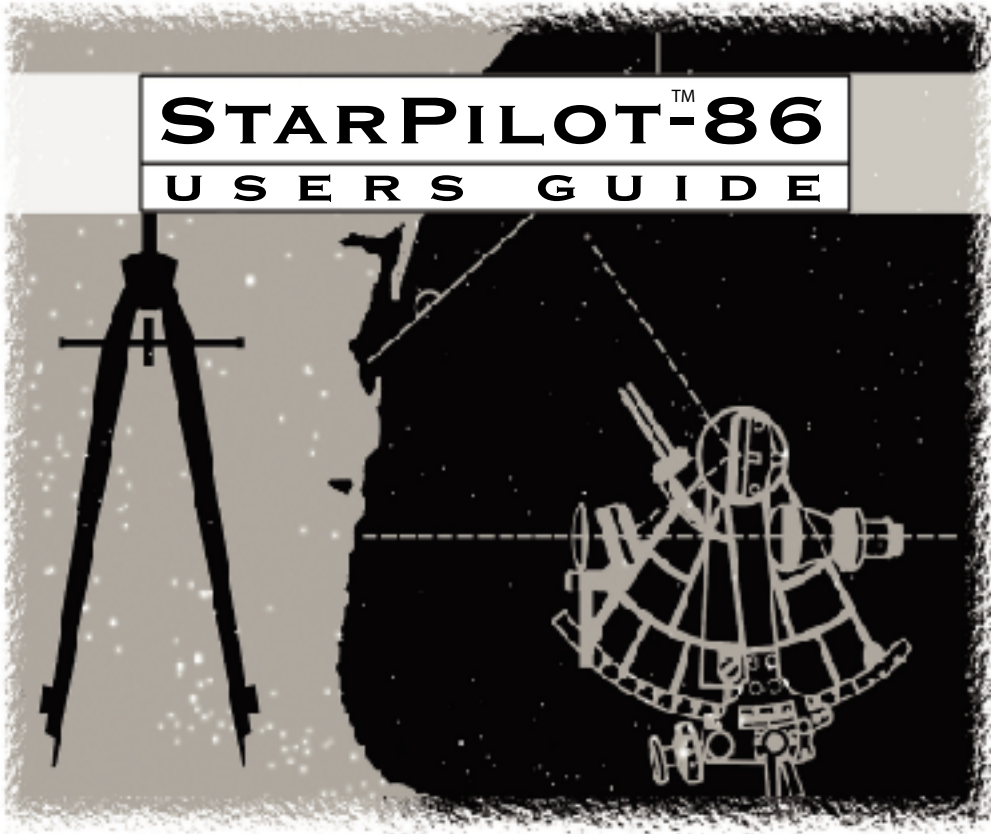
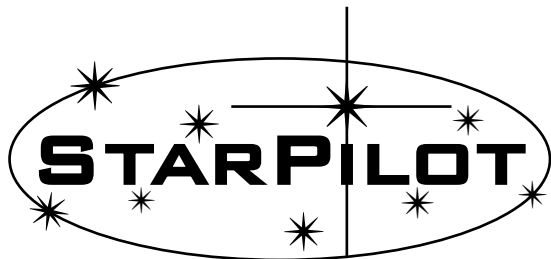
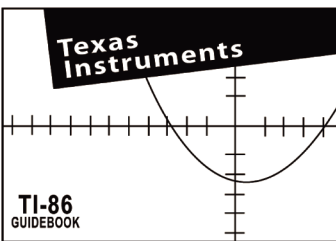


# STARPILOT™ USERS GUIDE



September 25, 2003

TI CALCULATOR MANUALS  
INCLUDED ON CD



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## QUICK START INSTRUCTIONS

This User's Guide is specific to the StarPilot-86 (SP-86) and closely resembles the version of the documents created for the calculator based product StarPilot-89 (SP-89) and PC based StarPilot-PC (SP-PC). If you are familiar with the workings of SP-PC or SP-89 then you will feel right at home with SP-86. If you are new to the product line then you will find SP-86 intuitive and easy to use.

The quick start instructions are intended to get users familiar with celestial navigation and the "StarPilot" approach to navigation off to a running start. If you are new to celestial navigation you may consider reading the manual starting at the "Introduction" found in the next section. Many examples and additional documentation for StarPilot can be found at our web site. Please visit the StarPilot home page at [www.starpilotllc.com](http://www.starpilotllc.com) for a detailed discussions on many celestial topics.

We at StarPilot are proud to bring this product to you and feel confident you will find StarPilot an invaluable navigational tool.

### Menu Structure...

In this manual, we indicate keys with square brackets with the key label inside, ie [ENTER] is the Enter key, bottom right of the keyboard.

The screen below is the **main menu** or **index**

```

**StarPilot**
1 Settings...
2 Cel Bodies...
3 Sight Reduction...
4 Celestial Fix...
5 Update DR
6 Utilities...
7 Off
  
```

of all StarPilot functions. This is the starting place for all operations. The back cover of the Guide shows which functions are reached from each of these. Note the cursor is on the 1. You can press [ENTER] to execute the Settings menu, or you can

press the [1] key. Likewise you can scroll down to the 3 and press [ENTER] or without scrolling press [3] to execute the Sight Reduction function. Scrolling is done with the 4 arrow keys, top right of the key board. Later in the Guide we organize all functions according to the key sequence you follow starting on this screen.

### Starting StarPilot...

In many cases just turning the calculator on with the [ON] key will lead you to the main index shown above. If it does not, then follow with the [ENTER] key, if that does not work, then [CUSTOM], [F1], [ENTER] will do it. The required operation will depend on how you exited the program or how you shut it off.

**To quit**, press [2nd] [OFF] or just put it away left on, it will go off in 2 minutes, and then the [ON] key brings you straight back to where you quit.

User defined values are entered in the **Settings** menu, item 1 on the main Index menu. There are 4 screens of settings, which we call [S1] to [S4.] To get to [S1] press the [1] key once from the main menu. To get to [S2], press [1] twice, etc. Refer to the Table of Contents to see what is entered on each Setting screen.

**Enter angles** as deg.min (d.m), i.e.

$$48.325 = 48^{\circ} 32.5'$$

N Lat & E Lon are +, S Lat & W Lon are -, entered with the (-) key bottom right of the keypad, i.e.  $122^{\circ} 14.2' W = -122.142$ . A Lat or any angle like  $12^{\circ} 5.3'$  must be entered as 12.053, the leading 0 is important.

**Enter times** as hr.minsec (h.ms), i.e.

$$12.3247 = 12h 32m 47s$$

On output they are displayed as 12:32:47. Note

that sometimes you might enter a time of 19.2100 and then see the display as 19:20:60. This is a quirk of the TI-86 that we cannot avoid.

StarPilot uses “watch time” (WT) for all events and book keeping. For celestial computations, GMT is obtained from:

$$\text{GMT} = \text{WT} + \text{WE} + \text{ZD},$$

where ZD is the zone description of the watch and WE is the watch error. If  $\text{WE} = 0$  and  $\text{ZD} = 0$ , then  $\text{WT} = \text{GMT}$  which is the same as UT or UTC. All times are 24h, i.e. 2 min and 5 sec past 2pm = 14.0205. WE and ZD are entered in the **Settings 3** menu [S3]. WE is in seconds, ZD in whole hours, + for West, -East, but we do not enter the + sign.

**SR mode** = Random means StarPilot asks for all input for each sight. With SR mode = Sequential, StarPilot will read IC, HE, Limb, and DR position from the user settings and only prompt for WT and Hs, the sextant reading. (If DR position is set to 0.0, however, it will ask for that even in Seq mode.)

All fixes are running fixes, so course and speed must be entered if underway. You will be prompted for these when needed.

**To change an input** you can use the back arrows, and then retype or use [DEL] key or [CLEAR] to take out entire entry.

**To interrupt any input sequence or on-going computation press: [ON] [F5] [ENTER].** This is equivalent to Escape [Esc] key on a computer — it is sort of like the rule for index error corrections, “If it’s on, take it off.” Here the [ON] key is your major OFF button...then you will see that [F5] = “Quit,” then when nothing shows, [ENTER] is a reasonable guess at what to do next. So if you want an instant bail out of some menu or calculation, press the [ON] key...When you press [On], the screen will show: “ERROR 06 BREAK,” but it is not an error. Just carry on.

Note that **you cannot hurt** the calculator nor the

StarPilot program in any way by randomly pressing keys. Have no fear and click away. If you get to a section or computation you want to leave, just do [ON] [F5] [ENTER]. Do not, however, get out the TI-86 manual and look up how to erase the complete memory and then do so, which requires you to twice say you want to erase the memory and then answer “yes” to “Are you sure?.”

In short, do not erase the memory. It is like reformatting the C-drive on your PC. If you do so, you have to start all over, with a new program install and a new KEY from StarPilot, LLC. Normal upgrading of the program, however, does not require a new KEY.

If you have calculator uses that require the full memory of the calculator for other applications, then it is best to get StarPilot-89 version which runs in the TI-89 calculator. The 89 version has a permanent KEY for each calculator, so you can partially or fully remove StarPilot and then easily reinstall it using your own unique KEY. You can read the permanent 89 KEY value from Support Info option in Settings 4.

### Menu Map

A diagram showing all menus and how they are linked is shown on the back cover. Reference to this picture will be helpful as you learn your way around the program.

### Settings locations

The back cover also has a summary of the settings used. A date, for example, is stored in Settings menu 1, position 2, so we might say Date = 1-2.

### -- More --

Is displayed whenever there are multiple screens of output data. When you see a “--More--” screen simply hit the [ENTER] key to display the next screen. You will be returned to the StarPilot when all the data has been displayed.

### Old routines, new manual...

The basic computations and mathematical routines

of the StarPilot have been tested for many years now, but each each new edition of this *User's Guide* presents us with new opportunities for typos as we add new features to the program or improve its interface. If you run across typos, errors, or unclear sections, please drop us a note at [info@starpilotllc.com](mailto:info@starpilotllc.com). We will address the issue immediately, and update the online version.

### **To update to a newer version of StarPilot...**

first download the latest version from [starpilotllc.com](http://starpilotllc.com) and follow the instructions that come with it to install the new program over the top of the old... do not manually delete the program or the calculator memory — there is no need to do this for any operation of the StarPilot, and, again, there is no way to do it accidentally). Whenever you download a new version it will come with complete instructions.

### **To use the calculator for math...**

that is, to interrupt navigation routines for simple (or even complex) math computations, do:

[ON] [F5] [CLEAR]

do the math you want...

then do [CLEAR]

[CUSTOM] [F1] [ENTER],

and you are back to StarPilot.

*Important note:* If you use exit the StarPilot and use the TI calculator for non-routine calculations such as statistical analysis or plotting of graphs then it is imperative that you do a “Set Defaults” (Settings [S4][2]) upon re-entry to StarPilot. The TI statistic and plotting routines share variables with the StarPilot and you will observe syntax errors when entering data into the StarPilot unless you reset these variables to a know state using the “Set Defaults” function.

### **Where's StarPilot?**

If you can't find a StarPilot menu no matter what

key you press, then you have somehow got out of the program. No problem. Press [CUSTOM] [F1] [ENTER] and you will be back underway.

### **Tip on typos...**

StarPilot takes all positive values without a + sign and all negative values using the [ (-) ] key next to the ENTER key, do not use the [+] sign or the [-] sign that is located just above it for data input. If you do use either of these by mistake, you will get an error message saying “Error 07 syntax,” with options “Goto” [F1] or “Quit” [F5]. Here is the tip: always use [F1] GoTo option to correct this. That will simply take you back to where you were and you can fix it. The Quit option forces you to start the whole routine over again.

### **Abbreviations**

During the operation of StarPilot you will notice the use of many strange abbreviations. These abbreviations, unfortunately, are caused by the TI-86's limited screen width which only permits the use of a maximum of 22 characters.

### **Quick Start Examples**

---

#### **Date input for Sight Reductions and Fixes**

Earlier versions of the program assumed that celestial fixes were made from data on the same date, since we assumed most users would choose to use the optional Zone Description input and thus be using effectively local time for the sights. In practice this is still the most convenient means of sight reduction since you can as well store the Watch Error and thus correct all sight times automatically at the input.

Some users, however, prefer to record and analyze all sights using only GMT. In these cases we must be careful about the date since it could change or not change within a series of sights or during a long running fix depending on our longitude. To

accommodate this approach, we now store the date of each sight reduction along with the other data, which means that unless the date is stored in the settings, it will be requested at each sight reduction and again when computing a fix from that set of sights. The example below will illustrate the modification. You may prefer to read through the rest of the Guide before going over this example.

### Example of Running fix using GMT and date

Sight 1.

22h 05m 10s on Apr 14, 2000 GMT, DR = 40° 58'N, 135° 20' W, S = 8.0 kts, C = 225 T, lower limb sun Hs = 55° 31.2', HE = 9 ft, IC = 1.5' On.

Sight 2.

01h 36m 02s on Apr 15, 2000 GMT, DR = 40° 38'N, 135° 46' W, S = 8.0 kts, C = 225 T, lower limb sun Hs = 22° 36.2', HE = 9 ft, IC = 1.5' On.

### Solution:

(1) First **Set defaults** using [S4] [2], so all start the same way, ie from **main index** screen, press key [1] 4 times, then key [2]. The main things we have done here is set all date info to 0 so it will ask for these each time, and it has set ZD = 0 so we are using GMT, and it has set SR mode to Random so it will ask for HE, IC, and limb each time. Then go back to the main index.

(2) From main index, press [3] for Sight Reduction, then [1] for sun. Then input the data from sight 1 as shown below:

```

**StarPilot**
1 Settings...
2 Cel Bodies...
3 Sight Reduction...
4 Celestial Fix...
5 Update DR
6 Utilities...
7 Off
Month?4
Year?2000
Lat?40.58
Lon?-135.20
IC(Min)?-1.5
HE(ft)?9.0
LIM I=U, -1=L?-1
HS?55.312

```

```

SUN-Lower Limb
# / WT / Hs / Zn / Int (nm)
022:05:10 1
055:31.2 10
208.8 1
-4.1
--More--

```

This first sight yielded an LOP of a = 4.1' Away from 208.8, based on an assumed position equal to the DR position we entered. The a-value was valid at the time and date we entered.

Now from the **\*\*Sight Reduction\*\*** screen, select Sun again and enter the data for Sight 2, as shown:

```

Sight #2
WT?01.3602
Day?15
Month?4
Year?2000
Lat?40.38
Lon?-135.46
IC(Min)?-1.5
HE(ft)?9.0
LIM I=U, -1=L?-1
HS?22.362
Month?4
Year?2000
Lat?40.38
Lon?-135.46
IC(Min)?-1.5
HE(ft)?9.0
LIM I=U, -1=L?-1
HS?22.362

```

```

SUN-Lower Limb
# / WT / Hs / Zn / Int (nm)
001:36:02 2
022:36.2 1
263.2 1
-5.9
--More--

```

Which is an LOP of 5.9' Away from 263.2, again based on the DR position and time we entered. To get a fix from these, we must now advance the first to the second with the course and speed. This is done from [6] on the **\*\*Sight Reduction\*\*** screen or from the **\*\*Celestial Fix\*\*** screen, which you get to from [4] on the main index (**\*\*StarPilot\*\***). From the **\*\*Celestial Fix\*\*** screen choose [2] Fix by Computation -- this implements a running fix according to a US Naval Observatory formula.

The calculator will first ask for a DR position. It does not matter which you use, but generally one would choose the DR position that corresponds to the Fix time that you will be asked for since these two positions are automatically compared at the end of the computation. A fix time rounded off to something near the time of the last LOP might be reasonable (ie 0136 GMT on 4/15/00). The input and results are as follows:

DR Position	Lat/Lon/R(nm)/Brng(T)
Lat?40.38	040°39.5'
Lon?-135.46	-135°38.4'
Speed(kt)?8.0	5.95
Fix Time(h.ms),	075.0
WT?01.36	Upd DR(1=Y,0=N)?
Day?15	
Month?4	

The running fix is at 40° 39.5'N, 135° 38.4'W. From the entered DR position, you would get to this fix by traveling 5.95 miles in direction 075T, that is how much the DR was off. Upd DR question means do you want StarPilot to put this last fix position into the stored DR location for further use.

### How StarPilot handles dates

Several functions in StarPilot use date as an input. Sight reduction and Celestial fix are two of them. It is important to keep in mind how StarPilot handles dates. If there are any values other than zero stored in any component of the date (day, month, or year) then it will read that value when executing a date sensitive function rather than ask for it. For example, in the previous exercise, had we stored 2000 in the year and 4 in the month, it would have asked only for the day on each sight and fix. This is a very convenient option, but we must remember how it works to avoid errors.

Alternatively, you can choose to leave day, month, and year set to 0 and then StarPilot will ask for these at every stage of every sight and fix. Practice with the various modes in various circumstances will lead you to the best choice for the job.

### How StarPilot handles DR positions

As with the date input mentioned just above, several functions in StarPilot use DR position as an input, and it is equally important to keep in mind how StarPilot handles this data if stored. If there are any values other than zero stored in DR Lat or DR Lon, then StarPilot will read that value when executing a function that needs it rather than ask for it. Like the date handling, this offers very convenient time-saving options, especially since the

DR position can be updated internally with other programs, but we must keep in mind how it works to be sure we are doing what we think we are.

Illustrations of the use of the feature are shown below (redoing the same running fix as before), but remember you can shut off this automatic reading anytime by simply entering zeros into the DR position or by executing Set Defaults which does the same.

### How StarPilot handles Times

StarPilot performs all time functions using “Watch Time” (WT) which differs from GMT by a Watch Error and a Zone Description:  $GMT = WT \pm WE + ZD$ . These two offsets from GMT, or UT as it is now called, are entered in setting 3-5. Set Defaults puts both of these equal to zero so that  $WT = GMT$ . If you have a ZD other than zero set, then many of the time-dependent answers will be labeled as being valid at, for example, GMT-8 for times in PST or  $ZD = +8$ . If you prefer GMT only, then set defaults and leave ZD and WE = 0.

### How StarPilot handles IC, HE, Limb

These data are primarily used in sight reductions. You have two options for entering these sight data: store them in the settings and always use the stored values, or choose to input them each time for each sight. For routine sights underway, the former is clearly better, but for practice doing examples or problems from a text book, the latter method is likely better. You choose which you want with the “SR mode,” that is, sight reduction mode. It is set in [S2] [5]. SR = Random means enter them every sight, SR = Sequential means read them from the settings... which also, of course, means you must enter them there first. All of these shortcut options are illustrated in the next example.

### Same running fix using local or other time zone and other shortcuts.

Suppose in the last example we kept all clocks set to  $ZD = +7$  corresponding to PDT as we sailed across.

Now we work the same set of sights using this option, plus a couple other shortcuts.

### Sight 1.

15h 05m 10s on Apr 14, 2000 (ZD=7), DR = 40° 58'N, 135° 20'W, S = 8.0 kts, C = 225 T, lower limb sun Hs = 55° 31.2', HE = 9 ft, IC = 1.5' On, WE = 0.

### Sight 2.

18h 36m 02s on Apr 14, 2000 (ZD=7), lower limb sun Hs = 22° 36.2', HE = 9 ft, IC = 1.5' On, WE = 0. Note we have Watch error = 0 and we do not yet know the DR at the second sight, but course and speed are the same.

Set defaults (setting 4-2), then at [S3] [5], enter ZD = 7 and WE = 0. Also go to [S2] [5], set SR mode = Seq, then at [S2] [2], [3], [4] set IC = -1.5', HE = 9.0 ft, limb = -1. Then set the date in [S1] [2], as day = 14, month = 4, year = 2000.

Then in [S3] [1] set DR Lat = 40.58 and DR Lon = -135.20. Then go to [S4] [5] and set DR mode = Speed, which will ask for DR time = 15.0510, Course = 225, and Speed = 8.0. Now check with setting 1-6, to verify that all is set right:

```
DR Lat/Lon      040°58.0'
                -135°20.0'
Dest Lat/Lon    000°00.0'
                000°00.0'
SR mode SEQUENTIAL
PC mode NORMAL
DR mode SPEED
DIP mode NORMAL
Times in GMT -7
Watch err= 000:00:00
Max sights= 15
```

```
Limb LOWER
Temp(F)= 50
Pres(mb)= 1010
Mag Var= 000°00.0'
IC= -000°01.5'
HE(ft)= 9
(D/M/Y)= (14/4 /2000)
Hc Min/Max/# Cutoff 000°00.0'
                       090°00.0'
Course(T)= 225.0°
Speed(kt)= 8
DR Time= 015:05:10
```

Which is what we wanted.

Then do the first sight reduction, but note you will only be asked for the time and Hs and then will get the same LOP

```
**StarPilot**
1 Settings...
2 Cel Bodies...
3 Sight Reduction...
4 Celestial Fix...
5 Update DR
6 Utilities...
7 Off

**Sight Reduction**
1 Sun
2 Star
3 Moon
4 Planet...
5 Delete a Sight
6 Celestial Fix...
7 Return
```

```
Sight #1
WT?15.0510
HS?55.312

SUN-Lower Limb
#/WT/Hs/Zn/Int(nm)
                                1
                                015:05:10
                                055°31.2'
                                208.8°
                                -4.1
--More--
```

Now go to the main index and select [5] Update DR, and enter time of second sight

```
**StarPilot**
1 Settings...
2 Cel Bodies...
3 Sight Reduction...
4 Celestial Fix...
5 Update DR
6 Utilities...
7 Off

New DR Time,
(h.ms)?18.3602
```

```
DR Lat/Lon      040°38.1'
                -135°46.2'
RL Crs(T)/Dist(nm) 225.0°
                  28.12
Upd DR<1=Y,0=N)?1
Upd C/S<1=Y,0=N)?0
```

The "1" stored the

new DR

Now we can do the second sight.

```
Sight #2
WT?18.3602
HS?22.362

SUN-Lower Limb
#/WT/Hs/Zn/Int(nm)
                                2
                                018:36:02
                                022°36.2'
                                263.2°
                                -6
--More--
```

which is the same LOP we got before (very slightly different since we have a slightly different DR). Now do Celestial Fix option [2]

```
Speed(kt)?8.0
Fix Time(h.ms),
WT?18.36
Course(T)?225

**Celestial Fix**
1 Review Sights
2 Fix by Computation
3 Sight Analyzer
4 Fix by Plotting
5 Delete a Sight
6 New Seq (Del ALL)
7 Return
```

and the answer is same as before:

```
Lat/Lon/R(nm)/Brg(T)
040°39.5'
-135°38.4'
6.04
076.4°
Upd DR<1=Y,0=N)?
```

The logical next step is accept the offer to update the DR and then carry on with the navigation. The running fix is complete.

This illustration of using stored values is not so much shorter in this particular example, but note we have only 2 sights here. Normally you would have (or should have) 4 or 5 sun sights at each sight session, and then this method is very much quicker. Note, too, how the DR function is incorporated into the sight routine automatically, and we do not have to re-enter that position. We could also update the DR using log settings (set DR mode = log).

We could also have updated the DR after a series of course and speed changes if these had been made between the two sets of sights, but if that were the case, then when doing the fix itself, one should use the speed *made good* and course *made good* between sight sessions when “course” and “speed” are asked for.

## INTRODUCTION

### Disclaimer

This sight reduction procedure is provided to the sailing community on an AS IS basis. No warranty of any kind, including MERCHANTABILITY or FITNESS FOR PURPOSE, is made with regard to this software. Although the author has made every effort to comply with equations and methods described in the explanation section of the Nautical Almanac and other sources, no guarantees are made concerning the accuracy of this sight reduction procedure. The author or StarPilot, LLC, or any of their agents or resellers shall not be liable for any errors or for incidental or consequential damages in connection with the furnishing, performance, or use of this software. Please use this product at your own risk.

### Features

The StarPilot software described here is intended

to run on a TI-86 programmable calculator. This product computes altitude, azimuth and intercept for Sun, Moon, Planets and Stars sights using an internal perpetual almanac in addition to providing a complete suite of navigational functions.

The TI-86 calculator has an 8 row by 22 column graphics display, 96 Kbytes of RAM, and fast processing power. It comes with a durable plastic cover and runs on 4 AAA batteries and a lithium CR1620 memory backup battery. The calculator consumes very little power. See battery notes later in this section.

The calculator has a manual of its own which covers more mathematical use of the calculator and how to program it. We include a copy of this manual in pdf format on the StarPilot CD. For navigation applications, however, you should not need any extra information from that large book. We are only using a few keys for the StarPilot application, all menu driven. If you do look at that book, do not follow the recommendation they give for erasing the memory. If you follow those very explicit instructions you can indeed erase the StarPilot from the calculator and then will need to contact StarPilot, LLC for another Installation.

### Installing StarPilot

StarPilot as delivered by StarPilot, LLC loaded into a TI-86 calculator comes fully functional, no further installation or programming is required. If, however, you already own a TI-86 and have chosen to purchase the software-only option for StarPilot or you are upgrading your StarPilot to the latest version then you will need to follow the installation procedure provided with the software.

The procedure is slightly different for PCs and for Macs, but full details are available with the software products — either online when downloading or on the StarPilot CD when purchased in that version. Please refer those instructions for installation.

When you first install StarPilot, you should see the screen below,

```
To enable StarPilot
contact Starpath
for activation key.
█
```

Press enter, then see:

```
Code #10341
Key? █
```

Here is where you enter the KEY you obtained from StarPilot, LLC. Note **this step is not required** for upgrading your software or for reinstalling it if you have loaded another program into the TI-86.

If there are any questions about this, please contact StarPilot, LLC at [info@starpilotllc.com](mailto:info@starpilotllc.com) or 865-379-8723 or by fax at 865-681-5017.

## Data Representation

Periodically StarPilot will prompt you for data such as the time of a sight, DR latitude or longitude, GHA, SHA, and Declination. The format used to enter these and other values depends on the type of data to be entered.

All time values are entered in hour-minute-second (h.ms) format. This is accomplished by entering the time values as numbers in the following format hh.mmss where the hh corresponds to hour portion of the time and the .mmss correspond to the minutes and seconds. Note that 2 digits must be used to represent each of the minutes (mm) and seconds (ss) fields. For example the time corresponding to 15h 5m 42s is entered as 15.0542.

On the other hand, times are displayed in the hh:mm:ss format. For example, a time entered as 17.0822 would then be displayed as 17:08:22, and the various times computed by StarPilot are displayed in that format.

Compass bearings, courses, and heading data are entered in ddd.d format. That is, three digits and a

decimal — the decimal is optional. Leading zeros (ie 090) are optional but recommended.

Sextant altitude (Hs), latitude, longitude, GHA, SHA, and declination (DEC) values are entered in ddd.mmm format, which we abbreviate as “d.m” format. For example the value 34° 55.2' is entered as 34.552, 34° 5.1' as 34.051, and 35° 0.6' as 35.006.

Index Correction (IC) is entered as decimal minutes (mm.m) format, i.e. an index error of -3.3' is entered as -3.3. When entering IC, values should have a minus (-) for “on the scale” errors and no sign (i.e. implicit +) for “off” errors. Horizontal Parallax (HP) and Additional Planet Correction (PCORR), used in some specialized applications, are also entered as mm.m.

Resultant data, such as computed altitude (Hc), azimuth (Zn), and time, are also displayed in d.m format. Unlike the data entry format above, you will see results displayed as nnn° nn.n'. All resultant values are displayed in this format with a few exceptions such as the intercept which is displayed in nautical miles (nm).

The following sign conventions apply when entering data. Positive values for LAT, DEC and LON are entered for North and East. Negative values for LAT, DEC and LON are entered for South and West. A positive intercept is considered to be TOWARDS the sighted body while a negative intercept value is considered to be AWAY. When computing latitude by the Sun’s meridian passage, observed altitudes facing south are entered as negative while north-facing observations must be entered as positive.

**Note, however, that we do not use the “+” sign for entering positive numbers.** Values entered into the calculator are assumed to be positive unless a “-” is entered before the value. Entering a “+” will cause an error.

Likewise, **do not use the subtraction sign “-”** (i.e.

the [-] key above [+] ) for negative values. This too will cause an error. When entering negative values you must use the [-] key immediately to the left of the [ENTER] key.

The year of an event should always be entered in full 4-digit format 1998, not 98. Valid values for day are 1 through 31, and 1 through 12 for month. StarPilot will happily complete sight reductions for the year 98 AD, without blinking, so be sure to use the full date you want. Other than that obvious caution, there are no so-called Y2K concerns with this product.

## StarPilot Operation

StarPilot is based on a TI-86 scientific/graphing programmable calculator and as such can be used as a general purpose calculator in addition to providing many navigational features. If you purchased the program installed, it will be active when you get it. Just turn the calculator on to see the main **Index** menu, labeled **\*\* StarPilot\*\***.

To start the program after an upgrade or new installation, press the [PRGM] key followed by [F1] key twice, then [ENTER]. Subsequently, you can start StarPilot with the [ON] then [ENTER] key or with the [CUSTOM] [F1], as explained in the quick start instructions.

You will see the following screen after successfully starting the StarPilot application.

```

**StarPilot**
1 Settings...
2 Cel Bodies...
3 Sight Reduction...
4 Celestial Fix...
5 Update DR
6 Utilities...
7 Off
  
```

All StarPilot functions are accessible via menus. After starting, StarPilot displays its main menu. Each StarPilot menu consists of a menu title followed by a number and a description. To execute the desired function simply press the numeric key which corresponds to the desired action or use the

arrow keys to highlight the action followed by the [ENTER] key.

To shut off StarPilot from the main Index menu, press [7] or push the [EXIT] key. To shut down from elsewhere in the program, do [2nd] [OFF] — if you do this in the middle of a computation, you may have to do it again. Alternatively, you can just set StarPilot aside when done. It will happily go off on its own in 2 minutes, and using this method as standard procedure will have no significant effect on battery life.

Data entered is not lost when you exit the program. Information from completed sights and your preferred settings are maintained for later use even if you turn the calculator off. The second and third mode of exiting the application are particularly useful if you decide to abandon a sight before completing it. Sight information is stored in memory only after a sight reduction sequence has been completed. Quitting the application during a sight reduction will discard all sight parameters specific to the current sight in progress, but not affect information from sights previously completed.

Executing [ENTER] immediately after terminating the program by one of the above methods will instantly re-start the program.

The [EXIT] key can be used at any time to cause a return action. Pressing [EXIT] at the StarPilot Index menu will shut the calculator off, while pressing [EXIT] in a sub-menu will cause the program to return to the previous menu.

Periodically StarPilot will prompt you for a numeric value such as the time of a sight. Enter the necessary value by typing its numeric equivalent in the corresponding entry format followed by [ENTER] (Section 4). Values entered may be corrected at any time prior to the execution of [ENTER]. To totally reenter a value depress the [CLEAR] button. To correct a specific digit or to partially correct a num-

ber use the arrow keys to position the cursor followed by the correct value. The [DEL] key may be used to eliminate unwanted digits at the cursor and the [2nd][INS] key sequence will insert characters at the cursor position without overwriting existing data. Please refer to the data entry portion of your calculator manual for more information on entering data.

## Resetting Factory Defaults

At times it may be desirable to reset your calculator to a known state. This can easily be accomplished using the following procedure. Later in this Guide we will refer to this sequence as [S4] [2], meaning it is the second option on the 4th settings screen.

1. Turn your calculator on and start StarPilot.
2. Press [ENTER] or the [1] key to get:

```

**StarPilot**
1 Settings...
2 Cel Bodies...
3 Sight Reduction...
4 Celestial Fix...
5 Update DR
6 Utilities...
7 Off

**Settings 1**
1 More Settings...
2 Date
3 DR Lat/Lon
4 Dest Lat/Lon
5 Course/Speed
6 View Settings
7 Return
  
```

3. Repeat twice more to get to:

```

**Settings 4**
1 Index
2 Set Defaults
3 Units
4 Mag Variation
5 DR Mode
6 Support Info
7 Return
  
```

4. Then scroll to 2 and [ENTER] or just press the [2] key and that will reset the calculator to defaults and show this screen:

```

Setting defaults
Date cleared
Sight sea cleared
DR pos cleared
Dest pos cleared
Initiating equations
--More--
  
```

There are many optional settings in the StarPilot so you may want to use this process at some point to get reoriented. See section [4] [2] for details, including a complete list of the specific values of the default settings.

## The [Custom] Menu

Pressing the [CUSTOM] key will cause the calculator to display a menu at the bottom of the screen allowing access to StarPilot's 15 most commonly used functions. The [CUSTOM] button may be pressed anytime regardless of whether StarPilot is running or not. After turning the calculator on or while running StarPilot, pressing the [CUSTOM] button will display the first 5 of 15 options. Then pressing the [F4] key, for example, will take you directly to the function that updates your DR position.

If StarPilot does not go directly to the selected function after pressing the selected key, it will instead print the name of the function you selected. At that point, press [ENTER] to go there. This different behavior is a result of executing the [CUSTOM] option from either within or outside of the StarPilot program.

Pressing the [MORE] key causes additional menu items to be displayed in groups of 5 entries. Once the selected action has completed the calculator returns to the state it was in prior to the execution of the function.

The [CUSTOM] key is a short cut to some StarPilot functions, such as Time, Speed, and Distance (TSD). All [CUSTOM] menu entries and their actions are documented below.

The following is a listing of the 15 options available through the Custom menu when executed from within StarPilot. (If you execute it from outside the program, you get **Piloting** as the last option.)

### [Custom]

#### [F1] Index

Invokes the StarPilot application.

#### [F2] View

View user settings.

#### [F3] CandS

Set Course and Speed

**[F4] DR**

Update DR.

**[F5] TSD**

Time, Speed, Distance calculator.

**[More]**

**[F1] Srise**

Sun rise, set, equ of time, LAN, Hs max.

**[F2] Plan**

Graphical sight planner.

**[F3] ID**

Star/Planet identification.

**[F4] Time**

Time calculator.

**[F5] Ang**

Angle calculator.

**[More]**

**[F1] DR pos**

Enter a new DR position.

**[F2] Dest**

Enter destination position.

**[F3] RLGC**

Rhumb line and Great circle computation.

**[F4] Curr**

Current sailings.

**[F5] Exit**

Closes the Custom menu display. (Exit will not appear if you have entered the custom menu from outside of StarPilot.)

## The “— More —” Scroller

After completing a computation or when presenting a sequence of data to the user, StarPilot clears the screen, prints the requested data and then prompts the user for some action by printing “— More—” at the bottom of the screen. For example, After computing a sun sight, StarPilot might display

```
SUN-Lower Limb
#/WT/Hs/Zn/Int(nm)
015:35:42 1
054°58.8' 1
214.3 2
9.5 3
--More--
```

In the simple case where only one screen of data is presented, hitting any of the key sequences listed below will clear the screen and return to the previous menu. In the case where multiple screens of data are displayed, the desired actions can be executed by selecting the appropriate key sequence. The following list describes the supported key sequences.

[ENTER] = Display the next screen of data or return to previous menu if displaying the last screen in a sequence.

[EXIT] = Return to calling menu.

[DEL] = When displaying a sequence of sights stored in memory, delete the one being displayed.

[2nd][QUIT] = Exit the application.

**NOTE** When viewing the Star List or Reviewing sights or when Viewing settings (each of which has several screens of data), the up and down arrows let you go forward and backward through the list.

## About batteries

The TI-86 uses 4 AAA batteries. New ones will last about 1 year, and as they get weaker the contrast will fade and require increasing with the [2nd] [up arrow] key, which after you push it shows briefly the contrast level in the top right corner of the screen. At a contrast level of about 8, the calculator will announce that batteries are low and need to be replaced. At that point, you typically have about 1 to 2 weeks of usage. Eventually, the calculator goes off and will not come on till the batteries have been replaced.

No program information or user settings will be lost if the AAA batteries go dead, as there is an internal

backup Li battery that will last up to 5 years, although it would be best to replace it every 3 or 4 years.

When changing the Li back up battery, be sure that you have a good set of 4 AAA batteries in the TI-86. The AAAs protect the system during the time you change the Li battery (CR1616 or CR1620)

Note the calculator will not run on the Li battery alone; it is intended only as backup while the AAA's are replaced. The AAAs can be dead or out of the machine for an extended period with no effect on the memory or program.

The batteries are fresh when shipped from StarPilot, LLC. For convenience, we recommend that users write the replacement date or due date on a piece of paper or label and attach it to the calculator or its housing.

## Contrast adjustments

To increase the contrast, do [2nd] [up arrow] and to decrease it do [2nd] [down arrow]. A number will briefly appear in top right of the screen. It varies from 1 to 9. With new batteries the screen will be solid black at about 4 or 5, and you will typically start with a setting of 1 or 2. When this gets to about 7 or 8, ie the screen is faint enough that you adjust it that high to see clearly, then you will start getting notices to change the 4 AAA batteries... but you will still have weeks of normal usage after that.

## ===== FUNCTIONS =====

### ORGANIZED BY KEY STROKES

In the following, each function of the program is described in order of its keyboard access, starting from the main menu screen above.

## [1] \*\* Settings 1\*\*

StarPilot stores a number of user defined options that makes sight reduction and DR more convenient. Access the list of settings from the key [1] option on the main index which takes you to the first of 4 pages of settings, which we call S1 to S4.

<pre> **Settings 1** 1 More Settings... 2 Date 3 DR Lat/Lon 4 Dest Lat/Lon 5 Course/Speed 6 View Settings 7 Return </pre>	<pre> **Settings 2** 1 More Settings... 2 Index Corr(IC) 3 Eye Height(HE) 4 Limb 5 SR Mode 6 PC Mode 7 Return </pre>
---	--

<pre> **Settings 3** 1 More Settings... 2 Temp/Press 3 Dip Mode 4 Hc Min/Max/#Cutoff 5 UT Offsets(ZD/WE) 6 Max Sight # 7 Return </pre>	<pre> **Settings 4** 1 Index 2 Set Defaults 3 Units 4 Mag Variation 5 DR Mode 6 Support Info 7 Return </pre>
--	--

The first option in Settings 1 is to go on to Settings 2 (More Settings), so we start each discussion with the second item which we would call [S1] [2], the Date, and so forth.

## [S1] [2] Date

The date is used to identify celestial sight times as well as the current DR position, and for sight planning. The date to enter is the date on your watch that you are using for the sight times. If using GMT time, use GMT date, and if local time, use local date.

<pre> **Settings 1** 1 More Settings... 2 Date 3 DR Lat/Lon 4 Dest Lat/Lon 5 Course/Speed 6 View Settings 7 Return </pre>	<pre> Day?10 Month?9 Year?1996 </pre>
---	---------------------------------------

## [S1] [3] DR Lat / Lon

<pre> **Settings 1** 1 More Settings... 2 Date 3 DR Lat/Lon 4 Dest Lat/Lon 5 Course/Speed 6 View Settings 7 Return </pre>	<pre> Lat?34.55 Lon?-35.50 </pre>
---	-----------------------------------

The stored date and DR position will be assumed as the current date and DR position in all calcula-

tions and StarPilot will therefore stop prompting the user for these values. Executing a factory reset ([S4] [2]) or manually resetting the date or DR position to 0 will cause the program to start prompting for the corresponding values once again.

**[S1] [4] Dest Lat / Lon**

This position is used for routing sailing computations. It can be very convenient to have it stored to save entering it for every computation.

**[S1] [5] Course / Speed (CandS)**

The **Course/Speed** entry in the **Settings 1** menu is used to set the vessel's Course and Speed needed for the DR function. When first invoked the procedure will prompt for a DR mode. The function then proceeds to prompt for C and S in speed mode or just C only when in log mode. In the [CUSTOM] menu, this function is called **CandS**.

The course will be requested with a (T) or (M) for true or magnetic depending on whether or not the magnetic variation has been set to a non-zero value in [S4] [4]. By definition, a zero variation is a true course. You can change this back and forth as you see fit.

```

**Settings 1**
1 More Settings...
2 Date
3 DR Lat/Lon
4 Dest Lat/Lon
5 Course/Speed
6 View Settings
7 Return
    
```

```

Course(T)?125
Speed(kt)?5.8
    
```

These values of C and S are used automatically for DR updates, but when it comes time to evaluate a running fix, you will be asked to enter these for each fix so you are certain that the proper values are entered for the fix computation. In principle you could be doing a routine DR computation with one set of values, but then want to use some effective CMG or SMG for evaluating sights with course changes made during the sight sequence. (The Traverse table function [6] [3] [3] is a convenient way to figure CMG over a series of course changes.)

**[S1] [6] View Settings**

This option steps you through the full list of all settings followed by a list of all sights stored in the program. use the [Enter] key to advance the pages. Since it is the DR position that might be checked most often, it is listed first. If that is all you need, just press [Exit] after you see it and you can go back to other functions. For quick reference, the sequence of items presented in the View Settings option is shown on the menu map on the back cover of this booklet.

Here is an example of what you might see when there is 3 sights stored in the calculator -- these are from the Sight Reduction examples presented in section [3]

```

**Settings 1**
1 More Settings...
2 Date
3 DR Lat/Lon
4 Dest Lat/Lon
5 Course/Speed
6 View Settings
7 Return
    
```

```

DR Lat/Lon  034°55.0'
Date        -035°50.0'
Dest Lat/Lon 000°00.0'
Course/Speed 000°00.0'
--More--
    
```

```

SR mode SEQUENTIAL
PC mode NORMAL
DR mode OFF
Dip mode NORMAL
Times in GMT-0
Watch err= 000:00:00
Max sights= 15
--More--
    
```

```

Limb LOWER
Temp(F)= 50
Pres(mb)= 1010
Mag Var= 000°00.0'
IC= 000°02.5'
HE(ft)= 10
<D/M/Y>= (10/9 /1996)
--More--
    
```

```

Hc Min/Max/# Cutoff
000°00.0'
090°00.0'
20
--More--
    
```

```

SUN-Lower Limb
#/GMT-0 /Hs/Zn/Int
1
015:35:42
054°50.8'
214.3°
9.5
--More--
    
```

```

12: CAPELLA 0.2
#/GMT-0 /Hs/Zn/Int
2
007:11:21
036°14.0'
300.8°
-18.5
--More--
    
```

```

5: JUPITER 0
#/GMT-0 /Hs/Zn/Int
3
021:07:26
031°36.0'
171.3°
-4.2
--More--
    
```

```

MOON-Lower Limb
#/GMT-0 /Hs/Zn/Int
4
010:01:04
033°39.3'
079.9°
-12.4
--More--
    
```

...and so forth, till all

sights stored in a sequence are displayed.

**Note and Caution:** pressing the [DEL] key while a particular sight is displayed will delete that sight from the sequence. This can be a convenient way to remove bad sights as they are discovered. See more discussion of removing sights in [4] [5].

## [1] [1] \* \* Settings 2 \* \*

```

***Settings 2***
1 More Settings...
2 Index Corr(IC)
3 Eye Height(HE)
4 Limb
5 SR Mode
6 PC Mode
7 Return
  
```

### [S2] [2] Index Correction (IC)

Enter the IC in minutes of angle, positive when OFF the scale, and negative when ON the save, ie -2.5. Use the gray [ (-) ] key for this, not the black [ - ] one. The stored IC is used in sight reductions without prompting when in SR mode = Sequential (see [S2] [5] below), but if SR mode = Random, it will be asked for on each sight, regardless of this setting.

### [S2] [3] Height of Eye (HE)

The height of eye is entered in feet or meters depending on how you selected the units in [S4] [3]. See discussion of SR mode [S2] [5] below.

### [S2] [4] Limb

The default limb for sun and moon sights is stored here. Normally this would be the Lower Limb.

```

***Settings 2***
1 More Settings...
2 Index Corr(IC)
3 Eye Height(HE)
4 Limb
5 SR Mode
6 PC Mode
7 Return
  
```

Note that instead of -1 or 1 you can also enter 0 here and compute to the center of the body if you have use for that information. This option can be used for some artificial horizon sights where the direct and reflected images are superimposed in the sextant.

Naturally, if you have Lower limb stored here and then choose to do an upper limb sight, then this setting must be changed for that sight... or switch to SR mode = sequential and StarPilot will ask for this value on each sight.

### [S2] [5] SR Mode

SR Mode stands for Sight Reduction Mode. It can be set in this option to be either “Random” or “Sequential.” Choose random mode when working problems that are not related to each other (ie different dates, places, bodies), as in text book exercises, exam preparation and so forth. In random mode, StarPilot will ask for all new inputs required for each sight reduction.

When doing sights underway, on the other hand, or doing a sequence of similar sights from the same time and place, then it is much more convenient to use “Sequential” mode. In sequential mode, the stored settings for HE, IC, Limb, and DR position will be used for each sight. Only body, WT, and Hs will be asked for.

In sequential mode it is important to verify these settings since they will be used without asking. When you switch to this mode you will be reminded of this. Check settings with [S1] [6].

Note that if the stored value of both DR Lat and Lon are zero, then they will be asked for during sight reductions, even in sequential mode.

### [S2] [6] PC Mode

StarPilot has the option to “precompute” the Hc and Zn of celestial bodies for planning or analysis. Often we have a lot of these to do, but even if just a few are needed to find the body in the sky, for example, we do not need high precision results. Since all hand held devices are relatively slow in computation, we have added this option to expedite this type of planning.

There are two modes, **Normal** and **High**. For routine precomputations, use Normal. If you want highest precision use High. For sun and stars there is essentially no difference in precision, between the two modes, but for the moon and planets, both the precision and time differences are significant. The default mode is Normal, so it is up to the user to switch this to High as needed.

Note that this option has no influence on the Sight Reduction function. That function always uses the High precision mode. These precision modes as well as the basis of the computations are discussed in the Appendix. The use of Precompute in general is discussed under [2] [4].

### [1] [1] [1] \*\* Settings 3 \*\*

```

**Settings 3**
1 More Settings...
2 Temp/Press
3 Dip Mode
4 Hc Min/Max/#Cutoff
5 UT Offsets(ZD/WE)
6 Max Sight #
7 Return
  
```

### [S3] [2] Temperature and Pressure

Temperature and pressure will be prompted for in the units specified in the units setting [S4] [3]. For example the following screen has StarPilot doing sight reductions at 77° F and 1015 millibars.

<pre> **Settings 3** 1 More Settings... 2 Temp/Press 3 Dip Mode 4 Hc Min/Max/#Cutoff 5 UT Offsets(ZD/WE) 6 Max Sight # 7 Return   </pre>	<pre> Temp(F)??? Pres(mb)?1015   </pre>
--	---

Extreme variations in temperature and pressure affects the magnitude of the atmospheric refraction correction. Valid temperature and pressure settings should be entered if low-altitude sights are to be taken in extreme conditions. StarPilot default values are 1010 millibars and 50°F — which correspond to “no additional corrections” data from the Nautical Almanac. See “Resetting StarPilot to Defaults” in [S4] [2] for additional information on StarPilot default values.

### [S3] [3] Dip Mode for Dip Short

<pre> **Settings 3** 1 More Settings... 2 Temp/Press 3 Dip Mode 4 Hc Min/Max/#Cutoff 5 UT Offsets(ZD/WE) 6 Max Sight # 7 Return   </pre>	<pre> DM(1=Short,0=Norm)?   </pre>
--	------------------------------------

“Normal” is the usual choice corresponding to typical sights using the true sea horizon, or more specifically, using the visible horizon as cut off by the actual curvature of the earth.

When using a shoreline beneath the sighted object as a horizon instead of a proper sea horizon, the dip correction must often be figured in a special manner, called “Dip Short.” This method is required whenever we are actually seeing the shoreline and not the true curvature of the earth. Dip short depends on the Height of Eye and the distance to the shoreline directly below the object sighted.

To decide if dip short is needed, compare the square root of HE in feet with the distance to the shoreline in nautical miles. If the latter is larger than the former, then you are indeed seeing the curvature of the earth cut off the shoreline and you can do sight reductions in the normal manner. If this is not the case, then you should use Dip Short (i.e. set dip mode = short), and the StarPilot will prompt you for the necessary extra input when doing sight reductions.

Dip short is very useful for sextant practice on inland waters, even rather small lakes. It is usually much better to practice this way than to use an artificial horizon. For practice, the general procedure would be to take the sights, then figure  $Z_n$  from the sight reduction, then return to the chart and from the known practice location and  $Z_n$  you can determine the necessary distance to the shoreline.

Underway dip short can also, though rarely, be of value if you happen to get close to shore but do not know where you are and the only sextant sight

is of the sun or moon over nearby land. There are various piloting techniques to figure distance off shore even without knowing where you are.

### [S3] [4] Hc Min, max, # Cutoff

Hc-min and Hc-max are used to set limiting values for the body search routines used in the Sight Planner [2] [2] and Star/Planet ID [2] [5]. Bodies with altitudes greater than Hc max and smaller than Hc min will not be displayed. The default cutoff # is 20, which means the Sight Planner will stop looking for stars and switch to planets once it has found 20 stars.... or you manually stop it with the [EXIT] key. The first 20 stars in view will always include the bright ones; larger numbers include fainter stars which clutters the screen and rarely helps with sight selection.

The default values for Hc are 0°, 90°, but for use underway, settings of 10°, 80° might be better. Lower sights have a larger uncertainty due to refraction uncertainties and sights higher are more difficult to take and require a more careful analysis.

Likewise, although 20 will usually get all the bright stars you need, sometimes their will not be enough there and you will have to go higher, but more often you can get by with a lower number maybe just 10 or so. Once you optimize this, it will typically be the same for many nights on a voyage.

### [S3] [5] UT Offsets (ZD / WE)

StarPilot navigates using “Watch Time” (WT), which is defined from:  $UT = WT + WE + ZD$ , where WE is the watch error (fast is -) and ZD is the zone description (east is -). The total UT offset (WE + ZD) is entered in this setting in two steps as shown below. UT is the same as GMT.

<pre> **Settings 3** 1 More Settings... 2 Temp/Press 3 DiP Mode 4 Hc Min/Max/#Cutoff 5 UT Offsets(ZD/WE) 6 Max Sight # 7 Return </pre>	<pre> ZD?? WE(Sec,+S,-F)?0 </pre>
--	-----------------------------------

### [S3] [6] Maximum No. of Sights

StarPilot-86 has memory enough to store up to 60 celestial sights. With this setting you can limit this maximum number, which might help with your book-keeping and prevent slowing down data review and some computations. Also note that a **Running Fix uses all stored sights**, so if you end up with more than you want in the list the results may be wrong or not optimum.

To set this option, simply type in the desired number at the prompt. By default the calculator keeps track of the last 15 sights. If a sixteenth sight is taken then the first sight in the sequence is discarded. Note that the order of the sights is important. When replacing sights it is not the oldest sight (timewise) which is discarded but the sight which was reduced the earliest. Sights are numbered in the list. With a max set to 15, when #16 is entered, #1 is discarded and #2 becomes #1, and your new one becomes #15.

### [1] [1] [1] [1] \* \* Settings 4 \* \*

```

**Settings 4**
1 Index
2 Set Defaults
3 Units
4 Mag Variation
5 DR Mode
6 Support Info
7 Return

```

### [S4] [2] Resetting Factory Defaults

This function is discussed in the INTRODUCTION. It results in the following actions.

- The internal date is cleared.
- DR Lat/Lon in memory is erased.
- Dest position in memory is cleared.
- DR mode set to OFF.
- Body limb is set to LOWER.
- Dip mode is set to NORMAL.
- Index error is set to 0.
- Height of eye is set to 0.
- Units are set to °F, mb, and ft.

- Temperature is set at 50° F.
- Pressure is set to 1010 Millibars.
- Magnetic variation set to 0.
- ZD is set to 0.
- Watch Error is set to 0.
- Course, Speed, Log each set to 0.
- Hc min/max /#cutoff set to 0°/90°/20.
- PC Mode is set to NORMAL.
- SR mode is set to RANDOM.
- Max number of sights is set to 15.
- All sights stored are cleared.

### [S4] [3] Units

Here you enter preferred units for Height, Temperature, and Pressure.

<pre> **Settings 4** 1 Index 2 Set Defaults 3 Units 4 Mag Variation 5 DR Mode 6 Support Info 7 Return </pre>	<pre> De9 1=F,0=C?1 1=in,0=mb?0 1=ft,0=m?0 </pre>
--	---

Typing 1 then [Enter] at the first question, specifies that temperatures should now be entered in Fahrenheit (not centigrade), then another question will appear and the 0 entered here means pressure in Millibars (not inches), and finally the 0 entered means use height in meters (not feet). At this point, the last [Enter] will return you to [S4] screen.

### [S4] [4] Local Magnetic Variation

StarPilot by default displays and queries bearing data in True format. Changing the default value of the magnetic variation causes the program to display and prompt for data in magnetic compass bearing format. Note that westerly variations should be entered as negative (-). Many StarPilot functions, such as the current sailings, work only in True format while others such as the star/planet finder work with either true or magnetic input. In all cases the program prompts for bearings and heading will contain a (T) for true or an (M) for magnetic depending on the state of the magnetic variation value.

<pre> **Settings 4** 1 Max Sight # 2 Set Defaults 3 Units 4 Mag Variation 5 DR Mode 6 Support Info 7 Return </pre>	<pre> Local Mag Var(d.m) W=(-)?-? </pre>
--	--

To change the default the local magnetic variation from 0° to 7° W simply execute the menu entry and enter the requested data as shown above.

### [S4] [5] Setting the DR mode

The **DR mode** determines how the **Update DR** function operates as well as several others. StarPilot has 3 DR modes: Off, Speed & Time, or Log. The default mode is “Off” which means that all functions that use course, speed, or time will prompt for the values needed to complete the computations. This is a “normal” or “non-interfaced” mode. It is simple and easy to use, but not the most efficient.

The Speed and Time mode (abbreviated Speed) assumes the traditional method of doing DR by speed and time. That is, the log book records positions and course changes by the time of the event, and also records the active speed.

When in the DR mode = Speed, each DR position stored in the calculator is associated with a specific time and speed. In this mode, you can update the DR by simply telling StarPilot the next time you care about. It knows the time of the last DR position, your course and your speed, so it can compute the new DR and store it.

The “Log” mode assumes you are keeping DR records by Log reading. This works like the Speed mode, but to update DR you simply input the next log reading you care about.

With these two modes we can project our present position into the future two ways: by either telling StarPilot we ran 45.8 miles on our course (Log mode), or that we ran for, say, 12h 30m on our course at whatever our speed is (Speed mode). It is also simple to switch back and forth between modes to select

the one that is most convenient for the task at hand.

These computations can be made as part of our ongoing navigation or as a simple navigation computation. Once the computation is done, you have the choice of updating the stored DR with that result or just abandoning it.

If you choose to update DR after the computation, then the DR Lat and Lon stored will be changed to these new values. In Off mode, that is all that happens. In Log mode, the DR Log is updated and in Speed mode, the DR clock is updated.

With this function, you can almost literally type your log book into the StarPilot, line by line, and figure the final DR position, just entering the new course and or speed as you come to them.

To get started, whenever executed, the **DR mode** function first prompts for the desired DR mode and then automatically calls the **Course/Speed** function from the **Settings 1** menu to set the appropriate course, speed, DR Log, and DR Time depending on the mode.

The most common mode to use will most likely be the Speed and time mode, unless you specifically use log readings or distance run to figure a new position. We include the log mode since this is indeed the most accurate way to keep DR records underway in small-craft at sea — that is, at each course change we record the log reading, since this is a more accurate measure of our progress than the corresponding time and speed.

## [S4] [6] Tech Support

This screen gives you version number and date, along with a reminder about Tech support. The most convenient and fastest source of help with StarPilot is most likely found online at tech support section of [www.starpilottllc.com](http://www.starpilottllc.com). All updates and a list of FAQs will be maintained there. Check the website for latest version, which can be loaded into any

working StarPilot calculator at no charge.

```
Contact support at:
www.starpath.com or
info@starpath.com
01.55 Nov 30, 2001
Copyright 1998-2001
Luis Soltero, Ph.D.
All rights reserved
--More--
```

If you cannot find what you need there, please call 206-783-1414 or fax 206-783-9209.

## [2] \* \* Celestial Bodies \* \*

The functions found in this menu are used to compute properties of celestial bodies such as time of rise and set, star and planet identification and compass calibration. *Note that most of the operations performed in this menu use values stored in the settings menu.*

### [2] [1] Sunrise, Sunset, Twilight, and LAN

**Sunrise/LAN/Sunset** computes the times of sunrise, sunset, nautical and civil twilight, and meridian passage (LAN). Also output are the bearing to the sun at rising and setting, height of the sun at LAN, and the LHA Aries at the midpoint between nautical and civil twilights. Input is DR position and date. To compute July 4, 2000 at 47.39, -122.20, enter these data in the settings. To see local times, set the ZD (Zone Description) in settings [3][5], in this case +7 for PDT, and then:

```
**Celestial Bodies**
1 Sunrise/LAN/Sunset
2 Sight Planner
3 Hc Min/Max
4 Precompute..id
5 Star/Planet ID
6 Moonrise/set/Phase
7 Return

Times in GMT-7
Naut/Civil/Rise
003:44:04
004:37:34
005:17:49
--More--
```

```
Times in GMT-7
Set/Civil/Naut
021:09:29
021:49:45
022:43:14

Times in GMT-7
LAN/EqT/Hc/Zn R/S
013:13:51
-000:04:31
065°08.4'
053.7°
306.2°
--More--
```

EqT is the “equation of time” which is the differ-

ence between 12:00 UT and the UT of LAN observed at Lon = 0°. Zn R and S correspond to the Suns azimuth at sunrise and sunset respectively.

```
Times in GMT-7
LHAA AM Twilight
004:10:49
328°08.6'
LHAA PM Twilight
022:16:30
240°18.3'
--More--
```

The values of LHA Aries is used for setting up Star Finders or Pub 249 for sight planning and star ID, although StarPilot will itself perform these planning functions for you.

The bearing of the sunrise and set relative to 090 and 270 is called the “amplitude” of the sun.

## [2] [2] Sight Planner

The sky view function (**Sight Planner**) graphically displays a radar-like projection of the sky at a specific time and place. Input are the date, time, and DR position. Active settings also used are in [S3] [4] which set upper and lower limits on Hc and a cutoff # of stars to compute. Please review that section for important details.

The program then searches through the internal almanac for the visible stars and planets, followed by displaying a graphical view of the sky. Note that stars are displayed as points on the screen, planets are identified by small X's, the Sun is a circle with a dot in the middle, and the moon is displayed as a solid square.

First a quick check for the sun and moon is carried out, then the stars are searched followed by the planets. Stars are searched in order of brightness with the magnitude of the current star in view. The search progresses until the number of stars found matches the cutoff # parameter set in the [S3][4] settings menu before moving on to the planet search. If you wish to see only the brightest stars, then press [EXIT] when you get to magnitudes of 1.5 or

so and that will switch to a searching planets.

Once the picture is drawn, use the arrow keys to select a specific body on the screen and obtain further information by pressing the [ENTER] key. In practice it rarely pays to display all the stars. A more practical approach is to just push the [EXIT] key according to your desired choice in brightness.

Mercury is included and you can take sights of it for navigation, although it is not listed in the Nautical Almanac because it is only rarely useful. Nevertheless, StarPilot will nicely warn you when it is there so it won't get confused with another star or planet.

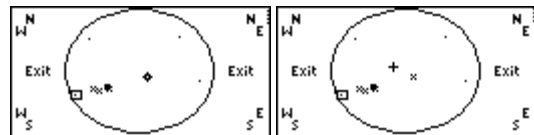
The following example displays the position of the brightest stars, moon, and the planets at 2200 GMT on January 1, 1998 at 12° N, 68° W.

```
**Celestial Bodies**
1 Sunrise/LAN/Sunset Day?22
2 Sight Planner      Day?1
3 Hc Min/Max/#Cutoff Month?1
4 Precompute:..# Year?1998
5 Star/Planet ID    Lat?12
6 Moonrise/set/Phase Lon? -68
7 Return
```

Next screens show just briefly during the search

```
5: HCHERNAR      0.6      6: SATURN      .8
Hc/Zn           018°36.1' Hc/Zn           076°39.5'
                168.2°      131.9°
```

then the star maps are drawn...



To exit the function, move the cursor out of the projection circle and hit the [ENTER] key returning to the “Celestial Bodies” menu. When you exit the diagram, you have the option to list all of the bodies shown.

Sight Planner runs in Fast almanac mode (See Appendix), so if you want very precise data for the moon or planets, it would be best to use the Precompute function [2] [4] rather than the values from the cursor, which are intended only for setting up the sextant sights or for identification.

See [www.starpilottlc.com](http://www.starpilottlc.com) for notes on choosing the best star-planet combinations for sight taking.

## [2] [3] Hc min/max / #Cutoff

This is just a direct link to the settings needed for the Sight Planner, namely [S3] [4].

## [2] [4] \* \* Precompute \* \*

The precompute function is used to compute Hc and Zn for a body when planning sights, working problems from a text book, or evaluating existing sight data. The function works exactly like the Sight Reduction from the main menu with the exception that only Hc and Zn are displayed and you have the option to perform the computations in “normal” mode as opposed to the slower high precision mode used in sight reductions. (Almanac modes are discussed in Appendix 2). Precompute mode (High or Normal) is set in [S2] [6].

Option 5 lets you input a GHA and Dec directly, from which it will compute LHA from the stored Lon and use the stored Lat to find Hc and Zn. If you want to input an LHA, then do so when asked for GHA, but set Lon = 0. If you wish to input a sequence of these, then store Lat/Lon = 0/0 in Setting 1-4 and it will request these each time rather than read stored values.

To precompute the expected Hc and Zn for the Sun, for example, you get the following results. This function reads the date and DR data in the settings, so if these are non-zero it will use them. In other words, if these are not what you want to use, you must either enter the proper data in the settings or set

them to zero so you get prompted for them. After setting stored date and DR to zero, the input would look like:

```

**Celestial Bodies**      **Precompute**
1 Sunrise/LAN/Sunset      1 Sun
2 Sight Planner           2 Star
3 Hc Min/Max/#Cutoff     3 Moon
4 Precompute...          4 Planet...
5 Star/Planet ID         5 Nautical Almanac
6 Moonrise/set/Phase    6 Settings...
7 Return                 7 Return
  
```

```

WT?15.3542                Hc/Zn/GHA/DEC
Day?10                    055°04.0'
Month?9                    214.3°
Year?1996                 054°43.4'
Lat?34.55                 004°40.0'
Lon?-35.50
  
```

--More--

This was in Normal mode. In High mode the answer is the same within 0.1' — ie there is little difference for the sun and stars in these modes, it is mostly of concern for speeding up moon and planet work.

Please review the discussion of PC mode in [S2] [6]

## [2] [5] Star and Planet ID

With this function it is possible to identify a star or planet by simply noting the altitude and bearing to the heavenly body. For example, say one would like to identify a *bright* body observed at GMT = 21h 7m on September 10, 1996 at an altitude of 31° 36' bearing 171° true, our DR position is 34° 30' N, 36° 30' W and our observation height is 10 feet.

```

**Celestial Bodies**      WT?21.0726
1 Sunrise/LAN/Sunset     Day?10
2 Sight Planner          Month?9
3 Hc Min/Max             Year?1996
4 Precompute...         Lat?34.3
5 Star/Planet ID        Lon?-36.3
6 Moonrise/set/Phase    IC(Min)?0
7 Return                IC(Min)?0
  
```

```

Month?9                   GHA/SHA/DEC
Year?1996                 028°00.6'
Lat?34.3                  081°06.7'
Lon?-36.3                 -023°26.2'
IC(Min)?0
HE(ft)?210
HS?31.36
Bearing(T)?171
  
```

--More--

Press [ENTER] here to start the search through the internal star and planet catalog to identify all bod-

ies within  $\pm 5^\circ$  of the observed data, First sun and moon are checked (this is automatic) and then through the stars starting from the brightest. Typical screens that pass by are shown below and then it stops when it finds one that matches, Nunki in this case.

```

16: BETELGEUSE *0.3 50: NUNKI 2.1
EXIT KEY FOR PLNT Hc/Zn 027°55.2'
STAR SEARCH...8 166.6°
--More--

```

The first shows star #16 which did not meet the id criteria and then #50 which did. The output shows #, name, magnitude, Hc, and Zn. Hc and Zn are both within  $5^\circ$  of the input data, which is why it was found. But noting the magnitude of the star (2.1) this is not a bright body at all. Press [ENTER] to continue.

First, the star search screen is displayed. Touching the [EXIT] key during the star search will cause the calculator to move on to the planet search. If no key is depressed then the entire star catalog is searched. The number of bodies searched so far is displayed at the bottom right of the screen.

While in the planet search routine the planet number is displayed at the bottom right corner of the screen. Pressing the [EXIT] key while in a planet search causes the calculator to return to the Celestial Bodies menu.

```

5: JUPITER -2.4
Hc/Zn 031°35.5'
171.3°
--More--

```

We find that Jupiter—a very bright body with magnitude -2.4—meets the search criteria precisely. Note that magnitude difference of -2.4 to +2.1 is 4.5 magnitudes or some factor of 100 in brightness. See Ref. 21 (*The Star Finder Book*).

Star and Planet ID uses the same internal function

used for the Sight Planner. That means that it also reads the settings for Hc min and max in [S3] [4]. If you have found a low or high star that is outside of the range you have set, then you need to first open up that range to find it. StarPilot will not find a star at Hc =  $8^\circ$ , when Hc min is set to, say,  $10^\circ$ .

The internal star search function searches for stars in order of brightness. Bright stars matching the search criteria will always be displayed before dimmer stars. The “STAR SEARCH #.#” line displays the number of stars searched so far and the number found. N is not the star number. This feature allows access to the more desirable stars quickly without having to search the 173 star catalog. The current star number, its name, and brightness are displayed at the top of the screen.

In the example screen for Betelgeuse, the “...8” means ...8.0 (no bodies found yet) but the TI drops a zero decimal.

The search routines always use the FAST Almanac Mode. You can use the Precompute function [2] [4] if it is necessary to compute the altitudes and azimuths of a body with more precision.

## [2] [6] Moon Rise, Set, Phase, Age

```

**Celestial Bodies**
1 Sunrise/LAN/Sunset
2 Sight Planner
3 Hc Min/Max
4 Precompute...
5 Star/Planet ID
6 Moonrise/set/Phase
7 Return

```

The example computes the moonrise for February 2, 1998 at  $12^\circ$  N,  $068^\circ$  W.

```

Day?2 Times in GMT-0
Month?2 Moon Rise/Set
Year?1998 015:19:27
Lat?12 027:58:34
Lon?-68 Moon Phase/Age
.34
6
--More--

```

The first half of the output screen displays the Watch Time (GMT - ZD) for rise and set of the moon. (If the ZD had been set to, say, +5, then the

time reported here would have been “GMT - 5” which is what we call “Watch Time.”) Note that times greater than 24 correspond to events on the next day and should have 24 subtracted from them. i.e. 27:58:27 means tomorrow at 03:58:27. The second portion of the display indicates the phase of the moon and its age. The moon is full when the value of its phase is 1 and new when the phase is 0. The moon age indicates the exact day in the moon cycle. Day 1 indicates a new moon while day 14 indicates a full moon.

### [3] \*\* Sight Reductions \*\*

StarPilot easily, accurately, and quickly reduces sights for the Sun, Moon, five major planets, and 173 selected stars using its perpetual internal almanac. This section describes procedures for doing sight reductions using the internal almanac.

To follow through the next examples, first Set Defaults [S4] [2] so we start at the same place. In particular, this will set the SR mode to Random so we will be asked for all inputs on each sight. Please review section [S2] [5] which explains Sight Reduction Mode, Random vs. Sequential.

#### [3] [1] Sun Sight Reduction

The procedure for doing celestial sight reductions is best illustrated by an example. Suppose we wish to reduce a Sun sight given the following parameters.

GMT = 15h 35m 42s  
 Date = Sept 10, 1996  
 DR Latitude = 34° 55' N  
 DR Longitude = 35° 50' W  
 Hs = 54° 58.8' for Lower limb Sun  
 HE = 10 feet  
 IC = 2.5' (ie 2.5' OFF the scale)

Note that GMT = Greenwich Mean Time, which is

the traditional name for the modern term universal coordinated time (UTC), which is the same as what we call watch time (WT) with the zone description (ZD) and watch error (WE) set to 0.

Before doing the sample sun sight please turn on the calculator and reset it to its factory default state, see [S4] [2]. Once the calculator has been reset return to the main menu and select the **Sight Reduction** menu entry [3]. The following screen will be displayed.

```

**Sight Reduction**
1 Sun
2 Star
3 Moon
4 Planet...
5 Delete a Sight
6 Celestial Fix...
7 Return
  
```

Select **Sun** for a Sun sight. The program will then inform you that you are performing sight number one and then prompts you for the time of the sight.

```

Sight #1
WT?15.3542
Day?10
  
```

In StarPilot, all times are entered as Watch Times (WT), which are defined by this equation

$$\text{GMT} = \text{WT} + \text{WE} + \text{ZD},$$

where the Watch Error in seconds and the Zone Description in hours are stored in the **Settings 3** menu. The default has both = 0, which makes WT the same as GMT.

Now enter the data being careful to observe the data entry conventions described in the **Quick Start** section and **Introduction**. Press the [ENTER] key after each value is entered. Note that hitting the [ENTER] key commits the value to memory. Errors in data entry must be corrected before the [ENTER] key is executed. A combination of arrow keys, [DEL], [2nd][INS], and [CLEAR] can be used to correct a value in error. Your data screens should look like a combination of the following.

```

Month?9
Year?1996
Lat?34.55
Lon?-35.50
IC(Min)?2.5
HE(ft)?10
LIM 1=0,-1=L?-1
HS?54.588
SUN-Lower Limb
#/WT/Hs/Zn/Int(nm)
1
015:35:42
054°58.8'
214.3a
9.5
--More--

```

```

**Sight Reduction**
1 Sun
2 Star
3 Moon
4 Planet...
5 Delete a Sight
6 Celestial Fix...
7 Return
Sight #2
WT?7.1121
Day?2
Month?5
Year?1988
Star,0=List?0

```

Note the minus in the -35.5 representation of 35° 50.0' West and the -1 for Lower Limb. IC is used to enter the index error in decimal minutes. The IC is simply added to the Altitude reading (Hs) and therefore should have a minus (-) for “on” errors and no sign (i.e. implicit +) for “off” errors, ie, “If it is on, take it off.”

The output screen shows the body sighted, sight number, and then a review of the input, WT and Hs, then the Azimuth Zn and the altitude intercept, called here “Int” but usually abbreviated “a” or the “a-value.” Here a = 9.5° T 214.3, where the Azimuth Zn is always a true bearing. Int(nm) is the intercept (a-value) in nautical miles, positive values are TOWARDS, negative values AWAY.

StarPilot records this sun sight for future use in a LOP plot or **Celestial Fix** option [4], described later.

If you detect an obvious error in the input, note the sight number, then press [Enter] and then [5] to delete the sight so it can be re-entered. The delete process is discussed shortly in the section [3] [5].

### [3] [2] Star Sight Reduction

To reduce star sights, select **Star** from the **Sight Reduction** menu. Sample:

```

Star = Capella
GMT = 7h 11m 21s
Date = May 2, 1988
DR LAT = 49° 32' N, DR Lon = 165° 12' W,
IC = -3.0', HE = 16 ft
Hs = 36° 14'

```

Above is the screen after the time, and date have been entered. From this screen you enter the star number or, as shown here, a 0 to show the list.

Once again StarPilot informs you that it is now processing sight number 2 and queries for the WT of sight and the date. StarPilot then prompts for the body number of the sighted star. The body number of the star is the numeric value assigned to each of the “named” stars in the Nautical Almanac. It is not necessary to know star number for all the named stars. If you do not know the number for the sighted star simply enter 0 and the calculator will display a scrolling list of stars in body number order.

```

Sight #2
WT?7.1121
Day?2
Month?5
Year?1988
Star,0=List?0
1:ALPHERATZ 2.2
2:ANKAA 2.4
3:DIPHDA 2.2
4:ACERNAR 0.6
7:ACAMAR 3.1
10:ALDEBARAN 1.1
12:CAPELLA 0.2
ALL A-E F-M N-R S-Z
--More--

```

Before the full list is displayed, however, a menu at the bottom of the screen limits the list of stars to those for which the first letter in the star name falls in the selected subset. Selecting [F1] or ALL will display all 173 stars. Use the key sequences listed in Section 8 which describes the “—More—” scroller to move through the star list and find the body number for the sighted star. Select [F2] for A-E, to see the list shown above, from which we learn that Capella is #12 and it has a brightness magnitude of 0.2. The Star List function is described in section [6] [5] [4].

Once you have spotted your star in the list, hit the [EXIT] key on the calculator and the body number prompt will immediately appear. Now enter 12 the body number for the sighted star *Capella*.

If you know the body number for the star then there

is no need to display the star list. Enter the body number directly. Completing the data entry then yields the following.

```
Sight #2
WT?7.1121
Day?2
Month?5
Year?1988
Star,0=List?12

Month?5
Year?1988
Star,0=List?12
Lat?49.32
Lon?-165.12
IC(Min)?-3.0
HE(ft)?16
HS?36.14
```

```
12: CAPELLA 0.2
#/WT/Hs/Zn/Int(nm)
007:11:21
036°14.0'
300.8'
-18.5
--More--
```

The output is star number, name, and magnitude, followed by similar data as in the previous sun sight. The a-value = 18.5° A 300.8°.

To prepare and evaluate star sights, StarPilot provides an easy method for identifying stars and planets and also a comprehensive **Sight Planner**. See section [2] [2] for details.

### [3] [3] Moon Sight Reduction

Moon, Lower Limb,  
 GMT = 10h 01m 04s,  
 Date = October 22, 1996,  
 IC = -1.7, HE = 18 feet,  
 DR Lat = 26° 20' S, Lon = 99° 27' E,  
 Hs = 33° 39.3'.

```
**Sight Reduction**
1 Sun
2 Star
3 Moon
4 Planet...
5 Delete a Sight
6 Celestial Fix...
7 Return

Sight #1
WT?10.0104
Day?22
Month?10
Year?1996
```

The almanac computation starts when you press [ENTER] following the year, and ends when it asks for Lat? For the moon, the longest computation, this can take some 70 seconds. You will see the “busy cursor” scrolling in the top right of the screen.

```
Month?10
Year?1996
Lat?-26.20
Lon?99.27
IC(Min)?-1.7
HE(ft)?18
LIM 1=U, -1=L?-1
HS?33.393

MOON-Lower Limb
#/WT/Hs/Zn/Int(nm)
010:01:04
033°39.3'
079.9'
-12.4
--More--
```

Answer, a = 12.4° A 079.9.

### [3] [4] Planet Sight Reduction

Select **Planet** for a planet sight reduction. Here is an example.

Planet = Jupiter,  
 GMT = 21h 07m 26s,  
 Date = Sept 10, 1996,  
 DR LAT = 34° 30' N, Lon = 36° 30' W,  
 Hs = 31° 36.0',  
 IC = 0, HE = 10 Feet.

```
**Planets**
1 Mercury
2 Venus
3 Mars
4 Jupiter
5 Saturn
6 Return

Sight #3
WT?21.0726
Day?10
Month?9
Year?1996
Lat?34.3
Lon?-36.3
```

```
Day?10
Month?9
Year?1996
Lat?34.3
Lon?-36.3
IC(Min)?0
HE(ft)?10
HS?31.36

5: JUPITER 0
#/WT/Hs/Zn/Int(nm)
021:07:26
031°36.0'
171.3'
-4.2
--More--
```

Sight #3, a = 4.2° A 171.3. Note that although these sights are numbered as we do them in this series of examples, they are totally unrelated and not part of any fix sequence. The “5” before Jupiter is simply the number of the planet in StarPilot, which includes 6 planets. This number is useful in judging progress in search routines such as Star/Planet ID and Sight Planner.

### [3] [5] Delete a Sight

In the last step of each sight reduction, you get back a list of the input data used for the sight and the output results. If there is clearly some error in the sight input, then note the sight number and execute this option to immediately delete it. This option [3] [5] is set up for deleting a single sight

that you know the number of. You can delete the last sight or any other numbered sight. When you delete a sight, the sequence is renumbered with that one missing.

To delete sight number 5, for example, one would execute the following sequence.

<pre> **Sight Reduction** 1 Sun 2 Star 3 Moon 4 Planet... 5 Delete a Sight 6 Celestial Fix... 7 Return </pre>	<pre> Sight to DEL?5 </pre>
---	-----------------------------

If you have been following through with the running example, you will note that sight number 5 does not exist, therefore, StarPilot simply ignores the request with a notice "Value out of range." Had the sight existed it would have been removed from the list. If you start to delete a sight and change your mind, just enter a large number and that will get you out of it. Or press [2nd] [Quit].

An alternative way to delete a sight is to Review the list of all sights and when the one you want is on the screen, press [Del] key. This will also renumber the set as before. With the delete-during-review method, discussed next in section [4] [1], you do not need to know the sight number. From the Sight Reduction screen, the quickest way to get to the Review Sights option is go to the Celestial Fix page where it is top item. See Next.

### [3] [6] Celestial Fix

This link takes you directly to the celestial fix page without having to go back to the Index. If you were on the Index page, you would get to cel fix with the [4] key.

### [4] \*\* Celestial Fix \*\*

StarPilot will record a series of sights over time and given more than 2 will advance them to a common time and calculate a position fix which we call "celestial fix". Alternately, the program provides for a

method of graphically displaying the LOPs from various sights. The user then manipulates the arrow keys to select the coordinates of the fix. Plotted LOPs can be advanced to a common time or not advanced based on user input.

Generally the first step in doing any fix would be to review the sight data stored, which can be done with option [1] of this screen. If you execute the function right now, however, you would see the 4 sights from the last example, but it would not make sense at all to execute a fix from that data since they were from different times, places, etc.

Hence to show how celestial fixes work in StarPilot, let us start all over again with a new set of data

### 3-Star Fix Example

On July 6, 1996 a vessel traveling at 20 knots on a heading of 325 True at approximately 32°N and 15° W made the following 3 observations. The index error was 0.0 and the height of eye was 10 ft. What is the expected position of the vessel at 2100 GMT determined from the following three sights? The ZD of the watch was set to 0 (WT = GMT) and there was no watch error.

1. Regulus (#26)  
WT = 20h 39m 23s, Hs = 25° 00.6'.
2. Antares (#42)  
WT = 20h 45m 47s, Hs = 27° 05.7'.
3. Kochab (#40)  
WT = 21h 10m 34s, Hs = 47° 27.6'.

Given that most of the parameters for these 3 sights are the same, it would be most expedient to use the StarPilot settings menu to set up the sight parameters before actually doing the sight reductions and then use Sight Reduction Mode = Sequential which will read the values for each sight. Refer to explanations in earlier sections as needed to complete the following sequence of instructions.

1. Reset the calculator to its defaults [S4] [2]. In practice this step is not necessary, you would generally just use [4] [6] New Sequence. We do it here for a common basis for this problem.
2. Set the date in [S1] [2]
3. Set the DR position in [S1] [3] and set HE = 10 in [S2] [3]. IC = 0 will be set in the defaults
4. Set SR Mode to Sequential in [S2] [5].
5. Check your input with View settings [S1] [6] and compare with the following.

```
SR mode SEQUENTIAL      Limb LOWER
PC mode NORMAL          Temp(F)=      50
DR mode OFF             Pres(mb)=     1010
Dip mode NORMAL        Mag Var=      000°00.0'
Times in GMT-0         IC=           000°00.0'
Watch err= 000:00:00   HE(ft)=      10
Max sights= 15         (D/M/Y)= (6 /7 /1996)
--More--
```

```
DR Lat/Lon 032°00.0'  Hc Min/Max/# Cutoff
            -015°00.0'  000°00.0'
Dest Lat/Lon 000°00.0'  090°00.0'
            000°00.0'  20
--More--
```

Now enter the 3 star sight reductions as explained earlier in section [3] [2]. We will check your work in the next step. Here is what the data screens will look like:

### 1. Regulus

```
Sight #1
WT?20.3923
Star_0=List?26
HS?25.006
26:REGULUS 1.3
#/WT/Hs/Zn/Int(nm) 1
020:39:23 3
025°00.6' 1/3
268.8° 020:39:23
-2.6
--More--
```

### 2. Antares

```
Sight #2
WT?20.4547
Star_0=List?42
HS?27.057
42:ANTARES 1.2
#/WT/Hs/Zn/Int(nm) 2
020:45:47 2
027°05.7' 2/3
154.2° 020:45:47
23
--More--
```

(Note "23" = 23.0; this is quirk of the TI-86.)

### 3. Kochab

```
Sight #3
WT?21.1034
Star_0=List?40
HS?47.276
40:KOCHAB 2.2
#/WT/Hs/Zn/Int(nm) 3
021:10:34 3
047°27.6' 3/3
357.9° 021:10:34
-21.2
--More--
```

### [4] [1] Review Sights

The **Review Sights** function displays the full list of sights stored in the calculator. This is a way to check that you have what you want before executing a fix, and it is also an alternate way to delete a specific sight. Pressing the [DEL] key will remove the displayed sight from the sight sequence and renumber the remaining ones.

If you execute Review Sights now you should see the 3 star sights you just entered. In the display, "2 / 3" means the 2nd sight of a set of 3.

```
**Celestial Fix**
1 Review Sights
2 Fix by Computation
3 Sight Analyzer
4 Fix by Plotting
5 Delete a Sight
6 New Seq (Del ALL)
7 Return
26:REGULUS 1.3
#/GMT-0 /Hs/Zn/Int 1/3
020:39:23 1/3
025°00.6' 268.8°
-2.6
--More--
```

```
42:ANTARES 1.2
#/GMT-0 /Hs/Zn/Int 2/3
020:45:47 2/3
027°05.7' 154.2°
23
--More--
```

```
40:KOCHAB 2.2
#/GMT-0 /Hs/Zn/Int 3/3
021:10:34 3/3
047°27.6' 357.9°
-21.2
--More--
```

Note that although it will not affect the final fix in any manner, the actual a-values displayed in the Review Sights list always depend on how the DR Mode is set in option [S4] [5]. The intercepts displayed in this sequence are the same ones reported at the time of the sight reductions, since DR mode is currently set to OFF. In other words, these a-values are not advanced. These particular a-values do not know you actually had a course and speed during the sights. When it comes time to do a fix, however, you will be asked for the course and speed so they will all be adjusted properly.

On the other hand, if DR mode is set to “Speed,” the Review Sights function will first use the internally stored values of course, speed, and DR position to advance each of the sights to a common time before presenting the a-values. The common time used is the time of the first sight and all intercepts are computed and displayed relative to this common time. This is a crucial option for evaluating a set of sequential sights of the same body from a moving vessel, but it has no significance in these three individual sights of different bodies. Also note that this option has no influence on the subsequent fix, since that will always require course and speed adjustment.

DR mode = Log acts like DR mode = Off as regards the Review Sights display. The log mode only makes a difference in the DR Update operation.

## [4] [2] Fix by Computation

```

**Celestial Fix**
1 Review Sights
2 Fix by Computation
3 Sight Analyzer
4 Fix by Plotting
5 Delete a Sight
6 New Seq (Del ALL)
7 Return
  
```

Once you have a set of sights stored in the calculator, you can obtain a fix two ways, either by direct computation [4] [2] or by plotting the LOPs and selecting the fix graphically yourself, discussed later under [4] [4].

The **Fix by Computation** option uses the standard US Naval Observatory (USNO) algorithm found in the Nautical Almanac. This is a set of formulas and procedures that take the raw data and compute the corresponding fix. The lines of position are advanced to a common time and a least squares fitting method is applied to compute the fix.

When you select either option [2] or [4] from within the Celestial Fix menu, StarPilot will prompt you for your current speed in knots, course track (magnetic if the variation is set, otherwise true), and time

(WT). The WT of the fix you desire could be a time of one of the sights, or any other time.

All sights will be advanced (or retarded) to the fix time you entered. Entering a value of 0 for the speed causes the application to suppress the course and time prompts bypassing the advance of the LOPs to a common time. Note that the DR position used in the running fix computation need not be the same one used in the original sight reductions since all sights are re-computed for the fix computation.

Note too, that if you are not moving (S=0) then the time of the fix does not matter. It just assumes you are at the same place but took sights at various times.

When doing sight reductions by tables we are used to using Assumed Positions. With calculators, however, we do not have a separate Assumed Position but instead all sights are reduced from the stored or advanced DR position. When using the USNO method, if the DR Position is in error by more than 20 miles StarPilot will re-compute your position after temporarily updating your DR position. Once the running fix computation has completed, answering “Yes” to the “Update DR Position?” question will cause StarPilot to update the stored DR position with your newly calculated fix. The following screens depict a running fix computation. Enter 0 (No) to the question on the final screen for purposes of this example.

```

**Celestial Fix**
1 Review Sights
2 Fix by Computation
3 Sight Analyzer
4 Fix by Plotting
5 Delete a Sight
6 New Seq (Del ALL)
7 Return
  
```

```

Speed(kt)?20.0
Course(T)?325
Fix Time(h.ms),
WT?21.00
  
```

```
PLEASE WAIT...
```

Lat/Lon/R(nm)/Brg(T)	Lat/Lon/R(nm)/Brg(T)
031°37.2'	031°37.2'
-015°01.6'	-015°01.6'
22.8	220.4
183.5	0
--More--	Upd DR(1=Y,0=N)?0

Select 0 = No, for now.

The R(nm)/Brg(T) on the output screen are the range and bearing from the DR position to the computed fix. This data should be recorded at this stage since it is very valuable in evaluating your overall navigation and it will be replaced in the display in the next step if the R is bigger than 20 miles.

In summary, the 3 star sights gave a fix of  $31^{\circ} 37.2'$  N,  $15^{\circ} 01.6'$  W and this fix was a distance of 22.8 miles off where we thought we were in the direction of 183.5 True.

The full effect of “Update DR position” depends on the DR Mode you are in, as explained further in section [5]. When DR Mode = Speed, “yes” will update the stored DR position and the stored DR Time. When in Log mode, StarPilot will update the position and turn the Log mode to Off, since we lose track of actual log readings during the sights. If you wish, you can switch back to Log mode at this point and re-enter the appropriate log reading

Please review the **Quick Start Examples** and discussion for more details.

## [4] [3] Sight Analyzer

To learn about the theory behind this process, see related articles online at [www.starpilotllc.com](http://www.starpilotllc.com).

The goal is to effectively average a series of sights to determine which one is a proper representative of the full set. To do this, we compute the theoretical values of Hc over the time interval of the sights stored—taking into account the motion of the vessel—and then compare the slope or curve of these data with the actual sights. This process shows

which sights are outside of statistical fluctuation, so they can be deleted or not considered, and lets you choose the best of the set.

To execute Sight Analyzer in StarPilot, enter a set of sights of the same body over a reasonably short time period (10 to 20 minutes or so) using the normal Sight Reduction function. If the Hs values change too much during your sight period (time is too long), then the Hs scale on the calculator display is too compressed and differences do not show up well. Once the sights are stored, set DR mode to Speed, DR time to the time of the first sight and enter the correct DR position for that time, along with your course and speed made good over the sight period.

Then from the Celestial Fix menu, select Sight Analyzer [4] [3]. The sample here shows its use for a series of sights at LAN, but it would more typically be used for any sequence of sights of the same body.

The Analyzer will then compute the Hc value (actually a computed Hs, since we undo all the corrections that have been applied to the sight at that time), then store this theoretical value, and then proceed on down your sight list, advancing the DR to the time of the next sight, computing Hc, and storing it, until all are done. Next the curve of theoretical sight values is drawn as a graph and your actual sights are plotted on the graph. Any sights that are far from the plot are most likely wrong.

To best compare the data, move the curve by placing the cursor at the place you want the curve to cross and press [Enter], and this way find the best fit to the data. Note the cursor cannot be right on a data point, since [Enter] then will report back the difference between line and data. Find a location off of a data point that will place the curve (line) such that there are about the same number of points above as below the line, but disregard any that are clearly far off the line. Then choose any one sight

that is on the line as your best. That one sight will be as good for a fix (or better) than all the sights plotted together.

This process can also be applied to any sights. Those taken before or after LAN could be used for a “reduction to the meridian” analysis (see older versions of Bowditch for reference).

To Exit the Analyzer, place the cursor on the word “Exit” and press Enter.

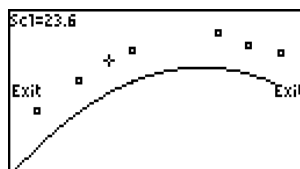
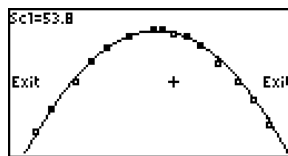
This tool is best suited for poor or sparse data. The LAN example sights have little spread, yet we can still improve the analysis as shown.

Remember that the Sight Analyzer analyzes all stored sights, so you must limit stored sights to a specific, rather short sequence of sights of the same body to take advantage of this feature. The most efficient procedure would be to enter sights in these short sets, analyze them, then take just one of the set to represent the lot and write down Hs and WT for it, then delete it and enter the next set and again select the best single sight from that group, then delete the rest and re-enter the first to make a running fix.

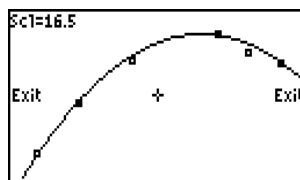
Alternately, you could enter all sights, then store them in a PC with the GraphLink program. We will explain this in more detail elsewhere. It is a quick and easy process to transfer all sights and related data to a PC and then later move them back into the calculator. See Appendix 3. on Storing Sight Data in a PC.

### LAN Analysis using Sight Analyzer

The example is a set of high LAN sights, peaking at about 87degrees, from July, 1982 in the Tropics (note it is not common practice to take sights this high). The first picture shows all 15 sights spanning LAN, and the analyzed results are not very interesting since the scale is too big.



But suppose we only got the few sights shown in the picture below it. Then we run the Analyzer, set the cursor where we want the line redrawn, and press Enter.



The pictures are still small but the scale is better. Notice the difference between solid dots (exact fit) and open circles (off the curve).

With the use of the Analyzer we see that even with just these few sights, we have a good LAN, and that the next to last sight was too low and that our peak height is a reasonable one for the LAN value even though we slightly missed the actual peak time. This also means that you could use the LAN utility [6] [5] [1] to get a reasonable Lon as well as Lat from the sights.

### [4] [4] Fix by Plotting LOPs

Alternately, to use a graphic method to obtain a fix, use the **Fix by Plotting** option under the Celestial Fix menu. **Fix by Plotting** will graphically display the LOPS on the screen allowing the user to actu-

ally select the fix from the plot.

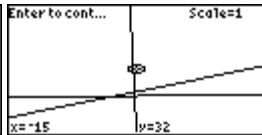
When first executed, the plotting function prompts the user for the vessel's speed in knots that was in effect during the sights. Entering 0 for the speed will cause the calculator to immediately plot the LOPs without advancing them to a common time. Entering a non-zero value for the speed causes StarPilot to prompt for the course (in True or Magnetic [S4] [4]) and a WT ([S3] [5]) in exactly the same manner as the computational fix methods describe above. The program then advances all LOPs to the given time and plots them on the screen. In either case the DR position is plotted in the center of the screen with a circle around it.

```

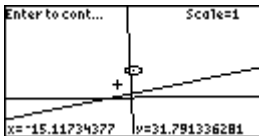
**Celestial Fix**
1 Review Sights
2 Fix by Computation
3 Sight Analyzer
4 Fix by Plotting
5 Delete a Sight
6 New Sea (Del ALL)
7 Return
    
```

```

Speed(kts)?20.0
Course(T)?325
Fix Time(h.ms),
WT?21.00
    
```



The first display shows the DR position (a circle) about 23 miles north of the intersections as we learned from the numerical fix (Section 11.3). The automatic scale of the initial plot is about 3 times the distance from the DR position to the farthest LOP intersection. The Lat (Y) and Lon (X) of the cursor position (a + sign) is displayed in decimal degrees at the bottom of the screen. Next we use the arrow keys to move the cursor into the “cocked hat” of intersections, as shown below.

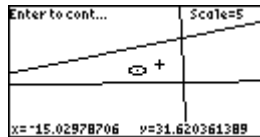


Then press [ENTER] to read the precise Lat/Lon of the cursor position.

```

Lat/Lon/R(nm)/Brg(T)
031°36.7'
-015°02.6'
23.36
185.5
Replot(1=Y,0=N)?0
Upd DR(1=Y,0=N)?1
ReScale(1=Y,0=N)?1
Scale(+/-1,2...)?5
    
```

Entering 1 for the Replot question will quickly redisplay the same plot to allow for another cursor selection if desired. An answer No (0) will ask if you want to update the DR. Yes to this will simply take the position you selected and store it in the DR position. Yes or No to this will lead to the next question of Rescale, which is a redraw of the same plot increased or decreased in scale by a factor you choose. Here we ask for it to be redrawn a factor of 5 larger. Note too that when we updated the DR that will move the center of the plot to the fix position we selected.



```

Lat/Lon/R(nm)/Brg(T)
031°37.2'
-015°01.8'
056.9
Replot(1=Y,0=N)?
    
```

Here we have moved the cursor to the right to coincide more with the choice made by the USNO computation. This latter is more the true centroid of the pattern, ie the point that is about 1.0' inside of each of the LOPs. Note the DR to cursor distance is 0.87 nm in direction 057.

You can more directly compare USNO to the Plot by updating DR to the USNO fix when you do it, then do the plot, expanding as needed. Again, we do not enter the “+” sign, and when using reductions use the (-) key next to the [ENTER] key. Also note that scale of 5 and then scale of 5 is the same, it does not build on the existing one but recomputes the LOPS fresh each time using the factor you provide.

### [4] [5] Delete a Sight

This is the same function described in the Sight Reduction section [3] [5]. It is for removing one

sight at a time according to its number. Remember that the sight numbers change when one is deleted. An alternative way to delete a sight is to Review Sights [4] [1] and press[Del] key to remove the one in view.

### [4] [6] New Sequence (Del All)

If you wish to remove all stored sights but otherwise leave all the settings unchanged, then use this New Sequence Option. This is the more common way to move on to a new set of sights underway. On the other hand, if you have a lot of changes to make, then the Set Defaults [S4] [2] might be a better option.

### [5] Updating DR position

It is often useful to determine a DR position from log book data without actually plotting out the track on a chart or plotting sheet. This functionality is provided in StarPilot by the **Update DR** function. Considerable effort has been taken to make this a convenient and versatile function since it is so crucial to the day's work in ocean navigation.

The operational behavior of **Update DR** as well as how this interacts with the **Celestial Fix** routines is controlled by two settings: **DR Mode** [S4] [5] and **Course/Speed** in [S1] [5].

When DR Mode = OFF, the Update DR function will ask for your course and then the distance run in nautical miles. Then it computes your new DR position. If you did not have a DR position stored in the Settings, then it will first ask for the starting point. At the end of the computation it will ask if you wish to update the stored DR position to this new value.

Example, we are at 47° 39' N, 126° 50' W. Our log reads 100.0. We wish to find our new position if we sail 123.7 miles on course 245 T, We do this first in the Off mode, then Log and Speed modes. From main **Index**, do [1] [3] to get to the DR Lat/Lon in-

put and type in 47.39 and -126.50.

You can also get there from [CUSTOM] [MORE] [MORE] [F1]. Note though, that if you go to an input station a second time you either need to input the data again or before entering anything press [ON] [F5] [ENTER]. If you quit before entering any data, the old values remain. If in doubt, do view settings [S1] [6]. If need be, set magnetic variation to 0 [S4] [4]

#### DR mode = Off

Now set DR mode = Off from setting [S4] [5]. Then from Main Index press [5] to Update DR and then input the course and distance run.

<pre> **StarPilot** 1 Settings... 2 Cel Bodies... 3 Sight Reduction... 4 Celestial Fix... 5 Update DR 6 Utilities... 7 Quit </pre>	<pre> Course(T)?245 Dist Run(nm)?123.7 </pre>
--	---

The [ENTER] key then gives:

```

DR Lat/Lon      046°46.7'
                -129°34.5'
RL Crs(T)/Dist(nm) 245.0°
                  123.7
Upd DR(1=Y,0=N)?

```

Entering a 1 here for “yes” will store this new position into the DR, 0 will just quit. Select 0 since we want to do other examples.

( If you select 1 instead, it will update the position, then ask if you want to change C and S. If you say yes to this, it will first ask for DR mode, since you are now in Off which does not need these.)

The output shows the new DR position as well as a summary of the leg we just computed. This is a double check that we entered the right values, but this latter info would be of more interest in the speed mode. Note that these values reported back may differ by a few tenths or so, since this is not just a repeat of what we entered, but an actual independent second computation of the Rhumbline route from departure point to answer point and there may

be some rounding off errors.

### DR mode = Log

Now set DR mode = Log from [S4] [5]. StarPilot will then prompt for Log (enter 100) and Course (enter 245). In this mode, to figure our position 123.7 miles along from here, we have to realize that our log will then read 223.7 — or if we were not using real log entries, we could just enter 0 here for our current log reading, and then enter 123.7 for the computation, which is like doing it in Off mode.

#### Reminder:

*To use the calculator for simple adding and subtracting in the middle of navigation routines, just do [2nd] [QUIT] [CLEAR], then do the math you want, then [CUSTOM] [F1] [ENTER] to get back to StarPilot.*

Now execute **Update DR** from the main **Index** and learn that all you need to enter is the log reading of interest, i.e. 223.7, to get the new DR position. You will get the same screen as in the Off mode. If you say “Yes” here, ie key [1], then this position will replace the one in storage and also the log in storage will go from 100.0 to 223.7. To carry on with these examples, choose Yes by pressing the [1] key, then say [0] for no course changes for now.

### DR mode = Speed

First do **View Settings** to confirm what we have so far. Do this from [S1] [6] or from [CUSTOM] [F2]. You should have the new DR position stored along with a log reading of 223.7 and a course of 245.

To start doing DR by speed and time, change DR mode to Speed, enter DR time = 12.04, Course = 245, Speed = 8.5.

Now let us ask where we will be at DR time = 1445. From main **Index**, do **Update DR**, and enter 14.45, and you should get:

```
DR Lat/Lon      046°37.1'
                -130°04.6'
RL Crs<T>/Dist<nm> 245.0°
                22.8
Upd DR<1=Y,0=N>?
```

Again, the bottom part of the display is the RL (rhumb line distance) from departure to destination. It should be very nearly the same as the timed run of the input, ie  $14.45 - 12.04 = 2\text{h } 41\text{m}$  at  $8.5\text{ kts} = 22.8\text{ miles}$ , see [CUSTOM] [F5].

Updating DR position will now store this new location along with the new DR time of 14.45. Do this and then view settings to check what you have.

Here is a logbook Sample A, to be computed.

Log	Course	Position
102	245	47.39, -126.50
150	260	
178	270	
190	170	
255	170	find position here

Using **Update DR** in Log mode, you should get 46.098, -128.359

Likewise, this one, Sample B (unrelated to A)....

WT	Course	Speed	Position
1204	245	8.5	47.39, -126.50
1512	260	7.0	
1806	270	7.5	
1900	170	6.0	
1950	170	6.0	find position here

Using **Update DR** in Speed mode, you should get 47.193, -128.038

### Note on DR over midnight

The Update DR function in Speed mode does not read the date stored in the calculator (date is for cel nav functions only). When you must DR across midnight in the Speed and time mode, take one leg up to 24.00, then start another at 00.00 by setting

DR Mode again in [S4] [5]. In the Log mode this is not an issue. Note that you can do running fixes that span midnight in any time zone, since the date is stored with all sight reductions.

### DR Mode and Review-Sights Display

When DR Mode = Speed, the Review Sights function [4] [1] uses the course and speed to advance the sights before displaying them. The common time used is the time of the first sight (#1). Hence for most logical presentation of the data, it is best to have the stored DR position consistent with the DR track in effect at the time of the sights. To do that, just set the DR mode to Speed (set it again, even if is set there now) and at the input enter any valid time and point on the DR track. If you care to, you could then do Update DR to the time of the first sight to double check with your printed records that all is correct, although if your input was correct this would not be needed. The program will automatically update the DR before presenting each sight.

Normally this is not a concern, since when the fix is computed it will be done right no matter where the DR is — it might just take a few iterations to converge. But things will work more smoothly and make more sense if you use for a DR position the one that corresponds to the sight time you requested. Needless to say you need to do it this way if you wish to test your GPS with celestial or vice versa.

### [6] \*\* Utilities \*\*

In addition to the celestial navigation aids already examined, StarPilot also provides a host of useful general purpose navigational functions. Access to these functions is via a series of cascading menus starting with the **Utilities** menu. Functions are loosely categorized and placed in a menu with other similar utilities. For example, the **Route Sailings** menu contains functions which cover the various ways to compute routes from point to point. All

StarPilot utilities and their corresponding menus are listed below. See also the menu map on the back cover.

<pre> **Utilities** 1 Speed/Time/Dist 2 True Wind 3 Route Sailings... 4 Current Sailings... 5 Celestial Utils... 6 Piloting... 7 Return </pre>	<pre> **Piloting** 1 ETA 2 Dist by Sextant... 3 Dist by 2 Bearings 4 Add Times 5 Add Angles 6 Geographical Range 7 Return </pre>
--	--

<pre> **Route Sailings** 1 Rhumbline 2 Great Circle 3 Traverse 4 Composite 5 View DR/Dest 6 Set DR Params... 7 Return </pre>	<pre> **Current Sailings** 1 CMG and SMG 2 CTS and Speed 3 CTS and SMG 4 Find Current 5 Current Interp 6 Tide Interp 7 Return </pre>
--	--

```

**Celestial Utils**
1 Lat/Lon by Mer Pas
2 Lat by Polaris
3 UT by Lunar Dist
4 List Stars
5 SR Naut Almanac...
6 Compass Cal
7 Return

```

### [6] [1] Speed, Time, Distance

Speed - time - distance computations are needed daily in marine navigation. StarPilot has a convenient routine for this. Get to it under **Utilities 1** or from [CUSTOM] [F5]. When executed the procedure prompts for the three values. Enter 0 (zero) for the one that you wish to compute. How long does it take to go 112.8 miles at 14.5 kts?

```

Speed(kt)?14.5
Time(h.ms)?0
Dist(nm)?112.8
Speed/Time/Dist
                                14.5
                                007:46:46
                                112.8
--More--

```

Answer is 7h 46m 46s. This is a very convenient function with numerous routine applications. Suppose you run a measured mile in 8m 32s. What was your speed?

```

Speed(kt)?0
Time(h.ms)?0.0832
Dist(nm)?1.00
Speed/Time/Dist
                                7.03125
                                000:08:32
                                1
--More--

```

The answer is 7.03 kts.

## [6] [2] True Wind Direction

Sailors and power-driven vessels as well often need to know the true wind speed and direction although only the apparent data are available. Use **Utilities 2** to get to the converter.

```

**Utilities**
1 Speed/Time/Dist
2 True Wind
3 Route Sailings...
4 Current Sailing...
5 Celestial Utils...
6 Piloting...
7 Return

Course(T)?115
Speed(kt)?6.5
AW Dir?145
AW Speed(kt)?16
Wind Dir(T)/Speed(kt)
162.4°
10.87
--More--

```

Given a ship course of  $115^\circ$  — true or magnetic, it does not matter, the output is all relative to the input — traveling at 6.5 knots, with an apparent wind direction of  $145^\circ$  (i.e. from  $30^\circ$  on the starboard bow), and apparent wind speed 16 knots we calculate a true wind direction and speed as follows. Note that the actual direction of the apparent wind is required, not just a relative direction.

The above example was in terms of actual wind direction. If you prefer to use relative values, then set course = 000, and all input and output will then be relative values. You will get that an apparent wind of 16 kt at  $30^\circ$  on the bow when traveling at 6.5 kts is the result of a true wind of 10.9 kts at  $47.4^\circ$  on the bow. The faster you go, the more you push the wind forward.

## [6] [3] \*\* Route Sailings \*\*

Functions in this category are used to compute routes from a start position to the destination. These functions use the stored DR position and Dest position if they have been set in the Settings menus. Use option [5] to see what is stored in these positions, and then option [6] to change them as needed.

```

**Route Sailings**
1 Rhumbline
2 Great Circle
3 Traverse
4 Composite
5 View DR/Dest
6 Set DR Params...
7 Return

```

## [6] [3] [1] Rhumb Line

The **Rhumb Line** (RL) function computes the straight line course to the destination on a mercator chart and the corresponding distance. The course shown will be the one true course that will take you from departure to destination on a constant heading, assuming no current, no leeway, nor any other errors.

```

**Route Sailings**
1 Rhumbline
2 Great Circle
3 Traverse
4 Composite
5 View DR/Dest
6 Set DR Params...
7 Return

```

Consider the course between San Francisco, at  $37^\circ 50.8' N$ ,  $122^\circ 25.5' W$  and Yokohama at  $34^\circ 52' N$ ,  $139^\circ 42' E$ . Use [6] and [5] to input and check the results, shown below.

DR Position Lat?37.508 Lon?-122.255 Dest Position Lat?34.52 Lon?139.42	RL Crs(T)/Dist(NM) 267.8° 4752.3 GC Crs(T)/Dist(nm) 302.6° 4488.8 --More--
---	--

For comparison, the Great Circle results are also displayed for each RL computation. These latter data represent the shortest distance, but the shortest route is a curved track on a mercator chart. The GC course presented here is just the *initial heading* on the great circle route.

In this example, the straight line course on heading 27.8 True will take you there in 4752.3 miles, whereas the actual shortest route will be a curved one, starting off at a higher course of 302.6 T but eventually being a lower course than the RL heading. The GC course is shorter by 263.5 miles, but the actual heading of the course will vary throughout the passage.

The Great Circle sailing option below takes the curved GC route and breaks it up into a series of straight RL segments.

## [6] [3] [2] Great Circle Sailing

The Great Circle function computes the great circle distance between two points and the course heading to a series of way points, determined by a user input Lon interval ( $5^\circ$  is typical), on the great circle route to the destination.

The following sequence computes the great circle route between San Francisco, CA at  $37^\circ 50.8' N$ ,  $122^\circ 25.5' W$  and Yokohama, Japan at  $34^\circ 52' N$ ,  $139^\circ 42' E$ . Start by using [6] Set DR/Dest to input DR and destination, then check it with View DR/Dest [5] shown as first screen below.

```
DR Lat/Lon  037°50.8'
            -122°25.5'
Dest Lat/Lon 034°52.0'
            139°42.0'
--More--
```

```
**Route Sailings**
1 Rhumbline
2 Great Circle
3 Traverse
4 Composite
5 View DR/Dest
6 Set DR Params...
7 Return
```

```
ΔLon(Deg)?5
```

```
Dist(nm)/Course(T)
4488.76
302.6°
Next Lat/Lon
039°05.9'
-125°00.0'
--More--
```

```
Dist(nm)/Course(T) 4346.39
301.0°
Next Lat/Lon
041°15.2'
-130°00.0'
--More--
```

```
Dist(nm)/Course(T) 4083.26
297.8°
Next Lat/Lon
043°04.3'
-135°00.0'
--More--
```

and so on until the destination point is reached. Notice that the Lon has gone up  $5^\circ$  each step, and you are told the corresponding Lat if you are to plot this route on a mercator chart. In each screen you are give the distance left to travel (in nautical miles) and the initial course of that leg, which would generally be treated as the Rhumbline course to the next GC waypoint.

## [6] [3] [3] Traverse Sailing

The traverse sailing function **Traverse** finds the single equivalent course given by a series of headings and distances such as might result from a sailing vessel beating and tacking its way to a windward point.

```
**Route Sailings**
1 Rhumbline
2 Great Circle
3 Traverse
4 Composite
5 View DR/Dest
6 Set DR Params...
7 Return
```

Given, for example, the following course headings and distances,

```
158° 15.5 nm
135° 33.7 nm
259° 16.1 nm
```

we compute the following single equivalent course made good (CMG) and distance.

```
Enter 0 to End
Dist(nm)?15.5
Course?158
Dist(nm)?33.7
Course?135
Dist(nm)?16.1
Course?259
Dist(nm)?0
CMG/Dist(nm)
161.5°
43.53
--More--
```

Note that for the Dist (nm) input you can also put differences, ie “100-60” is a valid input for “40.” This can be handy for subtracting recorded log-book readings.

## [6] [3] [4] Composite Sailing

**Composite** sailing is a hybrid of the great circle function discussed above. When the great circle course between two points carries a vessel to a latitude higher than desired, then composite sailing may be used to good advantage. The composite track consist of a great circle course from the departure point to the limiting latitude, followed by a course line along the limiting parallel and then a second great circle course to the destination.

```

**Route Sailings**
1 Rhumbline
2 Great Circle
3 Traverse
4 Composite
5 View DR/Dest
6 Set DR Params...
7 Return

```

Consider the great circle example explored previously in this manual. To compute the composite track between San Francisco (34° 50.8 N, 122° 25.5 W) and Yokohama (34° 52 N, 139° 42 E) with a maximum limiting latitude of 45° N we would execute this function with the following parameters.

DR Position Lat?34.508 Lon?-122.255 Dest Position Lat?34.52 Lon?139.52 Limit Lat?45 Lon(Deg)?5	Dist(nm)/Course(T) 2165.61 300.5 Next Lat/Lon 036°02.0' -125°00.0'
---	---

First we compute a great circle course up to latitude 45° N.

Dist(nm)/Course(T) 140.00 272.3 Next Lat/Lon 045°00.0' -168°18.0'	Follow Meridian To Lat/Lon 045°00.0' -174°18.0'
--	--

Arriving at the limiting latitude we then follow the meridian to the designated parallel. The great circle course is then followed to the destination.

Dist(nm)/Course(T) 2163.25 270.0 Next Lat/Lon 044°59.9' -175°00.0'	Dist(nm)/Course(T) 284.74 242.5 Next Lat/Lon 034°52.0' 139°52.0'
---	---

### [6] [3] [5] View DR and Dest

This is just a quick way to check the settings used in the route sailings. If these are not right, then press [6] below to enter the ones you want.

### [6] [3] [6] Set DR params...

Takes you back to the settings menu so you can change DR or Destination as needed for a route computation.

### [6] [4] \*\* Current Sailings \*\*

The **Current Sailings** menu provides access to a series of functions for solving typical vector problems encountered when planning around currents. The menu is accessed via the **Utilities** menu and includes the following functions.

Note that all current sailings functions override the mag variation — all input and output are labeled True. We do this since current set data are usually given in True, so if you are working in magnetic for other headings you will need to first convert any magnetic headings to True to use these functions. Likewise, convert any output here to Magnetic if needed. Current set is always the true direction toward which the current flows, drift is always in knots. We use this convention to remind you that all input must be consistent, and the output will then match. You can, of course, use all magnetic inputs and then will get magnetic outputs, but the labels will still be “T.”

### [6] [4] [1] Course and Speed Made Good through Current

The **CMG and SMG** function computes the course made good and speed made good when the course steered and speed through the water are given. The current set and drift must also be known.

Given that the course steered is 080° T, the speed through the water is 10 knots, the set is towards 140° T, and the drift is 2 knots, the solution for the course made good (CMG) and speed made good (SMG) would be as follows.

**Current Sailings** 1 CMG and SMG 2 CTS and Speed 3 CTS and SMG 4 Find Current 5 Current Inters 6 Tide Inters 7 Return	Course(T)?80 Speed(kt)?10 Cur Set?140 Drift(kt)?2 CMG/SMG(kt) 088.9° 11.14
--	--

## [6] [4] [2] Course and Speed to Steer to Achieve a CMG and SMG

The **CTS and SPEED** function computes the True course to steer and the knotmeter speed required when the course to make good and speed to make good are given, and the set and drift of the current are known.

This type of problem is encountered when the arrival time is crucial after a passage through current. You know the CMG — where you are to where you want to go — and you know the distance there, and you know the time interval you have to cover it so you can figure the required SMG to get there on time. Knowing that, what course do I steer and how fast should I go? Note that the answer may not always be achievable with your vessel.

Given that the course to make good is 265°, the speed to make good is 15 knots, the set and drift of the current are 185 T and 3 knots respectively, we compute the course to steer (CTS) and knotmeter speed in following sequence.

<pre> **Current Sailings** 1 CMG and SMG 2 CTS and Speed 3 CTS and SMG 4 Find Current 5 Current Interp 6 Tide Interp 7 Return </pre>	<pre> CMG?265 SMG&lt;kt&gt;?15 Cur Set?185 Drift&lt;kt&gt;?3 CTS/Speed&lt;kt&gt; 276.5° 14.78 </pre>
--	--

## [6] [4] [3] Course to Steer at Given Speed to Achieve a CMG

Function **CTS and SMG** computes the course to steer and speed made good when the course to make good and speed through the water are given. Additionally, the set and drift must also be known.

Given the course to make good is 095° T, the speed to maintain through the water is 12 knots, the current set is towards 170° T, and the current drift is 2.5, the course to steer (CTS) and the speed made good (SMG) would be the following.

<pre> **Current Sailings** 1 CMG and SMG 2 CTS and Speed 3 CTS and SMG 4 Find Current 5 Current Interp 6 Tide Interp 7 Return </pre>	<pre> Speed&lt;kt&gt;?12 CMG?95 Cur Set&lt;deg&gt;?170 Drift&lt;kt&gt;?2.5 CTS/SMG&lt;kt&gt; 083.4° 12.4 </pre>
--	---

## [6] [4] [4] Find current from GPS

Input your SOG and COG from the GPS and also your knotmeter speed and course steered, and this function computes the set and drift of the current which would account for any difference between these two.

<pre> **Current Sailings** 1 CMG and SMG 2 CTS and Speed 3 CTS and SMG 4 Find Current 5 Current Interp 6 Tide Interp 7 Return </pre>	<pre> Course&lt;T&gt;?200 Speed&lt;kt&gt;?7.5 COG&lt;T&gt;?220 SOG&lt;kt&gt;?6.0 Curr Set&lt;T&gt;/Drift&lt;kt&gt; 332.2° 2.77 </pre>
--	---

We are sailing course 200 T at a knotmeter speed of 7.5 kts, the GPS tells us we are making good course 220 T at a speed of 6.0. The current we are in is 2.77 kts flowing toward 332.2 T.

Note, you should not use instantaneous values for the input, but rather watch the GPS, compass, and knotmeter outputs for some time to be sure you have realistic average values for the input. (You can input True or Compass headings, providing both inputs are the same, and then the set will be in those units as well.)

## [6] [4] [5] Tidal Current Interpolator

The **Current Interp** function is used to find the velocity of a tidal stream given the time of slack and maximum tide and the maximum velocity of the tide. For example, to find the tidal velocity at 3h 30m given a slack water at 1h 42m and a peak current flow at 4h 43m with a drift of 4.6 knots one would execute the following.

```

**Current Sailings** Time Slack?1.42
1 CMG and SMG Time Max?4.43
2 CTS and Speed Max Speed?4.6
3 CTS and SMG Enter 0 to End
4 Find Current Sel Time?3.3
5 Current Interr Tide Velocity(kt) 3.71
6 Tide Interr Sel Time?0
7 Return

```

## [6] [4] [6] Tide Height Interpolator

The **Tide Interp** mode computes the height of tide at any selected time given the time height of low and high tide. To compute the height of the tide at 7h 35m given that the time and height of low tide is 1h 45m at 0.6 feet and the time and height of high tide is 9h 06m at 11.9 feet one executes the following sequence.

```

**Current Sailings** Height Low?0.6
1 CMG and SMG Time High?9.06
2 CTS and Speed Height High?11.9
3 CTS and SMG Enter 0 to End
4 Find Current Sel Time?7.35
5 Current Interr Tide Height 10.75
6 Tide Interr Sel Time?
7 Return

```

Note that the computed tide height is displayed using the same units as the input low and high tide. If the tide heights were to be entered in meters, for example, then the result would also be displayed in meters.

Note also that both the Tidal Current Interpolator and the Tide Height Interpolator offer the option to compute multiple values from the same input.

## [6] [5] \*\* Celestial Utilities \*\*

The functions found in this grouping compute miscellaneous tasks based on celestial sightings. All the functions are controlled by settings entered in the Settings Menus such as Date and DR Lat/Lon.

### [6] [5] [1] Meridian Passage of the Sun for both Lat and Lon

Measure the peak height of the sun at noon and note the GMT of the event. The height will give your latitude, the time will determine your longitude. For example, Hs max for lower limb sun viewed to the south on Mar 4, 2000 at 20h 55m 30s was 35°

15.2'. IC=2.0' ON, HE=9 ft. The following sequence yields the position of the observer to be 48° 31.0' N, 130° 59.2' W. Note that since the Sun is observed to the "South" a negative (-) value is used to represent the altitude of the Sun. Sun sightings towards North are positive.

```

**Celestial Utils** WT?20.5530
1 Lat/Lon by Mer Pas Day?4
2 Lat by Polaris Month?3
3 UT by Lunar Dist Year?2000
4 List Stars IC(Min)?-2.0
5 SR Naut Almanac... HE(ft)?9
6 Compass Cal LIM 1=U, -1=L?-1
7 Return HS?35.152

```

```

HE(ft)?9
LIM 1=U, -1=L?-1
HS?35.152
-1=S, 1=N?-1
Lat/Lon 048°31.0'
-130°59.2'
--More--

```

This function reads the settings, so if non-zero to begin with, you must go in and set them properly. Also note that although accurate peak sextant height is relatively easy to obtain underway, accurate time of the peak is not. Much care must be taken to determine this value accurately from a series of sights. In general, a simple running fix from two sets of sunlines is a more reliable approach to finding position from the sun.

To best use this function, take a series of sights spanning LAN as shown in the Sight analyzer section [4] [3], then analyze them that way to get the best values of Hs max and time of LAN. If that curve and the fit looks good, then chances are this is a reasonable fix. Note that with such a large set of data you might also try just computing a fix for comparison. Also compare the plot of all these LOPs, zoomed in to the fix position.

### [6] [5] [2] *Polaris* sightings for Latitude and Azimuth

The **Lat by Polaris** function provides for an alternate method of obtaining an observer's latitude using the pole star *Polaris*. Suppose vessel at DR

position 12° N, 65° W observes Polaris with an altitude of 12° 30' at 2200 GMT on January 1, 1998 from an observation height of 10 feet with no index error. The vessel's latitude, actual azimuth for Polaris, and intercept can be obtained using the following sequence.

```

**Celestial Utils**
1 Lat/Lon by Mer Pas
2 Lat by Polaris
3 UT by Lunar Dist
4 List Stars
5 SR Naut Almanac...
6 Compass Cal
7 Return
UT?22
Day?1
Month?1
Year?1998
Lat?12
Lon?-68
IC(Min)?0
HE(ft)?10

Day?1
Month?1
Year?1998
Lat?12
Lon?-68
IC(Min)?0
HE(ft)?10
HS?12.3

Lat/Zn/Int(nm)
011°45.9'
000.4°
-14.1
--More--

```

This routine would also be used to determine the **azimuth of Polaris** for compass or gyro calibration or for any surveying application that needed precise bearing reference.

Note that LOPs based on Polaris can also be obtained using standard sight reduction procedures such as the one described in the “Celestial Sight Reduction” sections of this manual (Section [3][2]).

## [6] [5] [3] GMT by Lunar Distance

The Lunar Distance Method for determining time (often called “Lunars”) was developed during the mid 1700s to synchronize inaccurate chronometers enabling the determination of Longitude. The method presented here can be used to set time to within 1 minute of accuracy -- sometimes rather better. Although, not as accurate as using a short wave radio tuned to WWV, it is included in the event that some accident prevents the setting of time by more conventional methods.

Time may be determined by measuring the angle between the Moon and any of the 179 bodies in the almanac (Sun, 5 planets, and 173 stars). Time can be set most accurately when measuring the Lunar-

Solar distance (or angle) and decreases with accuracy for lunar-planetary distances and it is at its worst when measuring angles between the moon and stars. The faster the ground movement of the celestial bodies, the better the time accuracy.

When measuring Lunar-solar distances, 1' of arc error in the reading of the angle yields about 3 minutes of error in time. It is, therefore, crucial that all lunar distances be measured as accurately as possible. Unfortunately, Lunar-solar angles can only be measured about 7-10 days a month. If the Lunar-solar distance cannot be measured then the navigator can measure angles between the moon and one of the 5 visible planets or a bright star on the ecliptic.

With IC = 0, and HE = 10 ft., to compute the correct GMT using the outer rim of the sun and the moon's inner rim with an angle of 62° 41.8' on June 19, 1998 at 12° 46' N, 70° 22 W at approximately 11h 54m 05s GMT, one would execute the following sequence. The inner rim of the moon corresponds to the rim closest to the body used in the measurement. A bodies outer rim is the rim farthest away from the moon. After entering the time, date, position, StarPilot then prompts for the body against which the moon is measured and inner/outer rims used in the measurement.

```

**Celestial Utils**
1 Lat/Lon by Mer Pas
2 Lat by Polaris
3 UT by Lunar Dist
4 List Stars
5 SR Naut Almanac...
6 Compass Cal
7 Return

UT?11.5405
Day?19
Month?6
Year?1998
DR Position
Lat?12.46
Lon?-70.22

**Body for Lunars**
1 Sun
2 Star
3 Planet
4 No Sun
5 No Star
6 No Planet
7 Return

```



tions in this menu group, the program will not prompt for either the DR LAT/LON and/or the local magnetic variation if they have been previously set in the "Settings" menu (Section [S1][3] and [S4][4]).

```

**Celestial Utils**
1 Lat/Lon by Mer Pas
2 Lat by Polaris
3 UT by Lunar Dist
4 List Stars
5 SR Naut Almanac...
6 Compass Cal
7 Return
  
```

```

WT?13.3      Year?1975
Day?3        Lat?35.15
Month?6      Lon?-70.25
Year?1975    Local Mag Var(d.m)
Lat?35.15    W=(-)?-7.15
Lon?-70.25   Sun Shadow Angle
Local Mag Var(d.m) 281.6
W=(-)?-7.15  --More--
  
```

If your compass pin shadow is at, say, 280, then your compass is too low on that heading by 1.6°.

You can use the precompute function to do this as well, but there is more arithmetic. You will find that the Zn of the sun is 094.3 T and the reciprocal at 274.5 T which is 281.6 M accounting for the variation of 7.25°. The bearing to any body can be used for a compass check using the precompute function. Use PC mode = Normal for this, not Fast, since generally one does want accuracy to the tenth of a degree for compass calibration.

## [6] [6] Piloting

The "Piloting" menu consists of miscellaneous routines used to help in piloting a vessel. ETA is also included in this section.

### [6] [6] [1] ETA

Computes Estimated Time of Arrival in destination time zone using either computed great circle distance or an input distance. It can account for a fixed delay along the way called Bunk T (bunkering). Example (from a USCG exam): leave Capetown at 0530 (ZD = -1) on Dec 20, 1981 bound for New York at ZD + 5, estimated SMG = 25 kts, distance = 6762 miles. What is arrival time with no delays under-

way? Note that this function will read stored ZD, date, DR and Destination positions if non-zero. Setting 4-2 clears all if desired, in which case all required inputs will be prompted for. Else check settings (1-6) to confirm what is stored.

```

1=GC,0=Other?0
WT?5.30      Dist(nm),Transit,ETA
Day?20       WT?5.30      6762
Month?12     Day,Hr:11    006:28:48
Year?1981    (D/M/V)= (31/12/1981)
DR ZD?-1     005:58:48
Bunk T(h.ms)?0
SMG(kt)?25   --More--
  
```

In line 1, "other" means user inputs the distance to travel, next is speed made good (SMG), then the destination ZD (not shown above). The answer would be 0559 Dec, 31. The option 1= GC, means you then input DR and destination positions and StarPilot will automatically compute the Great Circle distance and use it for the computation.

## [6] [6] [2] Distance Off by vertical Sextant Angle

The sextant is a powerful piloting tool for determining distance off a landmark whose height is known. This can be used for distances that are tens of miles off, on down to less than a mile off. It can also be used to find distance off of objects whose height is not known, provided they are fairly close and viewed from a higher eye height.

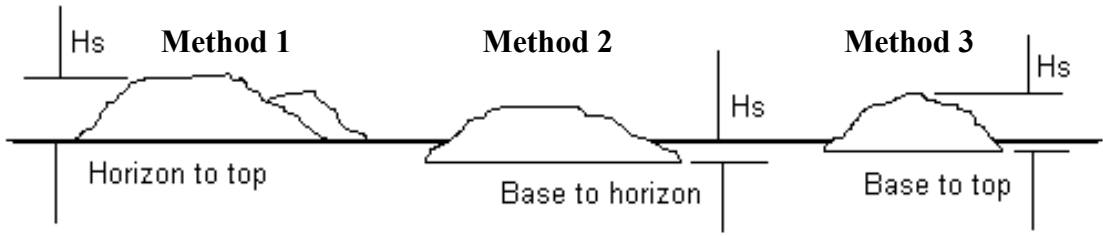
```

**Piloting**
1 ETA
2 Dist by Sextant...
3 Dist by 2 Bearings
4 Add Times
5 Add Angles
6 Geographical Range
7 Return

**Dist by Sextant**
1 Horizon to Top
2 Base to Horizon
3 Base to Top
4 Return
  
```

The three conditions illustrated below. The required input are: IC, HE (they will be prompted for at each sight regardless of SR mode which applies only to sight reductions) and sextant angle. Method 3 does not require an HE as it assumes you see the base from where ever you are.

Here are typical examples for IC=2.0' (off the scale), and HE = 30 feet.



**Case 1a (base hidden, over the horizon)**, mountain height = 3520 ft,  $H_s = 1^\circ 34'$ , answer = 19.9 nm.

**Case 1b**, mt height = 3520 ft,  $H_s = 0^\circ 25'$ , answer = 47.35 nm — a very clear day.

**Case 2, (base showing, distinctly closer than horizon)**. Sextant height = base to horizon =  $12'$ . Answer = 0.88 nm, at HE = 30 ft. Note that at HE = 9 ft, the answer = 0.3 nm; and at HE = 80 ft, answer = 2.0 nm. As an aside, this function is one way to investigate how far off a shoreline has to be to be useful for an index error check. It can also sometimes be used to determine how far off a vessel is.

**Case 3 (base to top)**, hill height = 460 ft,  $H_s = 2^\circ 30'$ , answer = 1.7 nm. This is the most common use of this technique for close in piloting, whereas method 1 is more common for coastal runs and for judging larger distance off at first landfall.

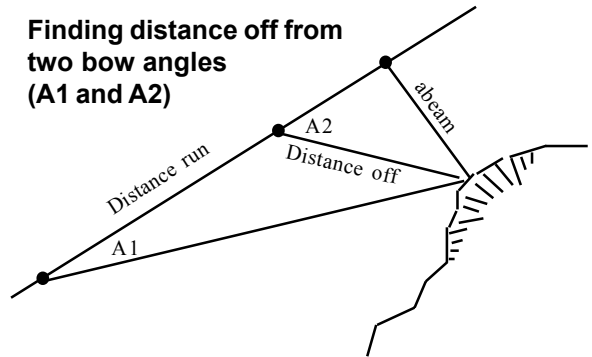
Method 2 is not a common technique as it requires higher precision in measurements which are themselves not available very often. All 3 methods lend themselves well to testing by radar or GPS so that when these electronic aids are not available we can fall back on the trusty sextant.

## [6] [6] [3] Distance Off by Two Bearings

The function computes distance off at the second bearing and the distance you will pass abeam based on two bearings and a distance run between them. The procedure assumes a constant course. Bearings are bow bearings, equal to the difference between actual bearing and vessel heading.

For example, given an initial angle on the bow to an object is  $18^\circ$  (A1) and after a distance run of 1.7 nautical miles the angle to the same object is

### Finding distance off from two bow angles (A1 and A2)



$45^\circ$  (A2), then you must now be 1.2 miles off the object, and if you carry on on this same course, it will pass 0.8 miles off at closest point when abeam.

```

**Piloting**
1 ETA
2 Dist by Sextant...
3 Dist by 2 Bearings
4 Add Times
5 Add Angles
6 Geographical Range
7 Return

```

Brng1?18
Brng2?45
Dist Run(nm)?1.7
Dist@Brng2/Dist@Beam
1.2
.8
--More--

If you are taking compass bearings to the object when on course 205, for example, you can also do the input as:

```

Brng1?223-205
Brng2?250-205
Dist Run(nm)?1.7
Dist@Brng2/Dist@Beam
1.2
.8
--More--

```

This is a versatile piloting technique. For charted objects it gives a position fix, but it can also be used without reference to a chart.

### [6] [6] [4] Add Times

This function provides a simple way to add or subtract times in h.ms format. The average value is also printed. The example below is: 12h 4m 12s - 32m + 1h 0m 4s = 12h 32m 16s. Just enter 0 when you want to stop the entry sequence.

```

**Piloting**
1 ETA
2 Dist by Sextant...
3 Dist by 2 Bearings
4 Add Times
5 Add Angles
6 Geographical Range
7 Return

```

h.ms?12.0412
h.ms?-0.32
h.ms?1.0004
h.ms?0
Sum/Mean
12:32:16
04:10:45
--More--

You can also get to this function from [CUSTOM] [MORE] [F4].

### [6] [6] [5] Add Angles

This function provides a simple way to add and subtract angles. In addition to the sum, the average value is also printed. In the following example we do:  $120^{\circ} 43.0' + 5^{\circ} 58.4' - 10^{\circ} 3.5' = 116^{\circ} 37.9'$

```

**Piloting**
1 ETA
2 Dist by Sextant...
3 Dist by 2 Bearings
4 Add Times
5 Add Angles
6 Geographical Range
7 Return

```

d.m?120.43
d.m?5.584
d.m?-10.035
d.m?0
Sum/Mean
116°37.9'
038°52.6'
--More--

You can also get to this function from [CUSTOM]

[MORE] [F5].

### [6] [6] [6] Geographical Range

Geographical range is needed to predict the visible range of a light or land given the height of the object above the waterline. The function prompts for height of eye and height of the object. It then computes the geographical range. The following example predicts the geo range of a light 125 ft high when observed from an eye height of 10 feet above sea level. The answer is 16.35 nautical miles.

```

**Piloting**
1 Dist Sextant Close
2 Dist Sextant Far
3 Dist by 2 Bearings
4 Add Times
5 Add Angles
6 Geographical Range
7 Return

```

HE(ft)?10
Height of Object
H(ft)?125
Geo Range(nm)
16.35
--More--

The geographic range is the distance off at which the object first appears or disappears over the horizon viewed from a specific height of eye. The visible range of a navigation light will be the smaller of its geographic range and its luminous range. Luminous range depends on the prevailing atmospheric visibility and can be read from tables in the Light List. It is the same as the charted nominal range in clear weather.

## Appendix 1. Almanac Precision Specs

StarPilot uses internally 3 levels of precision when doing almanac computations, Fast, Normal, and High. These variations are present to expedite the various auxiliary functions. For moon sights used purely for planning purposes, for example, we can save minutes of computation time for a modest sacrifice in accuracy, when this accuracy is not needed.

All sight reductions, on the other hand, are performed automatically with the highest precision in the High Mode. There are no user options on this setting for sight reductions.

The accuracy specifications for the various modes are shown in the Table 1. High mode matches the precision of the Nautical Almanac, although specific comparisons might differ by a tenth or two since that is the limit of the Nautical Almanac's stated precision, which is discussed in that publication.

We use Fast mode for Sight Planner, Star/Planet ID,

and for moonrise and moonset. These are planning functions that do not require precision to the tenth. For sunrise/sunset, however, we use the High Precision mode for this function since it might be used in an emergency as a way of finding time from a known position.

Compass calibration, Lat by LAN, and Lat and Azimuth of Polaris use High mode.

Users do have the option of Normal vs. High in the Precompute function. For sun and stars this will make little difference in time or precision, but for moon and planets the time savings is significant. Hence if you are precomputing for just planning or identification or data analysis (i.e. calculating the slope of a set of data for example), then Normal would be adequate and faster, but if you want high-precision results, then use the High mode. This choice is made with the PC Mode [S2] [6]. Again, the choice made here affects only the Precompute function, all other functions have internally fixed almanac precision modes.

**Table 1.** Summary of Almanac Precision modes used in StarPilot [NOTES]

	<b>Fast</b>	<b>Normal</b>	<b>High</b>
Sun	Good-Med [A]	10" [B]	2" [C]
Moon	Low [A]	Low [N]	10" [D]
Mer, Ven, Mar	Med [E]	Good [F]	10" [C]
Jup, Sat	Med, Low [H]	Good, Low [I]	10" [J]
173 Stars	10" [L]	2" [M]	2" [M]

### NOTES to Table 1.

All precision modes are acceptable for the computation of positions at sea with the possible exception of those listed with "low" precision. Modes listed as "low" may cause errors to intercept of up to several miles. Medium precision algorithms result in errors to intercept of less than 0.5 miles. Numeric values for maximum errors in precision are in seconds of arc. Please refer the listed Refer-

ences (Appendix 4) for further discussions on the accuracy of the methods used.

- A. Keplerian orbit using planetary elements for ecliptic circa 1990. Accuracy is approximately 10" of arc and increasing in error as one departs in time from the epoch. (Ref: 9)
- B. Keplerian orbits using planetary elements for ecliptic of date. Corrections for nutation and aberration are

also included. (Ref: 7, 9).

- C. Planetary programs are used to analytically compute positions. Corrections for nutation and aberration are also included. (Ref: 10, 9)
- D. ELP-2000/82 Lunar theory is used in addition to corrections for nutation and aberration. (Ref: 7,9)
- E. Keplerian orbits are computed using planetary elements for ecliptic of date. (Ref: 9)
- F. As in B with corrections for planetary aberration. (Ref: 7, 9)
- H. As in E with additional corrections for Saturn and Jupiter. (Ref: 9)
- I. As in F with additional corrections for Saturn and Jupiter. (Ref: 7, 9)
- J. Planetary tables are used for the period 1960-2100 AD. For years not in the stated period VSOP 87 planetary theory is used. Corrections for nutation and aberration are also included. (Ref: 10,7,9)
- L. Star positions for the ecliptic of 1975 are transformed to the positions relative to the ecliptic of date. (Ref: 3, 9)
- M. As in L with additional corrections for nutation and aberration. (Ref: 3, 9)
- N. As in A with corrections for nutation and aberration. (Ref: 3, 9)

## Appendix 2. Capturing Screens

All the screen captures in this Guide were captured using TI-GraphLink. You may want to capture your own for records of fixes, fits or other reasons, to paste into a log book or email to a friend. The Get Screen function is also a quick way to test that the Link between calculator and PC has been made.

### Procedure:

- (1) Connect StarPilot to your PC with Link cable and start TI-Graph Link program with TI-86 turned on.

- (2) Set up StarPilot to show on the screen what you want to capture.

- (3) Under the Link menu, select Get Screen, and then click the "Get Screen" button.

- (4) After it shows the screen, click "Clipboard" and that copies the image to your Windows clipboard. You can also choose to have the clipboard image be larger or smaller than shown.

- (5) Then paste the image into your favorite graphics program or even a page in MS Word, or an e-mail document.

**NOTE:** the size of the capture can be adjusted in the Get Screen window, but we have also noticed that the final size of the capture also depends on the font size selected on your PC display.

## Appendix 3.

### Transferring Data to and from a PC

This is a powerful feature of StarPilot that lets you save data from one sight session to a PC and then later reload it into the calculator for more analysis or plotting. It would be a good way to archive the full set of sights from a long passage. If you have not done so already, you must install the Graphlink software provided with the StarPilot into your PC.

### Procedure, StarPilot to PC:

- (1) First use Windows Explorer to set up a convenient folder (directory) structure for storing your sights.

- (2) Connect GraphLink cable, open GraphLink software, turn on calculator, and select Receive from the Link menu, and you will see the Receive TI-86 Files window.

- (3) Wait a moment until all the internal StarPilot files

have been loaded into the **File Name** window. Then scroll down this list to find the one called

L6.86l.

This is the file that includes all of your settings. Highlight it and click **Add** to move it to the **File Selected** column. Then do the same with

N.86n,

the number of sights, and

Site.86m,

the actual sight data.

(4) When these three are in the File Selected list, check the box that says group files, then click **OK**, and you will be presented with the Target Directory window that lets you choose the folder you set up for the sights in Step 1 and assign the group a name. Note the name must be 8 or less characters. You might at the same time make a txt file that you can use as an index to make notes on which sights and settings are in which files.

(5) Browse to the folder you wish to use and click OK. This will start the transfer and display the Sending window, and a few seconds later will tell you that the process is completed and the new file (unamed.86g) will now be in your chosen directory.

That is all there is to it. In the next section we show the reverse process for putting the sights back into the calculator. Note that copying the data from calculator to PC does not alter the data in the calculator. To test this procedure, load the calculator with a set of sights, then move them to a PC and then do Set Defaults. Check that you have no sights and all is zeros or default values, then reload the sights to see that they are now all back in and your calculator is in precisely the state you exported.

#### **Procedure, PC to StarPilot:**

This is exactly the same as when you load StarPilot into your TI-86 in the first place, if you did that.

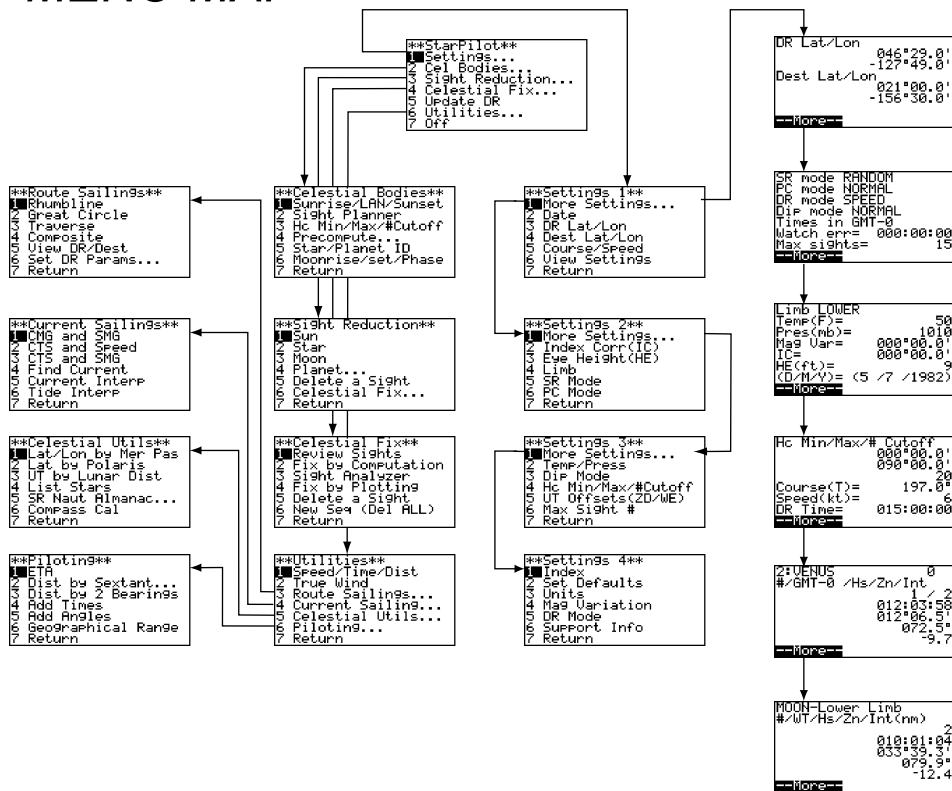
Follow the previous procedure but use the Send command, instead of Receive to load the group back into the calculator. This process will overwrite the sight data stored in the calculator. When it asks to overwrite, say overwrite all.

## Appendix 4. References and Bibliography

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**For the latest information on the StarPilot program** including more examples and articles on various aspects of celestial navigation, please see [www.starpilottllc.com](http://www.starpilottllc.com). Information is located in the Celestial Navigation section, the Resources, and in the Tech Support.

# MENU MAP



Setting .....	location		
Course/Speed .....	[S1] [5]	Max sight # .....	[S3] [6]
Date .....	[S1] [2]	PC Mode .....	[S2] [6]
Defaults .....	[S4] [2]	Set Defaults .....	[S4] [2]
Dest Lat/Lon .....	[S1] [4]	Speed/Course .....	[S1] [5]
Dip Mode .....	[S3] [3]	SR Mode .....	[S2] [5]
DR Lat/Lon .....	[S1] [3]	Support Info .....	[S4] [6]
DR mode .....	[S4] [5]	Temp/Press .....	[S3] [2]
Eye Height (HE) .....	[S2] [3]	Units .....	[S4] [3]
Hc min/max/#cutoff .....	[S3] [4]	UT offset (ZD/WE) .....	[S3] [5]
Height of Eye (HE) .....	[S2] [3]	View Settings .....	[S1] [6]
Index Corr (IC) .....	[S2] [2]	Watch Error.....	[S3] [5]
Limb .....	[S2] [4]	Zone Description .....	[S3] [5]
Mag Variation .....	[S4] [4]	Setting .....	location