may be one day before or after the date you input, in some cases. When the zone description is non-zero however, except for the Moon, the time of rise and set do not vary much from one day to the next. You can adjust the almanac date with the DTIME program to insure you get the day you want (DTIME is explained in detail in this chapter under the heading, "Change Date and Time of Completed Almanac Values"). Set a date one day later if one of the days comes out too early, or one day earlier if one of the days comes out late. Unless high accuracy is required, this is generally necessary only for the Moon. If you change the date, remember to reset the date and time with DTIME if you want to do any further almanac calculations!

The computed times are accurate to within a minute or so for the Sun, planets and stars, and to within about five minutes or so for the Moon.

Identify Unknown Stars

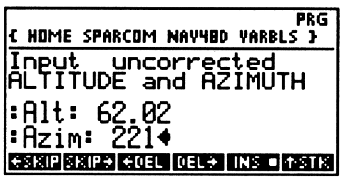
To identify an unknown star or planet, use the ID program and input the observed altitude and azimuth of the body. The program computes the astronomical coordinates of the place in the sky corresponding this altitude and azimuth and finds the object closest to this position.

This type of computation has several potential pitfalls and should be undertaken with care, and the results scrutinized. It is quite possible to incorrectly identify a star, and you should be cautious of the results. The pitfalls will be discussed below.

The ID program will prompt you for the altitude and the azimuth of an object. The altitude is presumably from a sextant observation, and the azimuth generally comes from a sight on the star with a hand-held compass. These must be input in the current angular format (decimal, DMT, or DMS).

> **WARNING: The azimuth is assumed to be a TRUE course. If you obtain a magnetic bearing on the body, you must apply magnetic variation to get a true course. Make sure that the position, and date/time input to the ALMN program are as accurate as possible since the identification will depend on these values. Both the position and the date/time must correspond to your position and to the time at which the observation of the star was obtained.**

We observed an unknown bright star at an altitude of 62° 02' and azimuth of 221° true on August 4, 1991 at 21:56:58 UT from a position of 27° 06' N and 149° 11' W. We entered this information at the start of this this example. So just press ID and input the altitude and azimuth. At the **:Alt:** prompt input 62[·]02. At the **:Azim:** prompt input 221.



Press [ENTER]. The program will compute the astronomical coordinates of the position in the sky you have indicated and will prompt you for the type of body to search for. If you want to search the short list of the 57 navigational stars, press STARS. If you want to search the long list of 268 stars, press LSTAR, and if you want to search the list of planets, press PLAN. Searching the short star list is fastest but you must be certain that the unknown star is one of the 57 navigational stars. Searching the long star list can take five to six minutes.

In this example, we are told that the star is a bright one, and can get away with the short star list, since the brightest stars are included in this list. Press STARS. The calculator will sort the star list for a short while and then display the following:

Thus, the unknown star is Procyon. The number in parentheses is the distance in degrees between the input position and the actual position of the star. A statement of the accuracy of the identification is always given:

True position within 0.5 degrees of input position: Excellent
True position within 1 degree of input position: Good
True position within 2 degrees of input position: Fair
True position within 5 degrees of input position: Poor
True position more than 5 degrees from input position: Unreliable

If no star is within 1 degree of the input position, the list of stars will be displayed one at a time with the distance of that star from the input position. After the entire list has been displayed, the best candidate is returned to the screen. You can press [ON] to terminate the computations at any time. When you press [ON], the best candidate displayed so far will be shown.

If you are searching the planets, they are searched in the order Venus, Mars, Jupiter, Saturn, Mercury until one is found within one degree of the input position. The best candidate is displayed when one is found within one degree of the input position, or when the program has cycled through all the planets.

Pitfalls

Now let us turn to the pitfalls mentioned above:

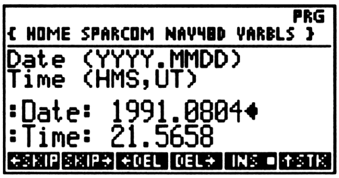
1. The identification depends on an accurate calculation of the astronomical coordinates of the position in the sky where the star or planet is observed. This, in turn, depends on an accurate knowledge of the time the observation was obtained, the position from which the observation was obtained, the altitude of the unknown star, and most difficult, the azimuth of the star. There are times when most of these values can be determined fairly easily, but it is always difficult to observe the azimuth accurately. The higher in the sky the object is, the more difficult it is to observe the azimuth: try to observe near rising or setting if at all possible.

2. If you use the short list of 57 navigation stars, there is a fair chance that the star is not in the list, unless it is a bright star. If the star is not in the list, the best candidate will be displayed and it should be obvious that it is wrong, since the distance between the input and the computed positions of the star will be large. On the other hand, if you use the long list of stars, the star will be in the list if it is brighter than third magnitude. However, the observation of altitude and azimuth will have to be more accurate in this case to distinguish between stars that are fairly close together. Furthermore, searching the long list can be frustratingly slow.

It is possible to misidentify a star, and you should be wary of this.

Change Date and Time of Computed Almanac Values

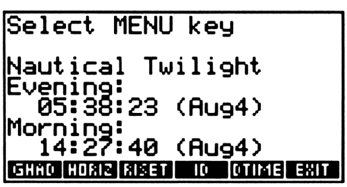
The DTIME program allows you to change the date and time at which the almanac values are computed. Press DTIME. You will be prompted for the date and time. In this case, however, the default date and time are not the date and time from the calculator's clock, but the date and time input previously.



Here you can edit the values if you need to. For the remainder of the examples though, leave them as they are. Press ENTER.

Twilight

To compute times of nautical twilight for the position and date input to the ALMN program, run the NTWI program. There is no input required, and the times of twilight before sunrise and after sunset are displayed. As with the RISET program, the computations are performed using UT but the results are displayed in zone time, so the date of twilight may be off by one day from the date you input to the ALMN program. The times of twilight change slowly, however, so this should not be a concern. Press NXT NTWI. The output is:



To compute the times of civil twilight, run the CTWIL program instead of the NTWI program on the second page of the ALMN menu. Press NXT CTWIL. The output is:

Equation of Time

To compute the Equation of time, on the date and time input to the ALMN program, press [NXT] [EQT]. No input is required, and the equation of time and the time of meridian passage of the Sun at Greenwich are displayed.

```
Select MENU key
Mer. Pass.
  12:06:04
EqT
  -00:06:04
GHAO HORIZ RISET ID DTIME EXIT
```

Semi Diameter of Sun / Horizontal Parallax of Moon

The SD/HP program computes the semi diameter of the Sun and the horizontal parallax of the Moon. Press [NXT] [SD / HP]. No input is required for this program. The values are computed for the time and date entered when the ALMN program was initiated or the DTIME menu key pressed. The output is:

```
Select MENU key
SD Sun:   0°15.8'
HP Moon:   0°59.2'
:Moon Phase: 0.34

GHAO HORIZ RISET ID DTIME EXIT
```

This program also displays the illuminated fraction of the Moon's disk (phase).

Greenwich Hour Angle of Aries

The Greenwich hour angle of Aries is computed with the GHAγ program.

Press [NXT][GHAγ]. No input is required to run this program; the GHA of Aries is computed for the time and date entered at the start of the ALMN program or the DTIME menu key was pressed. The output is:

```
Select MENU key
GHA Aries:
   282°12.4'
LHA Aries:
   133°01.4'
GHAO HORIZ RISET ID DTIME EXIT
```

The local hour of angle of Aries is also computed for the position entered into ALMN.

Add Your Favorite Objects

The following information is an advanced feature and is provided for individuals who are highly familiar with the HP 48SX, navigation and programming. It is not necessary to understand this information to enjoy the NAV48 Pac.

You can add your favorite astronomical objects to the ALMN program by creating a list saved in a variable named 'OTHERNAVDATA' (it can be saved in any port or in the {HOME SPARCOM NAV48D VARBLS} directory). If this list exists, you can access the data contained in it from the ALMN or ADDOB program by pressing [NXT] followed by [OTHER] when prompted for the body. However, you must put the list in the correct format:

```
{
 { "Name1" RA DEC PMA PMD MAG EPOCH }
 { "Name2" RA DEC PMA PMD MAG EPOCH }
   .
}
```

Here "Name" is the name of the object (a string, enclosed in quotes), RA is the right ascension of the body in decimal degrees, DEC is the declination of the body in decimal degrees, PMA is the proper motion of the body in right ascension (sec/century), PMD is the proper motion of the body in declination (arcsec/century), MAG is the magnitude of the body, and EPOCH is the date for which the coordinates (RA and DEC) are valid (in YYYY.MMDD format). For example, the first NGC ("New Galactic Catalog") object, the first Messier object, and the first navigational star would look like

```
{
 { "NGC 1 " 1.50 27.567 0 0 13.5 1975.01015 }
 { "M 1 " 83.625 22.017 0 0 0 2000.01015 }
 { "Acamar" 44.5654 -40.304714 -.391 1.94 3.42 2000.01015 }
}
```

Note 1: PMA is in units of sec/century not arcsec/century. 1 sec/century = 15 arcsec/century

Note 2: The objects in 'OTHERNAVDATA' are assumed to move as stellar objects (i.e. they should be objects outside our solar system).

Note 3: Objects with a number as part of the name (like the Messier or NGC objects) should be listed in *increasing* numerical order.

Chapter 9

Getting the Most from Nav48-Advanced Calculations

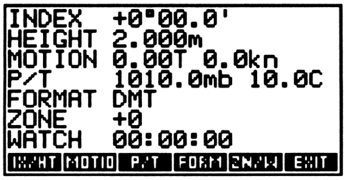
These examples will demonstrate how to use HP 48SX algebraic and program objects as input, how to use the almanac to do sight reductions "by hand", how to estimate your latitude from an observation of Polaris or from a noon sight of the Sun, and how to use NAV48 in coastal piloting. As these are advanced features of the NAV48 Pac you should know it is not necessary to understand these features to enjoy the program.

This chapter covers:

- ❑ Algebraic Input
- ❑ Traditional Sight Reduction
- ❑ Lines of Latitude
- ❑ Piloting

Algebraic Input

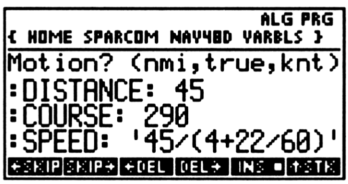
When prompted for data by the NAV48 program, the input need not be simply a number. You may use HP 48SX algebraic or program objects as input which allows you to perform some very useful tasks. There are many possibilities, some of which are demonstrated below in the examples. A good example of the use of algebraic objects as input is in the computation of your average speed when computing a running fix from log (distance) readings. For this example, suppose that we wish to compute a running fix by advancing a morning star sight. Our log shows that we have moved 45 nautical miles in 4 hours 22 minutes from the time of the morning star sight to the time of a later Sun sight. Since the average speed is the distance run divided by the time (in decimal hours), we can have the HP 48SX compute the average speed for us by using an algebraic object in the input to the ADV program. But first clear the old variables. From the first page of the main menu press [NXT] [NXT] [RESET] [YES]. Then press [INIT] [MOTIO], and make sure the course and speed are set to 0 then press [ENTER]. Set the set and drift to 0 then press [ENTER].



Press [EXIT] to quit the INIT program. Press [NXT] [ADV]. Set the dead reckoning position to 22°00.0 N and 155°00.0 W. Press [ENTER].

You now have one of two ways to enter your data. Either way will result in the same answer.

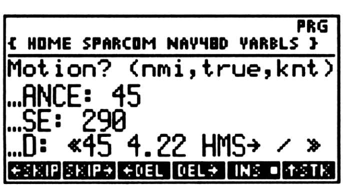
❶Set the Distance to 45 and Course to 290. At the **:SPEED:** prompt enter ['] 4 5[÷][↰][÷]4[+]2 2[÷]6 0 so that it resembles the screen below (this is the average speed, where (4+22/60=length of run in decimal hours).



Press [ENTER]. Make sure Set and Drift are at 0 then press [ENTER]. The new dead reckoning position is:

Lat: 22°15.4' N
Lon: 155°45.5' W

❷Alternatively, you can use a program object, and the HMS→ command. Press [NXT][NXT] [RESET] [YES]. Press [NXT] [ADV]. Set the dead reckoning position to 22°00.0 N and 155°00.0 W. Set the distance to 45 and the course to 290. At the **:SPEED:** prompt enter:
[α][↰][−]45[SPC]4[·]22[SPC][α][α]HMS[↱]0[SPC][÷][SPC]so that it resembles the screen below .



NOTE: The << >> should be input in alpha-entry mode to keep the input on a single line ([α][↰][-] rather than just [↰][-]).

NOTE: To create → on the screen be sure to press [↱]0 (zero) not [↱]O (oh).

Press [ENTER]. Make sure Set and Drift are at 0 then press [ENTER]. The new dead reckoning position is:

Lat: 22°15.4' N
Lon: 155°45.5' W

Another way to use algebraic objects is to define functions to be used as input to the various NAV48 programs. For example, suppose that you commonly advance your observations by reading your log which indicates the distance you have traveled through the water. To input this information in a simple way, key in the following program and save it in a variable 'RUN' in the 'NAV48D' directory.

```
<<
  → log1 tim1 log2 tim2 crs
    <<
       log2 log1 - crs
       log2 log1 - tim2
       HMS→ tim1 HMS→ - /
    >>
>>
```

Press [QUIT] [VAR] [SPARC] [NAV4] to get to the stack.
For the first line press: [↰][-][↱][·].
Second line press:
[↱]0[SPC][α][α][↰][α]log1[SPC]tim1[SPC]log2[SPC]tim2[SPC]crs[↱][·].
Third line press: [↰][-][↱][·].
Forth line press: log2[SPC]log1[SPC][-][SPC]crs[↱][·].
Fifth line press: log2[SPC]log1[SPC][-][SPC]tim2[↱][·].
Sixth line:
[↰][α]HMS[↱]0[SPC][↰][α]tim1[SPC][↰][α]HMS[↱]0[SPC][-][SPC][÷][↱][·].
Press [ENTER]. ['][α][α] RUN [ENTER][STO].

To check that you have entered this program correctly press ['] [RUN] [ENTER][↱][STO][↰][VAR] [BYTES] and match the screen with the numbers below.

Checksum: # 13981d or # 369Dh or #33235o

Bytes: 120.5

If they do not match edit 'RUN'. Press ['] RUN [ENTER] then press [→][VISIT]. this copies the contents of the variable 'RUN' to the command line for editing. (For more information refer to Chapter 3 of the HP 48SX Owner's Manual, "Viewing and Editing the Contents of a Variable").

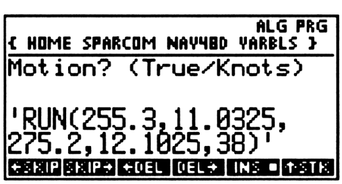
To return to NAV48 press [→] ['] [←][▲] [NAV4] [NAV4].

This program reads in 5 numbers: the first log reading (in nautical miles) and the time at which this reading is valid (in HMS format), the second log reading (in nautical miles) and the time it is valid (in HMS format), and finally, the average true (not magnetic) course followed between the two times (in the current angle format). The program outputs 3 numbers which are in the proper format for input to the ADV program.

IMPORTANT: If you use this program, make sure that the times do not cross through 24:00:00 to 00:00:00. In other words, if the first time is 23:00:00 and the second time is 01:00:00 the next day, the first should be input as 23.0000 and the second as 25.0000 since it is the *difference* in the times which is important here.

As an example, suppose you read your log at 11:03:25 UT and find a value of 255.3 nmi. You wish to advance your sights to 12:10:25 UT at which time your log reads 275.2 nmi. Assume you are following a course of 38 degrees true. Once you have stored the above program in the variable 'RUN', Press [NXT][ADV]. Set the dead reckoning position to 22°00.0'N and 155°0.00'W. Press [ENTER]. When you come to the **Motion?** screen, press [ON] to erase the screen. Now input the following information. Again, you can enter the data in one of two ways:

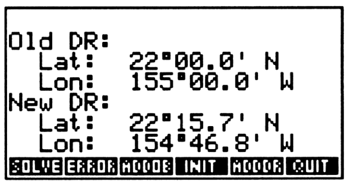
❶Press ['][α][α]RUN[←][÷]255 [·]3[←][·]11[·]0325[←][·][→][·]275[·]2[←][·]12[·]1025[←][·]38 (see the screen below).



❷Or you may enter the data in another way as in the screen below. Input 255[·]3[SPC]11[·]0325[SPC]275[·]2[SPC][↱][·]12[·]1025[SPC]38[SPC][α][α]RUN. Either way will work.

When finished press [ENTER]. There is no appreciable current, press [ENTER].

This advances the 11:03:25 sight to 12:10:25 without requiring you to compute average speed. Your new dead reckoning position is:



Following is another example involving the use of a program object. With the 'M→T' program listed below you can input course as a magnetic course instead of the true course required by NAV48.

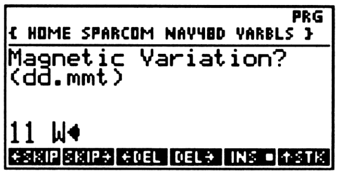
'M→T' is included in the NAV48 library, so you don't have to type the program in.

'M→T'
Bytes: 372.5
Checksum: # 27870d

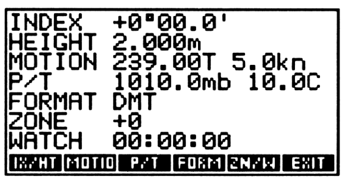
```
%%HP: T(3)A(D)F(.);
<< → crs
 << crs FMT→ 'crs'
STO DEPTH RCLMENU →
dsv om
   <<
     IFERR 28 MENU
0 TVARS 'MVAR' POS
       IF 0 ==
       THEN 0
'MVAR' STO
       END
"Magnetic Variation?
"
FMT + MVAR →FMT ABS
→STR
       IF MVAR 0 <
       THEN " W"
       ELSE " E"
       END + { 1 0
} 'V' 3 →LIST INPUT
OBJ→ →NUM NEG FMT→
DUP 'MVAR' STO crs
+ 360 MOD
     THEN DEPTH
dsv - DROPN crs
     END om MENU
→FMT
   >>
 >>
>>
```

'M→T' takes the magnetic course in the current angular format as input and outputs the true course (in the same format) after prompting for the magnetic variation. For example, suppose you are sailing on a course of 250 magnetic and your chart tells you that the variation is 11° W (the true course is 239 in this case). To input this magnetic course press INIT MOTIO. Type ['][α][α]M[→]0T[←][÷]250[α] as your input (see the screen below). Set the speed to 5 (5 knots).

Press ENTER. You are next prompted for the magnetic variation. Input the variation in the current angular format (DMT, DMS, or decimal) followed by a "W" or an "E" to indicate whether the variation is west or east (the "W" or "E" must be in upper case). In this case input 11 SPC α W (see the screen below).



Press ENTER. Set and drift should both be at zero. Press ENTER.



The magnetic course is converted to a true course which is displayed by INIT as 239.00 T. This program will work anywhere in NAV48 where you are prompted for a true course. Press EXIT to quit the INIT program.

IMPORTANT: When entering an algebraic or program object as input, make sure that the object returns the correct number of real numbers when evaluated. Also, make sure that program/algebraic objects leave the calculator in the same state in which they found it (flags set correctly, directory set correctly, etc.).

Traditional Sight Reduction

In "traditional" sight reduction, one picks an assumed position and computes the altitude and azimuth the observed body would have from this position. Comparing this computed altitude to the observed (corrected) altitude yields a distance from the assumed position to the true position. Combined with the computed azimuth, this yields a line of position which can be plotted on a chart. You can use the ALMN program to perform this calculation.

For example, analyzing our previous observation of Jupiter, from Chapter 3, a good assumed position might be 22° 00.0' N 155° 00.0' W.

Press [NXT] [ALMN]. At the **:Lat:** prompt input 22[SPC][α]N. At the **:Lon:** prompt input 155[SPC][α]W. Press [ENTER]. At the **:Date:** prompt input 1992[.]0210 and at the **:Time:** prompt input 16[.]1632. Press [ENTER]. Now press [HORIZ]. Press [PLAN] [JUPIT] to select Jupiter as the body.

The output of this program is the computed altitude and azimuth of Jupiter from the assumed position:

Press [EXIT] to quit the program.

To compute the distance of the true position from the assumed position "by hand" subtract the computed altitude from the observed (corrected) altitude. If the result is negative, the assumed position is too close to the geographic position (GP) of the body, and if the result is positive, the assumed position is too far from the GP. In this example, we have

26° 15.2' - 26° 00.2' = 0° 15.0'

Where 26° 15.2' is the observed altitude of Jupiter *corrected for refraction and height-of-eye*. Since the result is positive, the assumed position is too far from the GP.

To plot the line of position on your chart, first plot a point towards or away from the body's GP (in the direction of the azimuth or in the direction opposite the azimuth) depending on whether the assumed position is too far from the GP or too close to the GP. The distance, in nautical miles, from the assumed position to the plotted point is the difference in the two altitudes *in arc minutes*. Once this point has been plotted, the line of position is drawn through this point *perpendicular* to the azimuth line connecting the point with the assumed position.

In this example, we plot a point 15.0 nautical miles from the assumed position (22 N, 155 W), in a direction of 269 degrees true (towards the GP). Finally, to plot the line of position, we draw a line through the point we just plotted, perpendicular to the line from the assumed position to the plotted point. Our true position lies somewhere on this line.

You can check that the line of position you have drawn on your chart is correct by comparing several points along it with the plot drawn with the PLOT program.

Lines of Latitude

A common problem in celestial navigation is to compute latitude from an observation of Polaris or from a body which is transiting (i.e. reaching its maximum or minimum altitude). The simplest way to solve this problem with NAV48 is with the estimated position algorithm in the SOLVE program. Recall that the estimated position is computed when SOLVE is run with one celestial observation and one dead reckoning position as input.

First Method

To find latitude, enter the observation of Polaris or of the transiting body with ADDOB. Then input your dead reckoning position with ADDDR and run SOLVE. The output position will give your latitude and your dead reckoning longitude. **The latitude output by SOLVE is as accurate as your celestial observation, but the longitude is no better than your dead reckoning position; this technique is designed to find latitude, not longitude.**

Make sure that the observation is as close as possible to the time of transit. For Polaris, any time will do as it is so close to the celestial pole, however, for any other body, take several observations around the time of transit and pick the one with the maximum (for upper transit) or the minimum (for lower transit) altitude.

The dead reckoning position you input with ADDDR should, of course, be as accurate as possible, however, it is more important to estimate the longitude accurately than the latitude. In fact, the output latitude is unaffected by the dead reckoning latitude unless the dead reckoning latitude is *very* far off.

It is, however, somewhat dependent on the dead reckoning longitude and the time of the observation relative to the time of transit. Try hard to get your observation as close as possible to the time of transit, when the altitude is a maximum (or a minimum for a lower transit)!

The PLOT program provides an estimate of the error in the computed latitude due to an error in the dead reckoning longitude. Run the PLOT program and select the plot scale equal to your estimate of the error in the dead reckoning longitude in nautical miles. After the plot has been completed, move the cursor up or down over the range of latitudes spanned by the line of position in the display. Press the COORD key and observe how much the latitude changes during this process. This gives a good idea of the error in the latitude due to the uncertainty in the dead recknoing longitude. It does not estimate the error due to uncertainty in the celestial observation.

Suppose our dead reckoning position is 22° 00.0' N and 155° 00.0' W on February 10, 1992. At what time will the Sun transit? To answer this question, press [NXT] [ALMN]. At the **:Lat:** prompt input 22[SPC][α]N and at the **:Lon:** prompt input 155[SPC][α]W to enter the above dead reckoning position. Press [ENTER]. At the **:Date:** prompt input 1992[·]0210 and at the **:Time:** prompt input 22[·]0000, which is a crude guess of the transit time based on our dead reckoning longitude. Press [ENTER].

```
Select MENU key

  Lat:   22°00.0' N
  Lon:   155°00.0' W
1992,Feb 10,22:00:00UT

ΔT=TDT-UT=00:00:58
GHAD HORIZ RISET  ID  DTIME EXIT
```

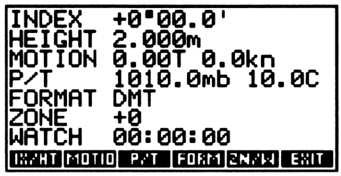
The time input is not critical, most any value will do for this particular computation. Now press [RISET] and when prompted for the body press [SUN]. The result is (times in UT)

```
Select MENU key

Rise: 16:54:20 (Feb10)
Rise Azm: 105°14.8'
Set: 04:13:48 (Feb10)
Set Azim: 254°34.4'
Tran: 22:34:10 (Feb10)
GHAD HORIZ RISET  ID  DTIME EXIT
```

Press [EXIT]. We are particularly interested in the last line, which gives the time of transit as 22:34:10. Since our position is only approximate, this may not be the exact time of transit so we take five to ten observations spanning the 10 minute time interval before the predicted time of transit and enough observations after the predicted time of transit to convince ourselves that the Sun's altitude has reached a maximum. The observation with the maximum altitude (assumed taken at transit) is:

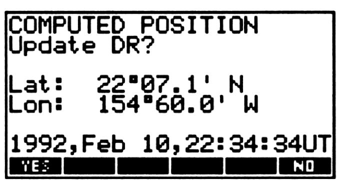
Body	Time	Hs
Sun (LL)	22:34:34 UT	53° 18.6'

First press [INIT] [IX/HT]. There is no index error for the sextant and the height of the eye should be at 2 meters. Press [ENTER]. Press [MOTIO] and set the course and speed to zero. Press [ENTER]. Make sure the set and drift are at zero as well. Press [ENTER].



When finished press [EXIT]. Now press [NXT] [NXT] [RESET] [YES] to clear away any old observations. Press [ADDOB]. At the **:Date:** prompt input 1992[.]0210 then press [ENTER]. At the **:Time:** prompt input 22[.]3434 and at the **:H_s:** prompt input 53[.]186. Press [ENTER]. Press [SUN], [LL], [YES]. Press [ENTER] to accept the time of fix.

When finished press [ADDDR]. At the **:DR_Lat:** prompt input 22[SPC][α]N and at the **:DR_Lon:** prompt input 155[SPC][α]W to enter the dead reckoning position of 22°00.0'N and 155°00.0'W. Press [ENTER]. Finally, press [SOLVE]. The estimated position is:



So, our latitude from the noon sight is 22° 7.1' N. Again, the longitude is no more accurate than the dead reckoning longitude! Press [YES] to accept.

If you would like to see the plot press [NXT] [PLOT]. Then press [ENTER] to accept the default plot center. Suppose we have reason to believe that the dead reckoning longitude is in error by as much as plus or minus 10 nmi. Press 10 then [ENTER] to input the plot scale as 10 nmi.

NOTE: The variation in the latitude of the line of position is about .006 degrees from about 22.114 to 22.120. By pressing the [COORD] key and moving the cursor up and down to span the range of latitudes covered by the line of position the coordinates are displayed in decimal degrees.

Now, multiply the span in degrees by 60 to get the error in nautical miles and divide by 2 to obtain the plus/minus error value (.006*60/2=.18 nmi, so the error on the latitude is plus or minus 0.18 nmi). This is only the uncertainty due to uncertainty in dead reckoning longitude, not the uncertainty due to errors in the celestial observation.

If you have entered the plot pressing [ON] will leave the plot.

Second Method

For an observation of a transiting body (not for Polaris unless it happens to be transiting), you can compute the latitude directly. First, use the ALMN program to find the declination of the body at the time of the transit observation. Run ALMN and set the position to anything convenient (GHA and declination do not depend on position) and the time and date to the time and date of the transit observation. Then run the GHAD program from within ALMN and select the appropriate body.

Once you know the declination, the latitude is computed from an observation of UPPER TRANSIT by the equation: latitude = declination - Zdistance

Zdistance is the zenith distance of the body at transit and is given by (90-Ho), where Ho is the *corrected* altitude at transit. The corrected altitude can be found by entering the observation with ADDOB and reading the corrected value off the screen when the program finishes.

There is a bit of complication when using this formula involving the signs of the various values: latitude and declination are positive in the north hemisphere and negative in the south hemisphere while the sign of the zenith distance is positive if you are looking north at the body at transit and negative if you are looking south at the body at transit.

In our previous example, the altitude of the Sun corrected for refraction, semi-diameter, etc. was 53°31.7' yielding a zenith distance of 36°28.3'. The declination of the Sun at 22:34:34 UT on February 10, 1992 is -14°21.2' (from the ALMN) program. Since our latitude is clearly north of the Sun's geographical position (at a latitude of -14°21.2'), we are looking south to the Sun at transit. Hence, the zenith distance should be taken as a negative number and the latitude is

latitude = -14°21.2' - (-36°28.3)'
= -14°21.2' + 36°28.3'

= 22°07.1'

which is exactly what we obtained previously with SOLVE.

CAUTION: This second method only works for bodies at UPPER transit!

Piloting

Since piloting can be a tricky business. We urge the novice to carefully read the sections on piloting in "The American Practical Navigator" Vols . 1 and 2, by Nathaniel Bowditch before using the programs given in this section.

NAV48 can be used for coastal piloting as well as for celestial navigation. In fact, the problems are not really all that different. In celestial navigation we have several lines of position and we fix our location by computing the intersection of these lines. In piloting we also have several lines of position for which we compute the intersection. The only difference is the source of the lines; in celestial navigation the lines come from celestial observations, while in coastal navigation the lines of position come from observations of coastal features or radio beacons.

The trick in solving coastal problems is to get the lines of position into the NAV48 program so that the intersection can be computed with the SOLVE program. Thus, we need to determine an equivalent celestial observation that yields the same line of position as a particular coastal observation. This is not too difficult, and we describe two cases below. First, you observe the bearing (direction) to an identified coastal feature. Second, you observe the range (distance) to an identified coastal feature. Of course, in some cases you will have both the range and the bearing of the object (usually from radar), but, in this case, if you know the position of the object you observed, you have enough information to determine your position directly and you don't need NAV48 to compute your position.

Bearing

Here we treat the case where we observe the bearing to some coastal feature or radio beacon whose position we know from our chart. Our problem is to compute a fictitious celestial observation with the same line of position as the observation of the coastal feature or beacon. Since visible light and radio travel along great circles, this line of position is a great circle passing through the observed coastal feature.

CAUTION: Radio bearings are generally not as accurate as visual bearings.

The altitude of the equivalent celestial observation is zero since this will give a great circle line of position. The GHA and declination will be chosen such that the great circle passes through the observed object and reaches the vicinity of our dead reckoning position with the observed bearing.

The equations for the computation of the GHA and declination of the equivalent celestial observation are straightforward but not particularly simple. The best way to compute them is with a program object as in the M→T conversion example at the beginning of this chapter. A program, 'BRNG', is included in the NAV48 library which can be used to compute the equivalent celestial observation.

The GHA, declination and altitude must be input with the EDIT program since this will take the values as is and will not attempt corrections such as atmospheric refraction which would be inappropriate here.

This program accepts one number as input. That number is the true bearing of the object observed in the current format selected in the INIT program (DMT, DMS, or decimal). The output is the GHA, declination, and altitude of the equivalent celestial observation, also in the current format (This is the data required in the EDIT program for adding an observation). The dead reckoning position is important in correcting the observation for the variation in the great circle course and you will be prompted for it after entering the data to 'BRNG'. 'BRNG' automatically applies this bearing correction. The default dead reckoning position is the current DR position.

NOTE: The current dead reckoning position will be changed to reflect the values you enter from 'BRNG'.

For technical reasons described in the next paragraph, the 'BRNG' program also adds the dead reckoning data to the list of observations. Hence, when you run 'BRNG', two observations are actually added. 'BRNG' will also prompt you for the position of the feature you have observed.

As a technical note on the bearing solution: if *all* your observations are bearings, then all the lines of position are great circles and the fix solution turns out to be ambiguous. If a set of great circle lines of position meet at a point on one side of the planet, then by symmetry they must also meet on the opposite side of the planet. SOLVE will not be able to choose between the two sides of the planet, in this case, since both solutions are equally good. Hence, you would get an error ("AMBIGUOUS SOLUTION") if you were to attempt this. To get around the problem, dead reckoning data MUST be included in the solution. Hence, for every bearing input, 'BRNG' will automatically include dead reckoning in the set of observations. Thus, for every bearing input, two observations are added to the 'OBS' variable.

WARNING: If *all* sights are bearings, the fix solution is not only ambiguous, but is *very* sensitive to numerical round off and even the 12 digit accuracy of the HP 48SX may not be enough to give an accurate fix. The dead reckoning data automatically included when using 'BRNG' will almost always alleviate this problem, however, always run PLOT to check that the solution is correct, as the PLOT program does not have this numerical sensitivity. Also, do not delete any of the DR data included by 'BRNG': it is necessary for a valid fix.

Range

When you observe the range of a coastal feature, the computation of the equivalent celestial observation is more straightforward. Here, the geographical position of the equivalent celestial observation is set to the position of the observed feature (read off your chart) and the altitude of the observation is set to the value which gives the proper radius to the circle of position. The altitude, in decimal degrees, is

Ho = 90 - (range in nmi)/60

The GHA, declination and altitude must be input with the EDIT program since this will take the values as is and will not attempt corrections such as atmospheric refraction which would be inappropriate here.

CAUTION: If you run SOLVE with two observations, at least one of which is a range, and include a dead reckoning position (from ADDDR or 'BRNG') to select the correct intersection of the two lines of position, the dead reckoning position must be very accurate. Since the circle of position from the range data is quite small (the equivalent celestial observation has Ho close to 90 degrees), the dead reckoning data will be useless unless the error in the DR position is significantly smaller than the radius of the circle (which is equal to the observed range). For example, if you observed a feature at a range of 5 nmi, the dead reckoning position should be accurate to 0.5 nmi or better to select the correct intersection of the lines of position. Since this kind of accuracy is often difficult to achieve in the dead reckoning position, it is best to avoid DR data when you are working with range observations. Use several other observations (celestial or bearing) instead of the DR data to select the correct intersection. If you do incorporate the DR data, ALWAYS use PLOT to check that the solution from SOLVE is good.

A program, 'RNG', is included in the NAV48 library which you can use to input the equivalent celestial observation. This program accepts a single number as input: the range of the observed feature in any valid unit (if no unit is given, nmi is assumed). It prompts for the position of the observed feature and outputs the GHA, declination, and altitude in the current format.

Finally, a technical note: In coastal piloting by range, the equivalent celestial observation typically has a very high altitude (close to 90 degrees). As mentioned previously in the section describing SOLVE, observations of bodies above 86 degrees are weighted less in the fix solution. While fine for celestial navigation, this is not ideal for range observations since, in this case, the effect of the weighting scheme may be to pull the fix away from the circle of position derived from the range observation towards the lines of position derived from celestial or bearing observations. For example, if you have a celestial observation, a bearing observation, and a range observation, and the three lines of position meet in a small triangle, SOLVE is likely to select the intersection of the celestial line of position and the great circle from the bearing observation as the best fix rather than selecting a point in the center of the triangle formed by the three lines of position.

WARNING: When using range observations, always use PLOT to verify the fix computed from SOLVE.

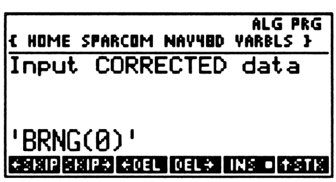
There is very little you can do about this effect. It is always difficult to include sights close to 90 degrees in any general purpose sight reduction algorithm, and it is necessary to include the lower weighting of these data. The best solution is to use SOLVE to get a reasonable fix and then use PLOT to refine the fix. From PLOT, move the graphics cursor to some position which you like better than the fix from SOLVE. Press [ENTER] to mark this spot, and, when you exit PLOT, the latitude and longitude of the selected point will be displayed. With PLOT, you can select a better fix if you find the fix from SOLVE undesirable. In essence, this reweights the solution "by eye".

Bearing and Range Examples

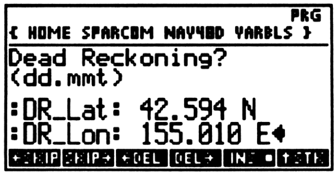
Of course, to get a fix, you need more than one line (or circle) of position. Once the equivalent celestial observations are input, however, you may treat them exactly like any celestial observation. You may advance or retard them to get a running fix using ADV, or you may combine coastal observations with celestial observations. You can use PLOT to examine the accuracy of the fix, exactly as you would with celestial observations.

Suppose you observe a spit of land due north (true) of your position and a prominent hill at a range of 2.52 nmi. The spit of land has a position of 155 E, 43 N and the hill has a position 43°01.0'N, 155°02.6'E (both determined from your chart). The date is February 2, 1992 and the observations are made at 18:37:51 UT and 18:40:22 UT. If your dead reckoning position is 42°59.4'N, 155°01.0'E, what is the fix? Assume you are not moving when these observations are taken. Press INIT MOTIO and make sure all the values are set to zero. When finished press EXIT.

After setting the speed to zero, start by resetting the NAV48 program. Press [NXT][NXT] RESET YES to clear away any old observations. Then use EDIT to input the above observations. First the bearing, press [NXT][NXT] EDIT then ADD. Press [ON] to clear the display. Then press ['][α][α]BRNG[←][÷]0.

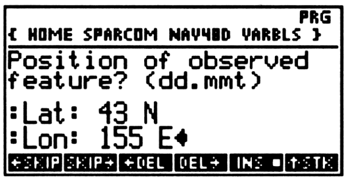


Press [ENTER]. You will be prompted for your dead reckoning position. Set the DR position to the position on the screen below:

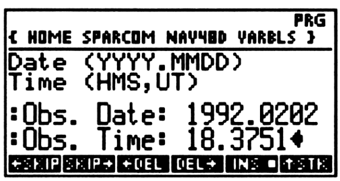


NOTE: The DR longitude is East not West.

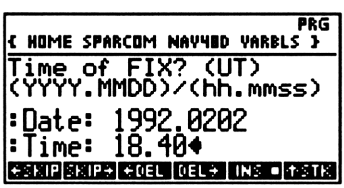
Press [ENTER]. You are next prompted for the position of the observed feature. Enter the data as follows on the screen below:



Press [ENTER]. This completes the 'BRNG' program. ADD will now prompt you for the date and time of the observation. Enter the data as follows on the screen below:



Press [ENTER]. You will be prompted for the time of fix. Enter the data as follows on the screen below to set the time of fix to 18:40:00UT:



Press [ENTER]. ADD automatically advances or retards the bearing observation to the time of fix using the course and speed set with the INIT program. **WHEN USING ADD, MAKE SURE THE COURSE AND SPEED ARE SET CORRECTLY, OR THE FIX WILL BE ERRONEOUS.** In this example, the speed should be zero.

You are now ready to input the range. Again press ADD, press ON to erase the display. Then press ' α α RNG ← ÷ 2 · 52.

```
                         ALG PRG
{ HOME SPARCOM NAV48D VARBLS }
Input CORRECTED data


'RNG(2.52)'
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

Press ENTER. You are next prompted for the position of the observed feature. Enter the data as follows on the screen below:

```
                             PRG
{ HOME SPARCOM NAV48D VARBLS }
Position of observed
feature? (dd.mmt)
:Lat: 43.010 N
:Lon: 155.026 E◆
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

Press ENTER. You will be prompted for the time of the observation. Enter the data as follows on the screen below:

```
                             PRG
{ HOME SPARCOM NAV48D VARBLS }
Date (YYYY.MMDD)
Time (HMS,UT)
:Obs. Date: 1992.0202
:Obs. Time: 18.4022◆
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

Press ENTER. Press EXIT then SOLVE.

```
COMPUTED POSITION
Update DR?

LAT:    42°59.3' N
LON:    155°00.0' E

1992,Feb 2,18:40:00UT
YES                          NO
```

Press YES to update the DR.

Since we have two observations but need three for a fix, we would normally run ADDDR and use the dead reckoning position as the third observation. However, when we ran 'BRNG', the dead reckoning data was automatically included, and we need not run ADDDR (it is already included).

NOTE: When combining two observations, at least one of which is a range, with a dead reckoning position requires that the dead reckoning position be very accurate.

Finally, press [NXT] [PLOT] to see the fix. Press [ENTER] to accept the default plot center, but press 4 to set the scale to 4 nmi. Press [ENTER]. Since the circle of position from the range is very "curvy" it will take a while to do the plot. The circle from the range observation and the line from the bearing cross at a fairly shallow angle to the north, and the fix is probably more accurate in the east/west direction than in the north/south direction. Since we combined a range observation with a DR position in the fix, check that the computed fix falls where the lines of position cross. In this case it does, since the DR position was sufficiently accurate.

Press [ON] to quit the plot.

We now move along a course of 306 degrees true for a distance of 1.2 nmi at a speed of 5 knots. Press [INIT] [MOTIO] and set the course to 306 (306 T)and the speed to 5 (5 knots). There is no appreciable current, leave set and drift at zero. Press [ENTER].

```
INDEX   +0°00.0'
HEIGHT  2.000m
MOTION  306.00T 5.0kn
P/T     1010.0mb 10.0C
FORMAT  DMT
ZONE    +0
WATCH   00:00:00
 HGHT  MOTIO  P/T  FORM  ZN/W  EXIT
```

Press [EXIT]. We observe the same spit of land, this time bearing due east true (18:54:24 UT). What is the running fix?

Since the EDIT program corrects the sights for the motion of the vessel, we could input the new observation and use the old time of fix. However, we don't want to know where we were, we want to know where we are. Hence, we advance the previous sights with the ADV program to set the time of fix to the time of the new observation. Press [NXT] [ADV]. Press [ENTER] to accept the dead reckoning position from the fix we obtained above. When prompted for the motion, enter the data as follows on the screen below:

```
                              PRG
{ HOME SPARCOM NAV48D VARBLS }
Motion? (nmi,true,knt)
:DISTANCE: 1.2◆
:COURSE: 306.000
:SPEED: 5.000
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

Press [ENTER]. There is no appreciable current, leave set and drift at zero. Press [ENTER]. This completes the ADV program and the updated DR position will be displayed.

```
Old DR:
  Lat:  42°59.3' N
  Lon:  155°00.0' E
New DR:
  Lat:  43°00.0' N
  Lon:  154°58.7' E
SOLVE ERROR MOOOB INIT MOOOR QUIT
```

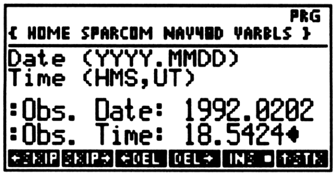
This advances the old observations to the time of the new observation. We now input the new sight. Press [NXT] [NXT] [EDIT] [ADD]. Press [ON] to clear the screen. Then press ['] [α] [α] BRNG [⬅] [÷] 90.

```
                         ALG PRG
{ HOME SPARCOM NAV48D VARBLS }
Input CORRECTED data


'BRNG(90)'
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

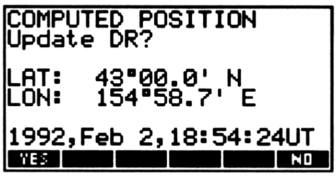
Press [ENTER]. You will be prompted for the dead reckoning position, and since we just set the DR position with ADV you can accept the default value by pressing [ENTER]. You are next prompted for the position of the observed object. Enter the data as follows on the screen below:

```
                              PRG
{ HOME SPARCOM NAV48D VARBLS }
Position of observed
feature? (dd.mmt)
:Lat: 43 N
:Lon: 155 E◆
←SKIP SKIP→ ←DEL DEL→ INS ■ ↑STK
```

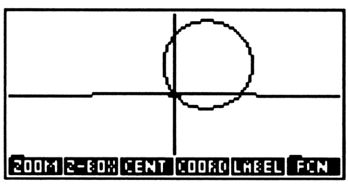
Press [ENTER]. ADD now prompts for the time of the observation. Enter the data as follows on the screen below:



Press ENTER. ADD will also prompt you for the dead reckoning position and you can press ENTER at this prompt to accept the default. This completes the data entry. Press EXIT then SOLVE to get the fix.



Press YES to accept the fix as the new DR position. Press ERROR to check the internal consistency of the data. ERROR indicates that the data is consistent (i.e. all lines of position fall very close to the fix position). Press NXT PLOT. Accept the default plot center and scale.



PLOT corroborates this estimate. You have finished the Advanced Calculations section.

Appendix A

Accuracy of the Almanac

The almanac included in the NAV48 program is quite accurate: where faced with a tradeoff between speed and accuracy, we have generally chosen accuracy. In general, the positions of the stars should be accurate to 0.1' of arc or better, the position of the planets to 0.2' of arc or better, the position of the Sun to 0.1' of arc or better, and the position of the Moon to 0.5' of arc or better. The almanac is valid from about the year 1900 through the year 2030. The almanac does not simply stop before 1900 or after 2030, some of the data (Moon, planets) just get less accurate. A comparison of the NAV48 almanac to the Interactive Computer Ephemeris published by the U.S. Naval Observatory yielded the following accuracies for the NAV48 almanac:

January 1, 1950

Body	Error in GHA (arcmin)	Error in Declination (arcmin)
Sun	0.1	0.0
Moon	0.3	0.0
Mercury	0.0	0.0
Venus	0.1	0.1
Mars	0.0	0.0
Jupiter	0.1	0.1
Saturn	0.0	0.0
Procyon	0.0	0.0

January 1, 2000

Body	Error in GHA (arcmin)	Error in Declination (arcmin)
Sun	0.0	0.0
Moon	0.3	0.0
Mercury	0.0	0.0
Venus	0.0	0.0
Mars	0.0	0.1
Jupiter	0.1	0.1
Saturn	0.1	0.1
Procyon	0.0	0.0

January 1, 2030

Body	**Error in GHA (arcmin)**	**Error in Declination (arcmin)**
Sun	0.0	0.0
Moon	0.4	0.0
Mercury	0.1	0.0
Venus	0.1	0.1
Mars	0.1	0.0
Jupiter	0.0	0.0
Saturn	0.0	0.0
Procyon	0.0	0.0

A problem with computing any almanac is that the rotation rate of the Earth is not constant and varies unpredictably by a small amount. Thus, The almanac is computed using Terrestrial Dynamical Time (TDT) which, unlike Universal Time (UT), is not affected by the variations of the Earth's rotation. However, the difference between UT and TDT is an important value in the computation of an almanac useful to navigators. Since this time difference cannot be predicted with great accuracy, we have simply extrapolated the increasing trend of the last decade. The further the date is from 1991, the less accurate the extrapolated time difference will be. This is the primary limitation in using the almanac over an extended period of time. This should not be a problem, however, up to at least 2030 or so.

The inaccuracy introduced is lessened for bodies which are far away. Hence, the inaccuracy will show up first in the position of the Moon, and will not affect the positions of the stars. If you wish to check the accuracy of the almanac simply use the ALMN program to compute the position of a body at a convenient time and compare to the entries in the "Nautical Almanac".

It is possible to change the value of (TDT-UT) used in the almanac. However, **THIS SHOULD NOT BE ATTEMPTED UNLESS YOU ARE CONFIDENT THAT YOU UNDERSTAND THE DIFFERENCE BETWEEN TDT AND UT AND CAN FIND AN ACCURATE VALUE FOR THIS PARAMETER.** To input a value of the time difference, store the number in a variable called '$$Nav48ΔT%%'. Delta can be accessed as [α][→]C. The number must be stored in HMS format. Hence, 58 seconds would be stored as 0.0058. The variable must be stored in the {HOME SPARCOM NAV48D VARBLS} directory.

NOTE: If you use this feature, be sure to update the variable every year or so to account for variations in the time difference.

We are grateful to Drs. Pierre Bretagnon and Gerard Francou of the Bureau des Longitudes, Paris, France for providing the VSOP87 planetary theory used in the almanac program.

Notes:

Appendix B

List of Stars

A short and long list of stars is included here, as well as a list of Greek letters and a list of constellations. The names in the short star list can be abbreviated by the first few letters of the name, so long as you type enough to uniquely identify the star. Watch out for ambiguities when you type only part of the name. For example, "Rigel" and "Rigil Kentaurus" are similar enough that you must type at least the first four letters to distinguish them. Case is unimportant when keying in the names, all upper case is fine.

IMPORTANT: The quotes are not a part of the name; they are included only to delimit the name and make the list easier to read. Do not include the quotes when typing the name into the calculator.

The Short List

"Acamar"	"Achernar"	"Acrux"	"Adhara"
"Al Na'ir"	"Aldebaran"	"Alioth"	"Alkaid"
"Alnilam"	"Alphard"	"Alphecca"	"Alpheratz"
"Altair"	"Ankaa"	"Antares"	"Arcturus"
"Atria"	"Avior"	"Bellatrix"	"Betelgeuse"
"Canopus"	"Capella"	"Deneb"	"Denebola"
"Diphda"	"Dubhe"	"Elnath"	"Eltanin"
"Enif"	"Fomalhaut"	"Gacrux"	"Gienah"
"Hadar"	"Hamal"	"Kaus Australis"	"Kochab"
"Markab"	"Menkar"	"Menkent"	"Miaplacidus"
"Mirfak"	"Nunki"	"Peacock"	"Polaris"
"Pollux"	"Procyon"	"Rasalhague"	"Regulus"
"Rigel"	"Rigil Kentaurus"	"Sabik"	"Schedar"
"Shaula"	"Sirius"	"Spica"	"Suhail"
"Vega"	"Zubenelgenubi"		

The Long List

In the long list, the stars are represented by their "Bayer Designation". This is a Greek letter followed by an abbreviation for the constellation in which the star is found. Generally, the Greek letter is assigned in order of the brightness of the stars in a given constellation. For example, the star Alpha Canis Minoris (Procyon) is the brightest star in the constellation of Canis Minor. Following standard astronomical practice, this is abbreviated here as "Alp Cmi".

The Stars

"Alp And"	"Bet And"	"Del And"	"Gam And"
"Alp Aql"	"Del Aql"	"Gam Aql"	"Lam Aql"
"The Aql"	"Zet Aql"	"Alp Aqr"	"Bet Aqr"
"Del Aqr"	"Alp Ara"	"Bet Ara"	"Zet Ara"
"Alp Ari"	"Bet Ari"	"Alp Aur"	"Bet Aur"
"Eps Aur"	"Eta Aur"	"Iot Aur"	"The Aur"
"Alp Boo"	"Bet Boo"	"Del Boo"	"Eps Boo"
"Eta Boo"	"Gam Boo"	"Bet Cap"	"Del Cap"
"Alp Car"	"Bet Car"	"Chi Car"	"Eps Car"
"Iot Car"	"Ome Car"	"The Car"	"Alp Cas"
"Bet Cas"	"Del Cas"	"Eps Cas"	"Gam Cas"
"Alp Cen"	"Bet Cen"	"Del Cen"	"Eps Cen"
"Eta Cen"	"Gam Cen"	"Iot Cen"	"Kap Cen"
"Lam Cen"	"Mu Cen"	"The Cen"	"Zet Cen"
"Alp Cep"	"Bet Cep"	"Eta Cep"	"Gam Cep"
"Zet Cep"	"Alp Cet"	"Bet Cet"	"Eta Cet"
"Tau Cet"	"Alp Cir"	"Alp Cma"	"Bet Cma"
"Del Cma"	"Eps Cma"	"Eta Cma"	"Omi Cma"
"Sig Cma"	"Zet Cma"	"Alp Cmi"	"Bet Cmi"
"Alp Col"	"Bet Col"	"Alp Crb"	"Alp Cru"
"Bet Cru"	"Del Cru"	"Gam Cru"	"Bet Crv"
"Del Crv"	"Eps Crv"	"Gam Crv"	"Alp Cvn"
"Alp Cyg"	"Bet Cyg"	"Del Cyg"	"Eps Cyg"
"Gam Cyg"	"Zet Cyg"	"Alp Dor"	"Bet Dor"
"Bet Dra"	"Del Dra"	"Eta Dra"	"Gam Dra"
"Iot Dra"	"Zet Dra"	"Alp Eri"	"Bet Eri"
"Gam Eri"	"The Eri"	"Alp Gem"	"Bet Gem"
"Eps Gem"	"Gam Gem"	"Mu Gem"	"Xi Gem"
"Alp Gru"	"Bet Gru"	"Eps Gru"	"Gam Gru"
"Alp Her"	"Bet Her"	"Del Her"	"Mu Her"
"Pi Her"	"Zet Her"	"Alp Hya"	"Gam Hya"
"Nu Hya"	"Pi Hya"	"Zet Hya"	"Alp Hyi"
"Bet Hyi"	"Gam Hyi"	"Alp Ind"	"Alp Leo"
"Bet Leo"	"Del Leo"	"Eps Leo"	"Gam Leo"

"The Leo"	"Zet Leo"	"Alp Lep"	"Bet Lep"
"Eps Lep"	"Mu Lep"	"Alp Lib"	"Bet Lib"
"Sig Lib"	"Alp Lup"	"Bet Lup"	"Del Lup"
"Gam Lup"	"Zet Lup"	"Alp Lyn"	"Alp Lyr"
"Bet Lyr"	"Gam Lyr"	"Alp Mus"	"Alp Oph"
"Bet Oph"	"Del Oph"	"Eps Oph"	"Eta Oph"
"Kap Oph"	"Nu Oph"	"The Oph"	"Zet Oph"
"Alp Ori"	"Bet Ori"	"Del Ori"	"Eps Ori"
"Gam Ori"	"Iot Ori"	"Kap Ori"	"Pi Ori"
"Zet Ori"	"Alp Pav"	"Bet Pav"	"Alp Peg"
"Bet Peg"	"Eps Peg"	"Eta Peg"	"Gam Peg"
"Mu Peg"	"Zet Peg"	"Alp Per"	"Bet Per"
"Del Per"	"Eps Per"	"Gam Per"	"Rho Per"
"Zet Per"	"Alp Phe"	"Gam Phe"	"Alp Pic"
"Alp Psa"	"Nu Pup"	"Pi Pup"	"Rho Pup"
"Sig Pup"	"Tau Pup"	"Xi Pup"	"Zet Pup"
"Alp Ret"	"Alp Sco"	"Bet Sco"	"Del Sco"
"Eps Sco"	"Eta Sco"	"Iot Sco"	"Kap Sco"
"Lam Sco"	"Mu Sco"	"Nu Sco"	"Pi Sco"
"Sig Sco"	"Tau Sco"	"The Sco"	"Ups Sco"
"Alp Ser"	"Eta Ser"	"Gam Sge"	"Del Sgr"
"Eps Sgr"	"Eta Sgr"	"Gam Sgr"	"Lam Sgr"
"Phi Sgr"	"Pi Sgr"	"Sig Sgr"	"Tau Sgr"
"Zet Sgr"	"Alp Tau"	"Bet Tau"	"Eta Tau"
"Lam Tau"	"Zet Tau"	"Alp Tra"	"Bet Tra"
"Gam Tra"	"Alp Tri"	"Bet Tri"	"Alp Tuc"
"Alp Uma"	"Bet Uma"	"Del Uma"	"Eps Uma"
"Eta Uma"	"Gam Uma"	"Iot Uma"	"Lam Uma"
"Mu Uma"	"Nu Uma"	"Omi Uma"	"Psi Uma"
"The Uma"	"Zet Uma"	"Alp Umi"	"Bet Umi"
"Gam Umi"	"Del Vel"	"Gam Vel"	"Kap Vel"
"Lam Vel"	"Mu Vel"	"N Vel"	"Alp Vir"
"Del Vir"	"Eps Vir"	"Gam Vir"	"Zet Vir"

Greek Letters

Letter	Name	Abbreviation
α	Alpha	Alp
β	Beta	Bet
γ	Gamma	Gam
δ	Delta	Del
ε	Epsilon	Eps
ζ	Zeta	Zet
η	Eta	Eta
θ	Theta	The
ι	Iota	Iot
κ	Kappa	Kap
λ	Lambda	Lam
μ	Mu	Mu
ν	Nu	Nu
ξ	Xi	Xi
ο	Omicron	Omi
π	Pi	Pi
ρ	Rho	Rho
σ	Sigma	Sig
τ	Tau	Tau
υ	Upsilon	Ups
φ	Phi	Phi
χ	Chi	Chi
ψ	Psi	Psi
ω	Omega	Ome

Constellations

The constellations are abbreviated as follows.

Constellation	Abbreviation	Constellation	Abbreviation
Andromeda	And	Antlia	Ant
Apus	Aps	Aquarius	Aqr
Aquila	Aql	Ara	Ara
Argo	Arg	Aries	Ari
Auriga	Aur	Bootes	Boo
Caelum	Cae	Camelopardalis	Cam
Cancer	Cnc	Canes Vanatici	CVn
Canis Major	CMa	Canis Minor	CMi
Capricornus	Cap	Carina	Car
Cassiopeia	Cas	Centaurus	Cen
Cepheus	Cep	Cetus	Cet
Chamaeleon	Cha	Circinus	Cir
Columba	Col	Coma Berenices	Com
Corona Austrina	CrA	Corona Borealis	CrB
Corvus	Crv	Crater	Crt
Crux	Cru	Cygnus	Cyg
Delphinus	Del	Dorado	Dor
Draco	Dra	Equuleus	Equ
Eridanus	Eri	Fornax	For
Gemini	Gem	Grus	Gru
Hercules	Her	Horologium	Hor
Hydra	Hya	Hydrus	Hyi
Indus	Ind	Lacerta	Lac
Leo	Leo	Leo Minor	LMi
Lepus	Lep	Libra	Lib
Lupus	Lup	Lynx	Lyn
Lyra	Lyr	Mensa	Men
Microscopium	Mic	Monoceros	Mon
Musca	Mus	Norma	Nor
Octans	Oct	Ophiuchus	Oph
Orion	Ori	Pavo	Pav
Pegasus	Peg	Perseus	Per
Phoenix	Phe	Pictor	Pic
Pisces	Psc	Piscis Austrinus	PsA
Puppis	Pup	Pyxis	Pyx
Reticulum	Ret	Sagitta	Sge
Sagittarius	Sgr	Scorpius	Sco
Sculptor	Scl	Scutum	Sct
Serpens	Ser	Sextans	Sex

Taurus	Tau	Telescopium	Tel
Triangulum	Tri	Triangulum Australe	TrA
Tucana	Tuc	Ursa Major	UMa
Ursa Minor	UMi	Vela	Vel
Virgo	Vir	Volans	Vol
Vulpecula	Vul		

Appendix C

NAV48 Library

This appendix describes the programs included in the NAV48 library. Most of these programs must be run from the {HOME SPARCOM NAV48D VARBLS} directory, however, NAV48 automatically changes to this directory when it is run, so any of these program can be used from within NAV48 or in programs which are called from NAV48 ("Algebraic Input" section of Chapter 9 of this manual) These programs are provided for the advanced user of the Pac.

NAV48:
Navigation program.

M→T:
A program to convert magnetic course to true course. The input is the magnetic course and the output is the true course, both in the current angular format (DMT, DMS, or decimal). M→T prompts for the magnetic variation.

T→M:
A program to convert true course to magnetic course. The input is the true course and the output is the magnetic course, both in the current angular format (DMT, DMS, or decimal). T→M prompts for the magnetic variation.

BRNG:
A program to compute the equivalent celestial observation for an observation of the bearing of some coastal feature. The input is the bearing of the feature (true) and the output is the GHA, declination, and altitude of the equivalent observation. Both input and output are in the current angular format. BRNG prompts for the dead reckoning position and the position of the observed feature. This program must be run from the {HOME SPARCOM NAV48D VARBLS} directory.

RNG:
A program to compute the equivalent celestial observation for an observation of the range of some coastal feature. The input is the range of the feature (nmi assumed, if no unit is appended to the range). The output is the GHA,

declination, and altitude of the equivalent celestial observation, all in the current angular format. RNG prompts for the position of the observed feature. This program must be run from the {HOME SPARCOM NAV48D VARBLS} directory.

ABOUTNAV:
Displays version and other useful information about NAV48.

→FMT:
This program converts a number on the stack (level 1) from decimal degrees to the current angular format. This program must be run from the {HOME SPARCOM NAV48D VARBLS} directory.

FMT→:
This program converts a number on the stack (level 1) in the current angular format into decimal degrees. This program must be run from the {HOME SPARCOM NAV48D VARBLS} directory.

RANGE:
This program takes two numbers off the stack, both angles in decimal degrees, and adds or subtracts multiples of 360 degrees to the angle in level 2 until it is within +/- 180 degrees of the angle in level 1. This modified angle is output on level 1 of the stack.

DOPOS:
This program is used to input a position. It takes 5 objects off the stack:

Level 5: String prompt for input
Level 4: String prompt for latitude
Level 3: String prompt for longitude
Level 2: Default latitude (decimal)
Level 1: Default longitude (decimal)

The output is the longitude (level 2) and latitude (level 1) input by the user (decimal degrees). This program must be run from the {HOME SPARCOM NAV48D VARBLS} directory.

GJD→EP:
This program takes a time of fix (variable 'TF') from the stack and converts it into YYYY.MMDD (level 2) and decimal hours (level 1). The time is UT.

Appendix D

NAV48 Variables

This appendix describes the data variables used by the NAV48 Pac. These variables are stored in the {HOME SPARCOM NAV48D VARBLS} directory. It is not necessary to change or understand these variables; they are described here for completeness.

CRS: The course the vessel is steering (true).

CSTAR: Data for the last star whose position was computed with the built in almanac.

DEC1: The declination of the first interpolation point in the ADDOB program (decimal degrees). North declination is positive and south declination is negative.

DEC2: The declination of the second interpolation point in the ADDOB program (decimal degrees). North declination is positive and south declination is negative.

DRIFT: The drift of the current (knots).

DRLAT: The current dead reckoning latitude in decimal degrees. North latitude is positive and South latitude is negative.

DRLON: The current dead reckoning longitude in decimal degrees. West longitude is positive and East longitude is negative.

E: A program object used to set the sign of longitude entries.

FFMT: a code indicating the current format for angular data (0=DMS, 1=DMT, 2=decimal).

FMT: A string describing the current format for angular data.

GHA1: The GHA of the first interpolation point in the ADDOB program (decimal degrees).

GHA2: The GHA of the second interpolation point in the ADDOB program (decimal degrees).

HGT: The default height of eye (meters).

HP: The horizontal parallax of the Moon or of the planets Venus or Mars (decimal degrees).

INDX: the default index error (decimal degrees).

LAT: The latest position fix, latitude (decimal degrees). North latitude is a positive number and South latitude is a negative number.

LON: The latest position fix, longitude (decimal degrees). West longitude is a positive number and East longitude is a negative number.

LU: Indicates the limb of the Sun or Moon observed (1=lower limb, -1=upper limb, 0=center).

N: A program object used to set the sign of latitude entries.

nCRS: The course steered by the vessel, excluding the effects of the current (true).

nSPD: The speed of the vessel excluding the effects of the current (knots).

OBS: The celestial observations in an HP 48SX matrix. Each row of the matrix contains the GHA, declination and corrected altitude in decimal format and in that order.

OFF~A: A program object used to set the sign of the index error.

OLAT: The previous position fix, latitude (decimal degrees). North latitude is a positive number and South latitude is a negative number.

OLON: The previous position fix, longitude (decimal degrees). West longitude is a positive number and East longitude is a negative number.

ON~A: A program object used to set the sign of the index error.

OTF: The previous time of fix (decimal days since October 15, 1582 at 0 UT)

PRESS: The atmospheric pressure in millibars.

S: A program object used to set the sign of latitude entries.

SDATE: The default date for the ADDOB program (YYYY.MMDD).

SHA: The default SHA for the ADDOB program.

SEMI: The semi-diameter of the Sun (decimal degrees).

SET: The set of the current (true).

SPD: The speed of the vessel (knots).

SVTIME: The default time used in the ADDOB program (decimal hours).

T1: The time of the first interpolation point (GHA and declination) in the ADDOB program.

T2: The time of the second interpolation point (GHA and declination) in the ADDOB program.

TF: The time of fix (decimal days since October 15, 1582 at 0 UT)

TMPTR: The atmospheric temperature in degrees Celsius.

tol: The default 'to' latitude in the SAIL program (decimal degrees). North latitude is positive and South latitude is negative.

toλ: The default 'to' longitude in the SAIL program (decimal degrees). West longitude is positive and East longitude is negative.

W: A program object used to set the sign of longitude entries.

WATCH: The current watch error in decimal hours.

ZONE: The current zone description (whole hours to UT).

Notes:

Appendix E

Quick Reference

NAV48 Menu Structure

NAV48 Page 1:

- SOLVE ....Reduces observations for a fix
- ERROR .... Displays formal of error on a fix
- ADDOB .... Allows input of a celestial observation
- INIT: ....Setup parameters
  - IX/HT .... Sets index correction and height of eye
  - MOTION .... Sets course/speed
  - P/T ....Sets pressure/temperature
  - FORMAT..............Selects format (DMT, DMS, or decimal)
  - ZN/W.........................Sets zone description and watch error
  - EXIT .... Exits the INIT program
- ADDDR......... Adds dead reckoning position to celestial observations
- QUIT ....Exits NAV48 program

NAV48 Page 2:

- PLOT ....Plots and displays lines of position
- PILOT: .... Displays various piloting programs
  - DREC .... Sets dead reckoning position
  - VANG Computes distance from an object using a vertical angle
  - DBRG Computes distance from an object using two bearings
  - ST/DT ....Computes set/drift (current)
  - TIDE ....Interpolates the tide at your location
  - EXIT ....Exits PILOT program
- PILOT **Page 2:** ....
  - M→T ....Converts your magnetic course to true course
  - T→M ....Converts your true course to magnetic course
  - D=ST .... Calculates distance/speed/time
  - EXIT ....Exits PILOT program
- ADV................................. Advances celestial observations to current

SAIL: .... Displays various SAIL programs
- RHUMB .... Computes rhumb line (course and distance)
- GC .... Computes Great Circle (course and distance)
- WAY Computes/displays waypoints along a Great Circle track
- VERTX .... Displays vertex of a Great Circle
- COMP .... Computes limiting latitude composite route
- EXIT .... Exits SAIL program

ALMN: .... Displays various Almanac programs
- GHAD .... Computes GHA/declination
- HORIZ .... Displays horizon coordinates of a body
- RISET .... Displays rise/set of a body
- ID .... Identifies body from height and azimuth
- DTIME .... Adjusts almanac date and time
- EXIT .... Exits ALMN program

ALMN Page 2: ....
- NTWI .... Displays nautical twilight on date selected
- CTWIL .... Displays civil twilight on date selected
- EQT .... Displays equation of time
- SD/HP Displays semi-diam. of sun/horiz. parallax of moon
- GHAγ .... Displays GHA Aries, LHA Aries
- EXIT .... Exits ALMN program

QUIT .... Exits NAV48 program

NAV48 **Page 3:**

WAYP .... Displays waypoints (waypoint viewer)

RESET .... Clears out old celestial observations to receive new

DSAVE .... Saves celestial data

DRCL .... Recalls celestial data

EDIT: .... Edits celestial data
- NEXT .... Selects next observation
- PREV .... Selects previous observation
- DEL .... Deletes observation
- ADD .... Adds observation
- EDIT .... Edits observation
- EXIT .... Exit EDIT program

QUIT .... Exit NAV48 program

Quick Reference for Sight Reduction and Running Fix

The following is a concise overview of the sight reduction and running fix process. If you do not have an expert grasp of navigation and the HP 48SX you may wish to review this section before proceeding with the tutorials.

Sight Reduction

Step 1. RESET:
Run RESET to clear any old observations.

Step 2. INIT:
Run INIT to set index error, height of eye, course & speed, atmospheric conditions, zone description and watch error

Step 3. ADDOB:
Run ADDOB for each observation.

Step 4. ADDDR:
Run ADDDR if you want to include dead reckoning position in the position fix.

Step 5. SOLVE:
Run SOLVE to get the position fix. At least 3 observations are required for a fix (one may be dead reckoning data). One observation combined with a dead reckoning position will give an estimated position.

Step 6. ERROR:
Run ERROR to get an idea of the internal consistency of the data (random error).

Step 7. PLOT:
Run PLOT to see the lines of position. Estimate the accuracy of the fix.

Running Fix:

Step 1. ADV:
Use ADV to advance or retard observations from the current time of fix to a new time of fix.

Step 2. INIT:
Are the settings correct? In particular, are the course and speed still set properly?

Step 3. ADDOB:
Enter any new observations.

Step 4. SOLVE:
Run SOLVE to compute the running fix.

Step 5. ERROR:
Check the internal consistency of the data (random error).

Step 6. PLOT:
Check the lines of position for the accuracy of the fix.

Notes:

Appendix F

Glossary

See "The American Practical Navigator", Vol. 2 by Nathaniel Bowditch for an extensive glossary.

Altitude
The angular height of a celestial body above the observer's horizon.

Arc Minute
An angular measure: one sixtieth of a degree (1/60°).

Arc Second
An angular measure: one sixtieth of an arc minute (1/3600°).

Azimuth
The true direction from the observer to the geographical position of a celestial body (along a great circle).

Circumpolar
A circumpolar body is always above the horizon when viewed from the observer's position; it never sets but travels in a circle around the celestial pole.

Civil Twilight
Civil twilight is the time when the Sun is 6° below the horizon.

Dead Reckoning Position
A position determined from a knowledge of the vessel's speed, course, and drift.

Declination
The latitude of a celestial body's geographical position.

Dip
The angle between the true horizon and the apparent horizon caused by the curvature of the Earth's surface. The angle is dependent on the height of eye of the observer, since the higher the eye the further around the Earth one can see.

Equation of Time
The time difference between the motion of the true Sun and a fictitious mean Sun which moves at a constant rate.

Estimated Position
The position on a line of position from a celestial sight which is closest to the dead reckoning position. The most probable position of a vessel from incomplete data.

Geographical Position
The point on the Earth's surface which is directly underneath a celestial body. To an observer at this point, the body would appear at the zenith.

Great Circle
The shortest path between two points on a sphere is a great circle. It is the intersection between the surface of the sphere and a plane passing through the center of the sphere.

Greenwich Hour Angle (GHA)
The east-west position of a celestial body's geographical position, measured in degrees westward from Greenwich, England.

Greenwich Mean Time (GMT)
Local time at Greenwich, England. It is the time measured from the Greenwich meridian to the fictitious mean sun (see Equation of Time). GMT is now known as Universal Time, abbreviated UT in this manual.

Horizontal Parallax
For a body which is relatively close to the Earth, the measured altitude from the surface is not the same as the altitude one would measure from the center of the Earth. Parallax is the difference between these, and horizontal parallax is the maximum value of this parallax, obtained when the body appears on the observer's horizon.

Index Error
This is an error in the measurement of the altitude of a celestial body caused by a misalignment of the horizon and index mirrors of the sextant. "On the arc" means that the measured altitude is too high (the correction is negative), while "off the arc" means that the measured altitude is too low (the correction is positive).

Latitude
The angular measure of the distance along the vessel's meridian from the equator to the vessel.

Longitude
The angle measured east or west from the Greenwich meridian to the observer's meridian.

Lower Limb
The point on the edge of the Sun or Moon which is closest to the horizon.

Magnitude
A measure of the brightness of a celestial body; the smaller the magnitude the brighter the object. The brightest stars have magnitudes of about -1, while the dimmest stars which are useful to the navigator have a magnitude of about +3.

Magnetic Course
The vessel's course relative to the Earth's magnetic north pole.

Meridian
A great circle passing through both the north and south pole. These are lines of longitude.

Nautical Mile
A nautical mile corresponds to one minute of arc along a great circle on the Earth's surface. A nautical mile has a value of 1,852_m.

Nautical Twilight
Nautical twilight is the time when the Sun is 12° below the horizon.

Random Error
This is measurement error which varies randomly from observation to observation and cannot be predicted.

Refraction
The bending of light as it passes through the atmosphere. The light bends towards the Earth's surface yielding an altitude which is too high.

Rhumb Line
A path on the surface of a sphere which always intersects meridians of longitude at the same angle. This is the path from one point to another such that the true course steered is constant and is represented as a straight line on a Mercator chart.

Running Fix
A position computed by advancing or retarding a line of position to the time of another line of position.

Sailings
The various routes one can take from one point on the Earth's surface to another. Great circle routes and rhumb lines are examples.

Systematic Error
An observational error which remains constant from one observation to the next.

Transit
When a celestial body reaches is maximum or minimum altitude as it appears to revolve about the celestial pole, it is said to "transit". When the body reaches its maximum altitude, it is at upper transit and when it reaches its minimum altitude, it is at lower transit.

True Course
The vessel's course relative to true north (the direction to the north rotational pole).

Universal Time (UT)
Local time at Greenwich, England. It is the time measured from the Greenwich meridian to the fictitious mean sun (see Equation of Time). For purists, UT in this manual refers to UT1. UTC, the time obtained from broadcast time signals, is kept within 0.9_s of UT1.

Upper Limb
The point on the edge of the Sun or Moon which is furthest from the horizon.

Vertex
The point at which a great circle reaches its highest latitude.

Waypoint
A position along a route from one point to another (usually along a great circle).

Zenith
The point in the sky which is directly over the observer's head.

Zone Time
Universal time corrected for the observer's longitude by 1 hour for every 15 degrees. The Greenwich time zone extends from 7° 30' East to 7° 30' West.

Notes:

Appendix G

Questions & Answers

Q: When I press ERROR I do not get any useful information. Why?

A: Perhaps only two sights have been entered. ERROR will not return meaningful information on the accuracy of the fix when only two sights are used. With two sights the lines of position cross at a single point and it is not possible to analyze the accuracy. Enter more sights and try again.

Q: In the DBRG command under Piloting the error message "ERROR Distance run is 0_nmi" appears. What happened?

A: The computation of your distance off by two bearing observations assumes that you move between the two sights. The motion entered in the INIT program is used to compute the distance run between these sights but if your speed is set to zero the calculator thinks that you are not moving and cannot compute the distance off. Set the motion in the INIT program to your average motion between the sights and run DBRG again. Alternatively, you may have input the same time for both bearing observations.

Q: The name of the star I wanted is not what is displayed or is not found. Why?

A: If the name is not found, you will be prompted for the name again, if it is found, the name of the star will be displayed. If the name displayed is not the star you intended, press [ON] to terminate the program. In this case, you must run the ADDOB program again to input the correct observation and star name. If the program finishes, and you realize that a mistake was made, use the observation editor (EDIT) to delete the observation and start over with the ADDOB program.

Q: Do I have to include a dead reckoning position as a sight every time I input a set of celestial observations?

A: No. You must include your dead reckoning position only if you have just two observations. If you have more than two observations, you need not include the dead reckoning position. If you do *not* include the dead reckoning position with the ADDDR program, the dead reckoning position is ignored.

Q: What happens if I select more than one position on the plot in the PLOT program by pressing enter more than once?

A: Only the last position marked with enter is recorded.

Q: Why do I keep getting strange answers that I know are incorrect or that I do not understand?

A: If the program outputs erroneous or confusing data, it is possible that you have incorrectly entered data which is confusing the program. Exit the program by pressing QUIT then return to the program by pressing NAV4.

Q: Why is there no dead reckoning prompt when I enter a new set of observations with ADDOB ?

A: The motion of the vessel is set to zero in INIT. Set the motion to anything besides zero and you will see the dead reckoning prompt (within ADDOB).

Q: What does "H_s" stand for?

A: "H" stands for *height* and "s" stands for *sextant*. Therefore, "H_s" stands for, the height of the observed object measured by the sextant.

Q: In INIT I left a prompt blank when setting a value to zero. Now a message "Invalid Syntax" appears. Why?

A: Even if the value is zero you still need to show "0". Input 0 at the prompt and try again.

Q: When I enter a new set of observations I am not prompted for the *time of fix*. Why?

A: The only time you will be prompted for a new time of fix is after you have reset the variables. Use the RESET program to clear out the old observations and try again. Use the ADV program to change the time of fix.

Q: If the NAV48 Pac appears to be functioning incorrectly-i.e., if you attempt to create a plot or run a fix and nothing happens-it is likely that there is not enough free memory in your HP 48SX to complete the operation. Possible solutions to the problem of too little free memory are:

- **A1:** Quit the NAV48 Pac and delete unwanted variables from the {SPARCOM NAV48D DATA} directory. (For more information, refer to Chapter 6 of the HP 48SX Owner's Manual, "Variables and the VAR Menu.")
- **A2:** Add additional free memory to your HP 48SX by merging a 32K or 128K RAM card. (For more information, refer to Chapter 5 of the HP 48SX Owner's Manual, "Calculator Memory.")

Appendix H

Warranty and Service

Pocket Professional™ Support

You can get answers to your questions about using your Pocket Professional™ Pac from Sparcom. If you don't find the information in this manual or in the HP 48SX Owner's Manual, contact us in one of the following ways:

❶ E-Mail

From Internet: support@sparcom.com
From Compuserve: >Internet:support@sparcom.com
From FidoNet: To:support@sparcom.com

❷ Standard Mail

Sparcom Corporation
897 NW Grant Avenue
Corvallis, OR 97330
Attn: Technical Support Department

❸ Telephone

(503) 757–8416
9 AM – 4 PM Pacific Time

❹ FAX

(503) 753–7821
Mark: Attention-Technical Support

Limited One-Year Warranty

What is Covered

A Pocket Professional™ Pac is warranted by Sparcom Corporation against defects in material and workmanship for one year from the date of original purchase. If you sell your card or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair or replace (at no charge) a product that proves to be defective, provided you return the product and proof of purchase, shipping prepaid, to Sparcom.

What is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by any entity other than Sparcom Corporation.

No other warranty is given. The repair or replacement of a product is your exclusive remedy. ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY. IN NO EVENT SHALL SPARCOM CORPORATION BE LIABLE FOR CONSEQUENTIAL DAMAGES. Products are sold on the basis of specifications applicable at the time of manufacture. Sparcom shall have no obligation to modify or update products, once sold.

If the Card Requires Service

Sparcom will repair a card, or replace it with the same model or one of equal or better functionality, whether it is under warranty or not.

Service Charge

There is a fixed charge for standard out-of-warranty repairs. This charge is subject to the customer's local sales or value-added tax, wherever applicable. Cards damaged by accident or misuse are not covered by fixed charges. These charges are individually determined based on time and material.

Shipping Instructions

If your card requires service, ship it to the address above and:

1. Include your return address and a description of the problem.
2. Include a proof of purchase date if the warranty has not expired.
3. Include a purchase order, along with a check or credit card number and expiration date (VISA or MasterCard), to cover the standard repair charge.
4. Ship your card, postage prepaid, in protective packaging adequate to prevent damage. Shipping damage is not covered by the warranty, so insuring the shipment is recommended.

Cards are usually serviced and re-shipped within five working days.

Environmental Limits

The reliability of a Pocket Professional™ Pac depends upon the following temperature and humidity limits:

1. Operating Temperature: 0 to 45° C (32 to 113° F).
2. Storage Temperature: –20 to 60° C (–4 to 140° F).
3. Operating and Storage Humidity: 90% relative humidity at 40° C (104° F) maximum.

Notes:

Appendix I

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Index

Celestial Navigation Pac Changes

The following changes were made to the Celestial Navigation Pac for version 2.5:

✔ A new program, HANG, has been added to allow horizontal sextant angles in piloting.

✔ A new menu option, BRH, has been added to the PILOT menu. BRH allows easier access to BRNG, RNG, and the new program HANG.

✔ In the MOTION program in the INIT menu, the user is prompted for the current set and drift before the motion of the vessel.

✔ A new program has been added, CRSV, which computes a course to steer to make good a given course in the presence of a current.

✔ A new program has been added, ARTH, to facilitate artificial horizon observations.

✔ A new program has been added, DIPS, to compute the dip short of the horizon.

✔ The program GDEC has been added to the NAV48 library menu. This program allows direct access to the internal almanac from outside NAV48.

✔ The program ADDDR now prompts for the time the dead reckoning position is valid and advances the position to the time of fix.

✔ The course displayed after DBRNG, and after an observation is input, is formatted to the current angle setting (DMT, DMS, or decimal).

HP 48GX USERS ONLY: You should install the application card in Port 1 for two reasons:

1. Application cards installed in Port 1 will execute ~ 20% faster than those installed in Port 2.

2. Application cards installed in Port 2 may experience long pauses (~ 5-10 seconds or more) intermittently during operation. This is not a software defect. It is caused by the new memory architecture of the extended HP 48GX Port 2, which is different from the HP 48SX Port 2. Such pauses will not occur if the application card is operated from Port 1 of the HP 48GX or if it is operated from either port of the HP 48SX.

Celestial Navigation Pac Manual Changes

These changes apply to the Celestial Navigation Pac Manual, Edition 1, August 1992.

Changes for the HP 48GX

General: To display all libraries on the HP 48GX, press [→] [LIBRARY] instead of [←] [LIBRARY].

General: On the HP 48GX, the [ATTN] key has been replaced by CANCEL.

General: To perform a screen dump on the HP 48GX, press [ON] – [I/O] instead of [ON]–[MTH].

Changes for Version 2.5

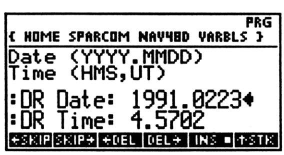
Additional Reference

Page I-165: Add: Metcalf, Thomas. "An Extension to the Overdetermined Celestial Fix", NAVIGATION, Journal of the Institute of Navigation, Vol. 39, No. 4, Winter 1992-93.

ADDDR Clarification

Page 2-52: Add after the [ENTER] on the second line from the bottom:

ADDDR prompts the user for the time that the dead reckoning position is valid. It is then advanced or retarded to the current time of fix. If the time of fix is not set when ADDDR is run, ADDDR will prompt for the time of fix. For this example, set the observation date to 1991.0223 and the observation time to 04.5702.



IMPORTANT: Check that the vessel's course and speed are set correctly in INIT before running ADDDR since these values are used to advance/retard the dead reckoning position to the time of fix.

New Program in the PILOT Menu: BRH

Page 7-96: Add the following description of the BRH program.

The BRH program in the PILOT menu allows you to easily include bearings, ranges and horizontal angle observations with celestial data in a position fix. Press **BRH** to start the program. There are three choices: BRNG, RNG, and HANG to input a bearing, a range, or a horizontal angle. When the corresponding menu key is pressed, each of these options will prompt you for a single quantity, the bearing (true course to an observed object), the range (nmi to an observed object), or the horizontal angle (the horizontal angle between two observed objects). The bearing and the range are discussed in the piloting section of chapter 9 of the manual. The horizontal angle is discussed in the addition to chapter 9 below. Be sure to read the appropriate sections of chapter 9 completely before using BRH. The BRH program should be considered an advanced feature of NAV48. You do not need to understand it to enjoy the NAV48 celestial programs.

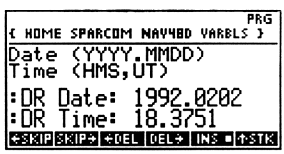
After BRH has completed, the observation is included in the OBS variable and will be used in the computation of position fixes, and can be used exactly as any celestial data.

IMPORTANT: Make sure that the course and speed are set correctly in INIT before running BRH. They will be used in advancing/retarding the observation to the current time of fix.

Dead Reckoning Clarification

Page 9-128: Add after the dead reckoning screen:

After the dead reckoning position has been input, the BRNG program prompts for the date and time at which the dead reckoning position is valid. This is necessary since the dead reckoning position is included in the OBS variable and must be advanced/retarded to the correct time of fix.



IMPORTANT: The dead reckoning position input to BRNG must be valid at or near the time of the bearing observation.

Horizontal Sextant Angles in Piloting

Page 9-132: Add the following description of the HANG program:

The most common sight used in coastal piloting is a bearing from your vessel to some object which appears on your chart. However, on a small vessel, the bearing can rarely be measured to better than a few degrees, so it is not particularly accurate unless the object sighted is relatively close by. A less common, but potentially very accurate observation is the measurement of the horizontal angle between two known objects. Since the measurement is made with a sextant, a very precise instrument, a high degree of accuracy can be achieved. See the chapter on the "Use of Sextant in Piloting" in Bowditch, "The American Practical Navigator".

The first step is to measure the horizontal angle between two coastal objects which also appear on your chart. Turn your sextant on its side and bring the image of one object across to the second object, just as you bring a star down to the horizon in a celestial sight. Technically, the sextant should be held horizontally, but, if the two objects are roughly the same apparent elevation, just putting one on top of the other will insure that the sextant is nearly horizontal. This measurement is actually easier than a celestial sight since the timing is not critical and the objects do not move.

The largest errors in the measurement of the horizontal angle are due to problems identifying the observed object on your chart, and due to tilt of the sextant when you make the observation. To minimize the error from identification, try to use small objects like flagpoles or fixed aids to navigation. Extended objects like islands are much more difficult since it is often hard to identify one point on the island with the exact corresponding point on the chart. Floating aids to navigation are also inappropriate since the position on the chart is often uncertain.

To minimize the error from the tilt, make sure you are holding the sextant horizontally. It is best to use two objects which have roughly the same apparent elevation above the shoreline to insure that the sextant is horizontal. For example, a high mountain and a short flagpole which appear at very different apparent elevations will NOT give a good observation, but two flagpoles might.

CAUTION: Since the equivalent celestial observation for the horizontal angle which is put into the OBS variable generally has a high altitude (close to 90 degrees), all the warnings associated with the RNG program in Chapter 9 apply equally well to the HANG program. Be sure to read and understand the section on piloting in Chapter 9. Always check the results of SOLVE with PLOT, particularly when incorporating piloting data, as range and horizontal angle observations are quite sensitive to the dead reckoning position.

IMPORTANT: The HANG program uses plane geometry and should not be used with objects more than about 100 miles apart.

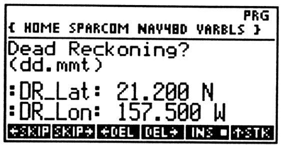
After you press HANG from BRH, you are prompted for the horizontal angle in the current format and then for your dead reckoning position and finally for the positions of the two observed objects. The dead reckoning position is used to decide on which side of the line connecting the two objects the vessel is on. The dead reckoning position need therefore only be accurate enough to make this distinction.

IMPORTANT: The dead reckoning position must be on the correct side of the objects.

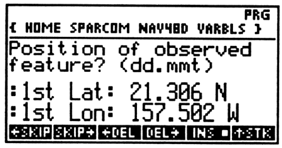
The observation is corrected for index error so you must input the uncorrected sextant observation.

Example: Suppose you observe that the horizontal angle between two objects is 46 degrees 01.0 minutes. Your sextant has an index correction of 1.0 minutes on the arc. The position of the two objects is 21° 30.6' N, 157° 50.2' W and 21° 26.8' N, 157° 45.4' W. Before inputting the sight, run RESET to clear any old observations and then run INIT. Set the index error to 1.0 minutes off the arc and set the motion to 0. To input these data, press PILOT and then BRH. At the BRH prompt, press HANG to start the input of the horizontal angle, and input the angle.

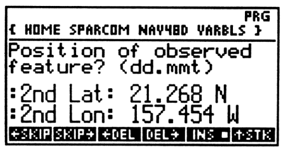
Input the dead reckoning as 21° 20' N and 157° 50' W.



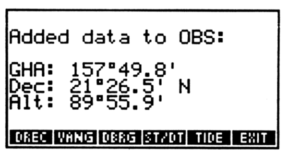
You are now prompted for the position of the two observed objects.



and



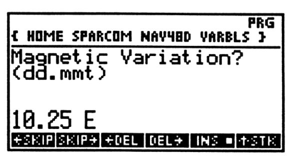
You are next prompted for the observation date, time, time of fix, and, if the vessel were moving, the dead reckoning position. Accept all the default values.



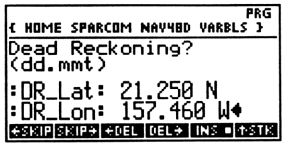
The observation is now input, and, with at least three observations, you can run SOLVE and PLOT to fix your position. The data from HANG can be used just like any other data, it can be advanced, retarded or used to compute a position fix.

To continue with the example, we observe the bearing to one of the objects and compute a position fix.

We observe the bearing to the object at 21° 30.6' N, 157° 50.2' W as 316 degrees magnetic. The magnetic variation is 10:25 E. To input the bearing observation, run BRH again and press BRNG. Input the observation, using the M→T program to convert to a true bearing from a magnetic bearing (Chapter 9):

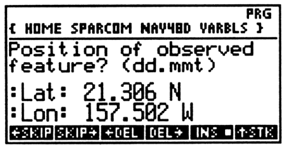


Input the dead reckoning as 21° 25' N and 157° 46' W:

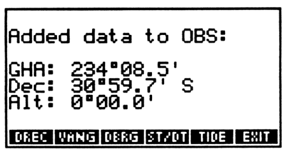


Accept the default date/time for the dead reckoning observation.

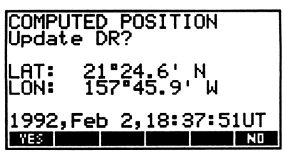
You are now prompted for the position of the observed object.



Accept the default values for the date/time of the observation.



Exit PILOT and run SOLVE to get the fix. Normally with only two observations, we would have to run ADDDR before SOLVE, but the BRNG program adds the dead reckoning for us (see BRNG description in Chapter 9).



Run PLOT to check the results. You should ALWAYS run PLOT whenever dealing with piloting data since range and horizontal angle data are quite sensitive to the accuracy of your dead reckoning position. If you do not like the fix shown in PLOT, move the cursor to a better position and press ENTER before exiting the graphics environment.

MOTION in INIT

Page 2-16: Reverse the order of the prompts for MOTION: The prompts in the MOTION program in the INIT menu have been reordered in version 2.5. Previously the motion of the vessel was prompted for before the current. This has been reversed so that the first prompt is for the current and the second prompt is for the motion of the vessel. The actual prompts remain unchanged.

Course-Vector Solutions

Page 2-17: Add the following description of CRSV after the "IMPORTANT" box:

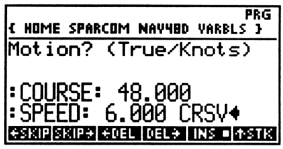
In the INIT program, to compute your motion, you input both your course and speed through the water and the set and drift of the current. These are combined into your net motion which is displayed on the INIT screen. Sometimes, however, you want to input a desired course and the set and drift of the current and have the calculator compute the course you should steer to make this desired course.

A new program, CRSV, has been added to the NAV48 menu to accomplish this.

To use this program, simply append CRSV to the input at the Motion prompt after running INIT and MOTION. For example, suppose you want to sail at a course of 48 degrees true and are moving through the water at 6 knots. There is a current of 1 knot due east.

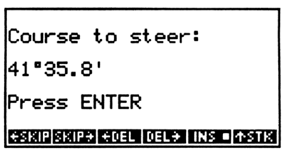
First, you must input the current set and drift. Run INIT and press MOTION. Make sure the set and drift are 90 and 1 respectively. Press ENTER. You have set the current.

You are next prompted for the motion of the vessel. Append CRSV to indicate that this is the desired course and actual speed through the water.



Press ENTER.

The course we must steer to attain the requested net course is displayed.



Press ENTER to continue. The net motion is displayed at the INIT menu as 48 true at 6.7 knots. Note the net course is exactly what we asked for. The speed is the speed through the water of 6 knots (along a course of 41° 35.8') combined with the current of 1 knot (due East).

CAUTION: There is not always a solution to the problem. If there is not a solution, the program will find the best answer it can. Always check that the course displayed by INIT is in fact what you requested. If it is not, you cannot make the requested course.

Artificial Horizons

Page 9-117: Add the following description of the ARTH program just before the "IMPORTANT" box:

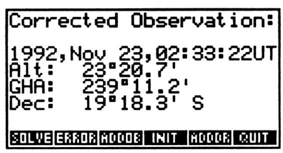
The artificial horizon is basically a pool of liquid that you can use to obtain sights when the true horizon is not visible. By bringing the image of the body observed through the sextant down to the image of the body reflected in the pool of liquid, you can compute the altitude of the body: the altitude is simply 1/2 the reading on the sextant.

However, inputting this type of data into NAV48 is not quite as simple as just dividing the observed altitude by two. The process is complicated by the corrections which are required to the data. The index error has nothing to do with the type of observation: it is a property of the sextant. Thus, the observation must be corrected for index error before dividing by two. Since the observation is not made relative to the actual horizon, there is no dip correction, regardless of the height of eye. The rest of the data corrections (refraction etc.) depend on the true altitude and must be applied after dividing by two.

A program, ARTH, has been added to the NAV48 library menu to handle artificial horizon observations.

This program is used in the ADDOB program to input the H_s value from an artificial horizon observation. For example, suppose that we observed the lower limb of the Moon with an artificial horizon by bringing the lower limb observed through the sextant into contact with the apparent upper limb of the reflected image of the Moon. Our sextant has an index error of 2.0' on the arc and the time of the sight is November 23, 1992 at 02:33:22 UT. The observed sextant altitude is 44° 28.3'. Run INIT and set the index error to 2.0'. The height of eye would be set to zero for an artificial horizon sight, but we have already accounted for that in the ARTH program, so it is not necessary to set the height of eye to zero (the value is effectively ignored). Set the motion to 0 knots and the zone description to 0 hours. Now run the RESET program to clear out any old observations and then run ADDOB. Set the date to 1992.1123 and the time to 02.3322. Now set the H_s value to 'ARTH(44.283)'.

The body is the Moon and the limb is the lower limb. Compute the almanac, and accept the default time of fix. The final screen shows



If you use an artificial horizon often, you may want to put the ARTH program into your CST list in { HOME SPARCOM NAV48D }. See "Additional Information for Advanced Users" below.

Dip Short of the Horizon

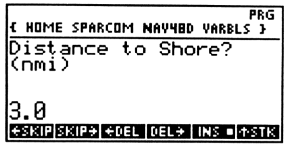
Page 9-117: Add the following description of the DIPS program just before the "IMPORTANT" box:

A new program, DIPS, to compute the dip short of the horizon has been added to the NAV48 library. This should be used if you cannot see the true horizon, but you can use your sextant to bring an observed body down to a nearby shoreline instead. You will need to know the precise distance to the shoreline to use this program.

DIPS is used in conjunction with the ADDOB program, at the Time/Altitude prompt. For example, if the altitude of the observation is 45 degrees at noon (UT), input

Press ENTER.

You will be prompted for the distance to the shoreline in nautical miles.



Press ENTER.

After the distance prompt, proceed with ADDOB as usual. DIPS turns off the standard dip correction and replaces it with the correction for dip short of the horizon.

New Programs in the NAV48 Menu

Page C-144: Add the following descriptions at the end of Appendix C.

HANG:
This program takes a single number off the stack: the observed horizontal angle in the current format. The output is the GHA, declination, and altitude of the equivalent celestial observation for the horizontal angle, all in the current angle format. The program prompts for the observer's dead reckoning and for the position of the two observed objects.

GDEC:
This program allows the user to access the internal almanac from outside NAV48. It takes the date and time from the stack and returns a list with the position of the object. The program prompts for the body. It takes 2 objects off the stack:

Level 2: Date (YYYY.MMDD)
Level 1: Time (decimal hours) in UT

The output is a list of tagged data in the current format (DMT, DMS, or decimal). South declination is a negative number.

CRSV:
This program computes the course the vessel must steer to maintain an absolute course in the presence of a current. It is used in conjunction with MOTION in the INIT menu. The program take two numbers off the stack: the desired course (in the current angle format) in level 2 and the speed through the water in level 1. The output is the course to steer (in the current angle format) in level 2 and the speed through the water in level 1.

ARTH:
This program is used to enter artificial horizon observations into ADDOB. The input is a single number in the current angle format: the uncorrected sextant reading. The output is an angle in the current format. The output angle is an intermediate value which needs to be passed to ADDOB for further processing; it is not useful by itself.

DIPS:
This program computes the dip short of the horizon and is used in conjunction with ADDOB. The input is a single number in the current angle format: the uncorrected sextant reading. The output is an angle in the current format. The output angle is an intermediate value which needs to be passed to ADDOB for further processing; it is not useful by itself.

Additional Information for Advanced Users

Saving Positions

Page 9-132: Add "Saving Positions" as a new section in Chapter 9:

A very useful feature of the NAV48 program is the ability to run your own programs at prompts. Several examples of this are given above. A useful program, an example of which is given below, generates positions which you use repeatedly. For example, the position of your home port or a waypoint. Suppose that your way point is at 22 degrees 50 minutes north latitude and 157 degrees 20 minutes west longitude. Rather than entering this position repeatedly, you can enter a short program to automatically input this position at any position prompt in NAV48.

All the position prompts in NAV48 require a position in the current angle format (DMT, DMS, or decimal). Thus, our program must output the position in the current format, whatever it is. To do this, we use decimal format in the program and convert to the current format with the →FMT program included in the NAV48 library. In our example, the position in decimal format is 22.8333 north latitude and 157.3333 west longitude. The program we write must leave the latitude in level 2 on the stack and the longitude in level 1:

« 22.8333 →FMT 157.3333 →FMT »

Call this program WAY1 and store it in the { HOME SPARCOM NAV48D } directory. It must be stored in this directory so that the program is visible to NAV48 which runs from the { HOME SPARCOM NAV48D VARBLS } directory.

Now run NAV48. Run the DREC program in the PILOT menu. At the dead reckoning prompt, press [ATTN] once to clear the display and key in WAY1 (you will have to put the calculator in ALPHA mode). Press [ENTER], and the waypoint is entered as the dead reckoning position. In the next section, we will see how the HP 48SX custom menu can be used to make this even easier.

Using the CST Custom Menu

Page 9-132: Add "Using the CST Custom Menu" as a new section in Chapter 9:

The HP 48SX calculator has a powerful custom menu feature built into it. This feature can be used very effectively with the NAV48 program. For example, suppose we want to use the custom menu so that we don't have to type "WAY1" every time we want to use the waypoint position we set in the previous section. Enter the following list into a variable called CST in the { HOME SPARCOM NAV48D } directory:

{ WAY1 }

Now run NAV48 and execute the DREC program from the PILOT menu again. As before press [ATTN] once to clear the display but, rather than typing in "WAY1", press [CST] on the calculator's keyboard. You will see a single menu key WAY1. Press this menu key to put WAY1 on the screen. Press [ENTER] to input the waypoint as the dead reckoning position.

Another useful thing to put in the CST list is "_ft" which allows easy entry of the feet unit if you measure your height of eye in feet. Exit NAV48 and add "_ft" to the CST list in the {HOME SPARCOM NAV48D} directory. Your CST variable now looks like

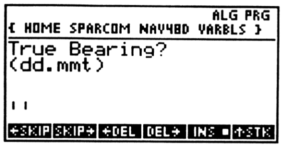
{ WAY1 "_ft" }

Note that the quotes must be present around the feet unit. Now run NAV48 again and press [INIT]. Press [IX/HT] to enter the index error and the height of eye. Suppose our height of eye is 9 feet. Erase the default height of eye and type 9 CST _FT to enter 9_ft at the height prompt. Another useful unit to put in the CST variable is "_h" which is often used in the ADV program to indicate a "distance" in hours rather than nautical miles.

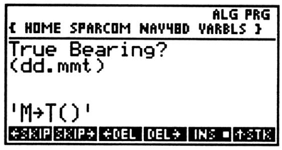
Other useful program names to enter in the custom menu are M→T and RUN (see NAV48 manual):

{ M→T RUN WAY1 "_ft" "_h"}

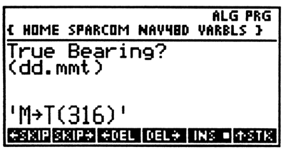
As an example, input a bearing of 316 magnetic into the BRH program. To access M→T which converts the bearing from magnetic to true, press ['] to get

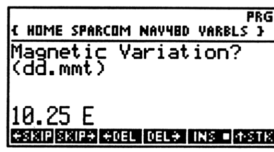


Press CST and then M→T to get



Finally, add the magnetic bearing and press ENTER.





etc.

Using a Larger PICT

Page 9-132: Add "Using a Larger PICT" as a new section in Chapter 9.

The size of the plotting window used in the HP48 is adjustable. You can use a larger window than the physical size of the screen in PLOT if you desire. This uses up some of your memory, though, so don't make the window too big. Use the PDIM command (built in to the HP 48) to set the size of the window. The default is 131 by 64, the physical size of the display. For example, suppose you want to make the display 150 by 100. Enter the following on the stack OUTSIDE of NAV48.

```
2: # 150d
1: # 100d
```

Execute PDIM.

Now, when you run NAV48 and then PLOT, you can move the cursor "off the edge" of the display to force the displayed window to scroll. This way, you can see more of the plot if you desire.

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