STARPATH®

CELESTIAL NAVIGATION WORK FORMS

For All Sights and Tables, with Complete Instructions and Examples

Starpath work forms have been used for a long time.

By David Burch
Author of *Celestial Navigation: A Complete Home Study Course*

Contents

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Overview of Starpath Work Forms

Not all celestial navigators use work forms to help with the paperwork, but I think it's fair to say that most do. Or they at least like to have the forms at hand just in case they are needed (even very experienced navigators). There are a lot of steps in some of the reductions, and we may have to do the work when we are very tired and not feeling well, as the boat rocks around in the seas. Having a guide that takes us step by step, with little thought required, can be a blessing. So even if you do not use them routinely, it is good practice to add them to your checklist and have at least one of each type tucked away in the *Almanac*. Also, these days we rely mainly on GPS; so we might be rusty when we need to do the sights. These forms will remind you of the steps involved and guide you though any sight reduction. Those who want to use them routinely can duplicate the ones needed most from this book.

There are one or more forms for all routine sights using various sight reduction methods. Each has annotated step-by-step instructions for filling out the forms, which in themselves are a good refresher for the process. After a little practice, the forms are all we need to work through the sight reductions.

The main Form 104 for all sights has three levels of guidance. The long instructions with details of each step, the short instructions, which abbreviates the steps, and finally the forms themselves, which are organized in a logical, numbered format that guides you though the process.

After teaching celestial navigation for 40 years using our basic Form 104, we have heard back many times from navigators who have been away from the subject for a long time, who told us how easy it was to recall the paperwork with the use of these forms. This was, of course, an intention of the forms, along with the main design criteria that they allow all sights to be done essentially the same way. Another goal was to have a place to write in every step of the process, and to have some reasonable element of smooth flow throughout. Alternative designs that one sees are typically vertical strip forms that usually do not meet any of these criteria. Form 104 and the detailed instructions included here are effectively a short course in celestial navigation.

Our Form 106 for the Nautical Almanac Office (NAO) Tables included in every *Nautical Almanac* are especially valuable, because the instructions for the process given in the *Nautical Almanac* are difficult to follow. As a result of that problem, these valuable sight reduction tables have not been used as much as they deserve. Some instructors go so far as to ridicule the NAO Tables for their complexity, driving new users away before they even get to try them. Misguided magazine articles have not helped. Our Form 106 makes the process very simple, and with just a few samples worked, you will be doing them routinely with nothing but the form to look at.

The NAO Tables have a great virtue these days when cel nav is often just a back up to GPS. Since there is a full set of the NAO Tables in every *Nautical Almanac*, you just need to buy one book to have a complete solution. Pub 249, and especially Pub 229, are large, heavy books when it comes to stowage on a small boat at sea. Also if you choose to do sight reduction by computation, then the NAO Tables as part of the Almanac are a natural back up.

Likewise with the more basic reductions of Latitude at LAN and Latitude by *Polaris*, we have longer forms (Form 107 and 110) with more details of the process along with a combined short form (117) to use once the procedures are recalled.

About This Booklet

This booklet explains the motivation of the individual forms and provides detailed instructions on using them with numerical examples. We also include notes on the history of the NAO Tables and discussion of the relative merits of the various sight reduction methods. There is also a set of blank forms provided of each type, the most of which being our primary Forms 104 and 106.

The main goal of this booklet is to provide the instructions and examples with enough printed forms to allow them to be evaluated by those who do not have ready access to a printer. Blank forms in PDF format suitable for printing are available at no charge.

Where to Download Free Forms

These forms are used in our textbook *Celestial Navigation: A Complete Home Study Course,* as well as in our Online Course in Celestial Navigation. To support these training programs and the marine navigation community more generally, we offer a free, complete set of the forms in a PDF file that can be printed for further use. These and other resources are available on the support page for our text at:

www.starpath.com/celnavbook.

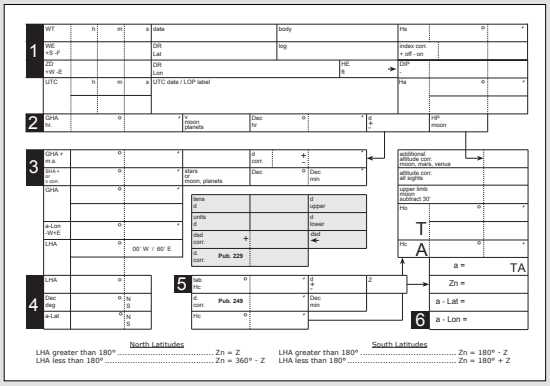
Readers are welcome to download and reproduce these forms for their personal use.

Note to Ebook Readers

The ebook editions of this booklet are intended only to provide a convenient reference to the discussions, instructions, and numerical examples used in the forms. The forms themselves are available from the link above. This way the instructions can be kept in a phone or tablet for quick reference as needed, and only the chosen forms need to be reproduced. Also, the design of the forms alone may be all that is needed to solve the reductions using a blank piece of paper.

FORM 104

All bodies, using Pub 249 or Pub 229



Sun Sights with Form 104

BOX 1–Sight Data

Record the watch time (WT), watch date, log reading, celestial body, measured index correction, and sextant reading (Hs) for the sight. Find the watch error (WE) and the zone description (ZD) of the watch from WWV radio broadcasts or chronometer logbook, and apply these to WT to get the universal time (UTC) of the sight. Use the extra space provided to adjust time and date if necessary. Choose and record a LOP line of position (LOP) label for the sight. From your dead reckoning (DR) track on a chart or plotting sheet, figure your DR position (DR-Lat and DR-Lon) and log reading at the time of the sight. Record your height of eye (HE) for the sight.

BOX 2–*Nautical Almanac* Daily Pages

From the *Nautical Almanac* daily pages, record the Greenwich hour angle (GHA-hr) and declination (Dec-hr) of the sun at the exact hour of the UTC. Record the declination d-value, and label it "+" if declination is increasing with time, or "-" if decreasing. Cross out the spaces for v-value and HP; they do not apply to the sun.

BOX 3–Increments and Corrections

From the increments and corrections pages of the *Nautical Almanac*, record the sun's increment of GHA (GHA-m,s) for the minutes and seconds part of the UTC. Also record the d-correction to the declination based on the d-value given in Box 2. Cross out the SHA or v-correction space; these do not apply to the sun.

Add GHA-hr to GHA-m,s to find GHA and record it. Apply the d-corr to Dec-hr to find Dec and record it. The sign (±) of d-corr is the same as that of d-value. Use the extra space provided to adjust minutes to less than 60 if necessary. You now have the GHA and Dec that apply for your precise UTC. For later use, record the degrees part of the declination (Dec-deg) in Box 4 with a prominent N or S label, and also record the minutes part (Dec-min) in Box 5.

Assumed Position and Hour Angle

Figure the assumed longitude (a-Lon) from your DR-Lon and the minutes part of GHA. In western longitudes, it should be the one longitude that lies within 30' of your DR-Lon that has the same minutes as the minutes part of GHA. In eastern longitudes, it should be the one longitude that lies within 30' of your DR-Lon that has minutes equal to 60 minus the minutes part of GHA. Record a-Lon below GHA and also in Box 6. Figure the local hour angle (LHA) from:

$$LHA = GHA - a\text{-}Lon(W)$$

in western longitudes or

$$LHA = GHA + a\text{-}Lon(E)$$

in eastern longitudes. With the proper choice of a-Lon, LHA will always be in whole degrees with no minutes left over. Record LHA in Box 4.

Choose the assumed latitude (a-Lat) as your DR-Lat rounded off to the nearest whole degree. Record a-Lat in Box 4 with a prominent N or S label. Also record a-Lat in Box 6.

BOX 4 and BOX 5–Sight Reduction Tables

Box 4 now contains all data needed to enter the Sight Reduction Tables, Pubs. 249 or 229. Same or Contrary Name labels of Dec and a-Lat are clear at a glance.

From the Sight Reduction Tables, record in Box 5 the tabulated value of the calculated altitude (tab Hc), the d-value with its tabulated sign (±), and the azimuth angle (Z).

Convert the azimuth angle (Z) to the azimuth (Zn) using the rules on the work form (also given on each page of the Sight Reduction Tables) and record it in Box 6. CAUTION: For "high-altitude" sights, meaning Hc above 70° or so, you should interpolate for Z to account for the minutes part of Dec. Use:

$$Z = Z(\text{Dec-deg}) + dZ,$$

where

$$dZ = [Z(\text{Dec-deg} + 1^\circ) - Z(\text{Dec-deg})] \times (\text{Dec-min})/60.$$

Hs to Ho

The upper right side of the work form is used for converting the sextant altitude (Hs) to the observed altitude (Ho). Altitude corrections are inside the covers of the *Nautical Almanac*. Record the dip correction and apply dip and index corr to Hs to get the apparent altitude (Ha).

Cross out the additional altitude corr space and the upper limb moon space; these do not apply to the sun.

Record the altitude correction for the sun and apply it to Ha to get Ho. Compare Hc and Ho in the space provided above Box 6. Subtract the smaller from the larger to get the altitude intercept (a). Extra space is provided to rewrite Ho or Hc if necessary for this subtraction. Choose the label, A for Away or T for Toward, which is beside the larger of Hc or Ho, and record the a-value and mark its label in Box 6.

Form 104 — Pub 249 (v2, v3) and Pub 229

1	WT	14 h	50 m	12 s	date	July 11, 1986	body	LL Sun	Hs	49°	48.5′
	WE +S -F			-8	DR Lat	25° 13′ N	log	2606	index corr. + off - on		+1.5′
	ZD +W -E	+10			DR Lon	147° 15′ W	HE ft	9 →	DIP -		-2.9′
	UTC	24 h	50 m	04 s	UTC date / LOP label	0050 July 12 / 1450 ⊙			Ha	49°	47.1′
	=	00	50	04							
2	GHA hr.	178°	37.6′	v moon planets	Dec hr	N 22°	2.6′	d + - -0.4	HP moon		
3	GHA + m.s.	12°	31.0′		d corr. + -	-0.3′			additional altitude corr. moon, mars, venus		
	SHA + or v corr.	°	′	stars or moon, planets	Dec	N 22°	Dec min	2.3′	altitude corr. all sights		+15.2
	GHA	191°	8.6′						upper limb moon subtract 30′		
	a-Lon -W+E	-147°	8.6′		tens d		d upper		Ho	49°	62.3′
	LHA	44°	00′ W / 60′ E		units d		lower		T		
					dsd corr. +		dsd				
					d. corr. Pub. 229				Hc A	49°	43.3′
4	LHA	44°		5	tab Hc	49°	43′	d + - +13	Z 085	a =	19.0 T
	Dec deg	22°	N S N		d. corr. Pub. 249		0.3′	Dec min 2.3′		Zn =	275°
	a-Lat	25°	N S N		Hc	49°	43.3′		6	a - Lat =	25° N
										a - Lon =	147° 8.6′ W

Figure 104-1. *Sight reduction of the sun using Form 104 and Pub 249. The crossed out box is for Pub 229 only.*

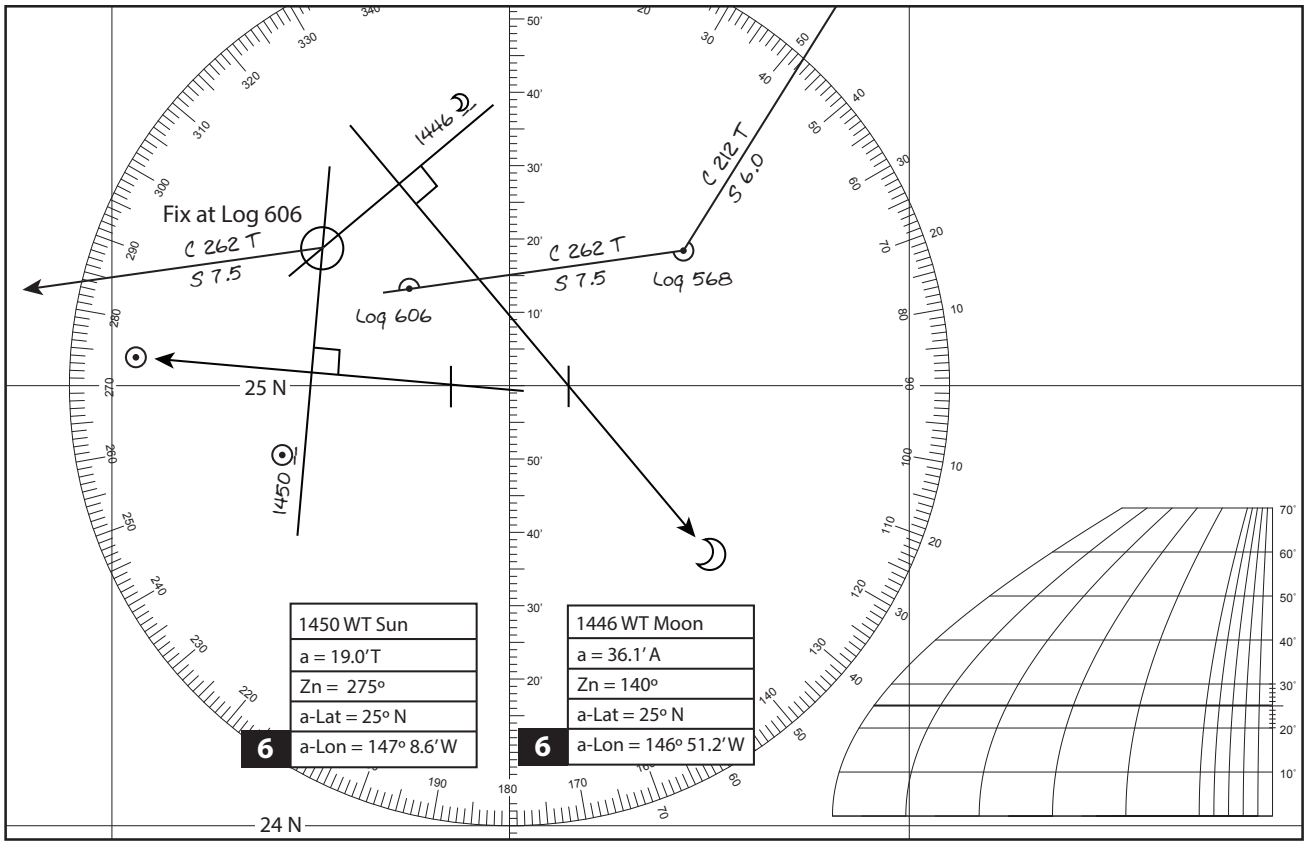
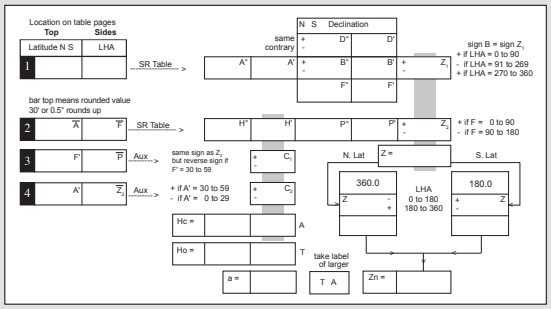


Figure 104-2. *Plot of a celestial fix from a sun and moon sight. The work form for the sun is shown in Figure WF-1. The moon sight is shown worked out on the next page in Figure 104-3.*

FORM 106

All bodies, using NAO Tables



About the NAO Tables

Starting in 1989, there was a significant change in the available tables for celestial navigation. Prior to then, Sight Reduction Tables were usually chosen from Pub 249 (most popular with yachtsmen) and Pub 229, which is required on USCG license exams. The latter have more precision, but this extra precision would rarely affect the final accuracy of a celestial fix from a moving vessel in routine circumstances. Pub 229 is much heavier, more expensive, and requires a couple extra steps.

In 1989 the Nautical Almanac Office (NAO) began to include a set of Sight Reduction Tables at the back of the *Nautical Almanac*. Now when you buy an almanac, you get a set of Sight Reduction Tables with it, even if you don't intend to use these tables. As always, the almanac data must be replaced each new year with a new almanac, but the Sight Reduction Tables they include each year will be the same. Like all standard Sight Reduction Tables, these are not dated and can be used for sights from any year. We coined the nickname "NAO Tables" at the time, and it seems to have stuck.

The tables are very short, but they will reduce any sight, and provide the same Hc precision as the Pub 249 tables (0.5', rounded to nearest 1') and the same azimuth precision (0.05°, rounded to nearest 0.1°) as the Pub 229 tables. The price we pay, however, for a free set of concise tables is the amount of work necessary to get the numbers out of them.

All Sight Reduction Tables start with Lat, LHA, and Dec and end up with Hc and Zn. With Pub 249, the answer is obtained in two steps. With Pub 229, it takes three steps, sometimes four, and with the new NAO tables it always takes four steps with some adding and subtracting between the steps.

At first glance, the NAO Tables are awkward to use and not an attractive alternative to Pub 249. There are several reasons, however, to not rule them out too quickly. First, they will always be there. As of 1989, everyone has them, like it or not. Second, celestial itself is a backup navigation method to most sailors these days. Most rely on GPS, only using celestial to test it or to replace it if it fails. Sailors who rely on celestial daily, on the other hand, usually do not use tables at all, but instead do all the paperwork with a calculator. In short, traditional navigation using tables is becoming less and less common. Since we are not using tables often, it is not so bad that the tables take a bit longer to use.

In short, if we take the time to learn these new tables and are comfortable with the knowledge that we can use them if we need to, we can save space, money, and complexity in the long run by not having to bother with various sources of tables. With this in mind, we have developed a work form that makes the use of these tables considerably easier than just following the instructions given in the almanac. With the use of our work form, the NAO tables do not take much longer than Pub 249 does for this step of the work. Naturally, the first few times go slowly, but after a few examples it becomes automatic and easy. The form guides you through the steps.

We have included here a few of the earlier examples, redone using the new tables. Try a few if you care to see how it goes.

A Bit of History

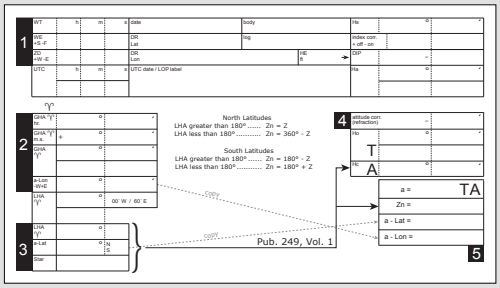
The NAO tables were the invention of Admiral Thomas Davies and Dr. Paul Janiczek, then Head of the Astronomical Applications Department of the US Naval Observatory. They were originally published as the *Concise Tables for Sight Reduction* by Cornell Maritime Press. This type of table is referred to as "concise," or "compact," as opposed to the full form tables such as Pub 229 and 249, which are referred to as "inspection tables," since they require fewer steps.

Forerunners of these short tables were the Ageton Tables (Pub 211) and the Dreisenstock Tables (Pub 208). The Ageton Tables were included in Bowditch, Vol. 2 (editions prior to 1985) but not included in later editions, perhaps because they are now in the *Nautical Almanac*. Both Ageton and Dreisenstock are long out of print. US Power Squadron courses on celestial switched to the new NAO Tables shortly after they were published, with the help of US Power Squadron National Education Director Dr. Allan Bayless, who had published his own version of the tables called *Compact Sight Reduction Tables*.

Admiral Davies was aware of the Starpath work form (Form 106) for the NAO Tables and suggested at the time that it be included in the *Nautical Almanac*, which was agreed upon by the US NAO. The almanac, however, is a joint publication with the British NAO, and at the time they did not want to include any forms in the almanac, so this was dropped. In 2006, there was a change of heart in the UK, and a single-column work form now appears in the almanac for these tables. It is better than none, but it remains valuable to keep a Starpath form for these tables at hand; it takes you step by step through the process with no further instructions required.

FORM 111

Pub 249, Vol. 1 Selected Stars



Form 111 Star Sight Reduction with Pub 249 Vol. 1, Selected Stars

Pub 249 Sight Reduction tables come in three volumes. Vols. 2 and 3 are meant for sun, moon, and planets and thus only cover declinations (dec) under 29º. Vol. 2 is for observing latitudes of 0º to 40º; Vol. 3 is for latitudes of 39º to 89º. We can use it for stars, providing they have dec <29º, which would be the ones circling the earth over the subtropical belt of the earth. These two volumes are permanent publications, just as Pub 229, that apply to any year.

Pub 249 Vol. 1, on the other hand, is unique in this set, as it applies to any latitude, but only covers selected stars. It is also unique in providing Hc and Zn directly for each of the selected stars at specific times and latitudes, as well as recommending which triad of stars offers the best fix, based on relative bearings, altitudes, and brightness. Because it is so specific, it must be recomputed every 5 years, labeled by the valid Epoch year, with the data being valid for the 2 years before and after the Epoch year.

Pub 249 Vol. 1 can be used to predict the best 3 stars to use for a star-only fix and also then used as a way to sight reduce these stars to get the 2 LOPs for a fix. It does not take into account the use of planets, so it will likely miss the truly best triad of sights when Venus or Jupiter are in view at sight time. However, we know from Vols. 2 or 3 the bearings and heights of the planets so we can figure the best sights on our own in these cases.

Form 111 is designed to accommodate the unique sight reduction procedure that is used with Vol. 1. The instructions that follow apply to the sight reduction itself once the sight has been taken. But users will find that if Vol.1 has been used to predict the best stars, then most of the data needed will already be at hand. In short, an advantage of this method is that usually the very process of predicting the best stars completes most of the sight reduction. On the other hand, even if just used for sight reduction, the process is much faster than other methods.

In the instructions that follow, we look at the Vol. 1 method using Form 111 compared to the same sight reduction using Vol. 2 and Form 104. The results look a bit different in the two forms, but they yield the same LOP as shown in Figure 111-1.

Instructions for Sight Reduction with Pub 249, Vol. 1

Box 1. This is the raw sight data and time corrections covered in the instructions to Form 104.

Box 2. Use the almanac to find GHA of Aries at the UTC of the sight. Choose an assumed Lon in the normal manner (see Form 104 instructions). And then find local hour angle of Aries in the normal manner. Copy a-Lon to Box 5 for later use in plotting.

Box 3. Enter star name, and LHA Aries from Box 2, and enter an assumed Lat equal to actual DR-Lat rounded to nearest whole degree. Box 3 now contains all we need to enter Pub 249 Vol. 1. Copy a-Lat to Box 5 for later use in plotting.

Inside Pub 249 Vol. 1, find the right Lat on the top corners of the pages, go to your star column and down to the corresponding LHA Aries. Copy the Hc to Box 4 and Zn to Box 5. (This step takes seconds; there are no corrections as when using other methods.)

Box 4. Correct Hs to get Ho in the normal manner using the star altitude correction from *Nautical Almanac.*

Box 5. Find the difference between Hc and Ho, which is the altitude intercept (a). Give it the label T or A depending on which is larger in Box 4. Now Box 5 contains all the information we need to plot the LOP.

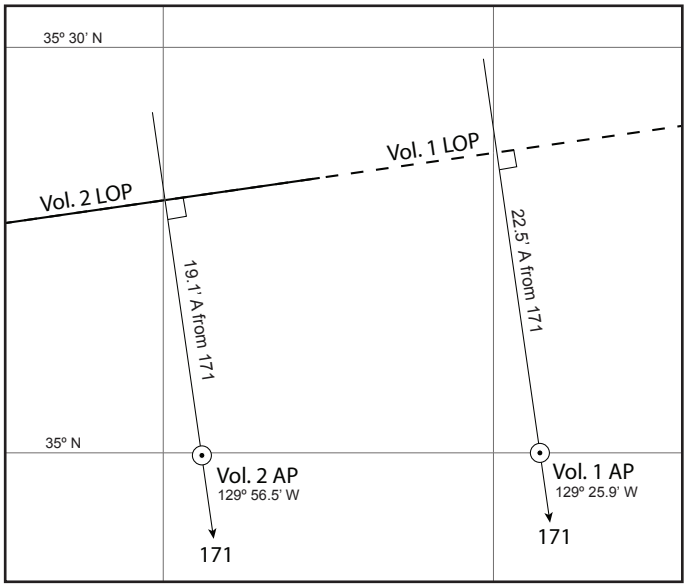


Figure 111-1. *Plots of the two LOPs from Figure 111-2. Since the procedures call for different assumed longitudes, we cannot compare the final a-values, but once plotted we do indeed get the same LOPs. The Vol. 1 method is fast, but it calls for a different procedure for these sights. If we use Pub 229 or the NAO Tables, then all sights are worked the same way, which has some virtue.*

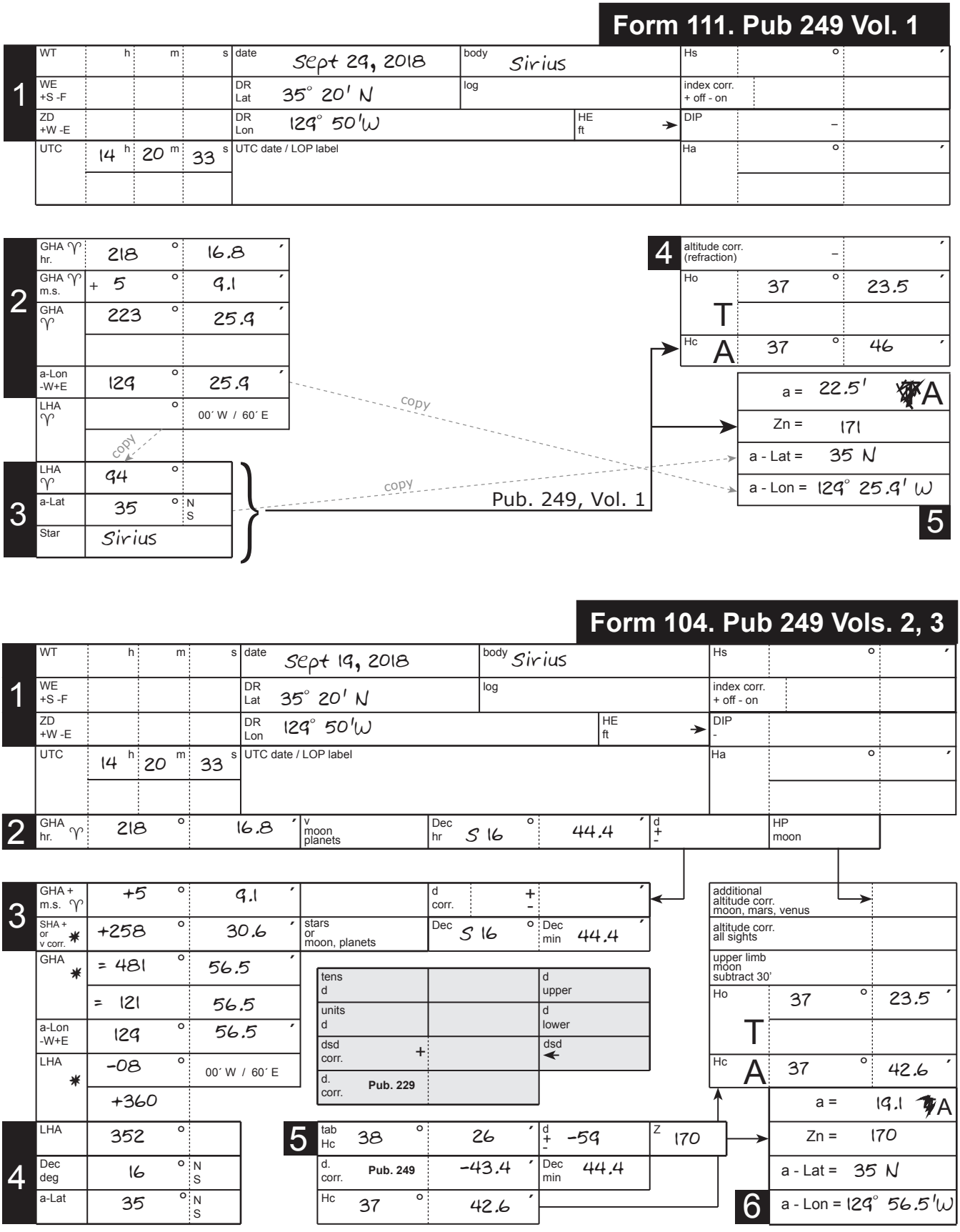
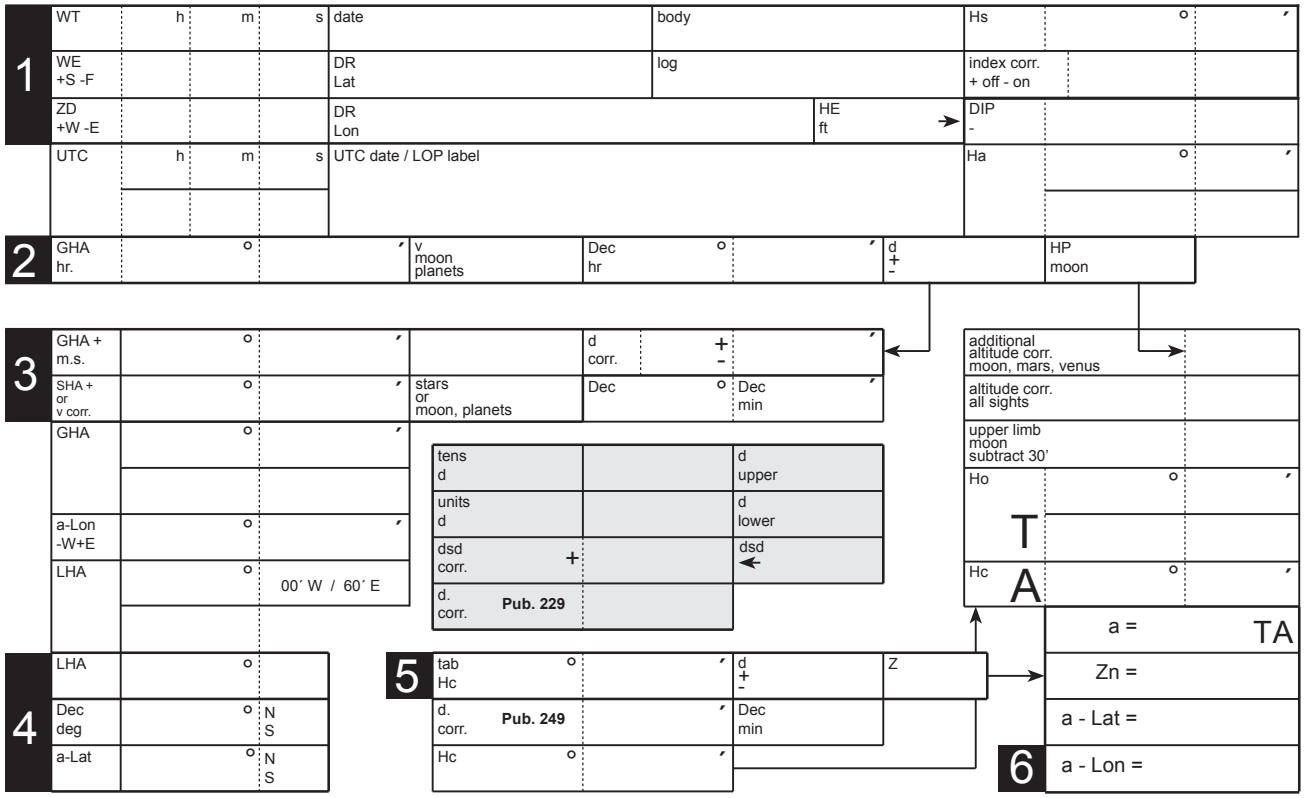


Figure 111-2. *The top shows the sight reduction of a selected star from Pub 249 Vol. 1 using Form 111. The bottom part is the same star sight reduced with Pub 249 Vol. 2 using Form 104. The Vol. 1 solution is much faster and yields equivalent results (Figure 111-1), but only applies to the specific Selected Stars listed in Vol. 1. Vols. 2 and 3 can only be used with star declinations <29°.*

Form 104, All Sights, Pub. 249 or Pub. 229

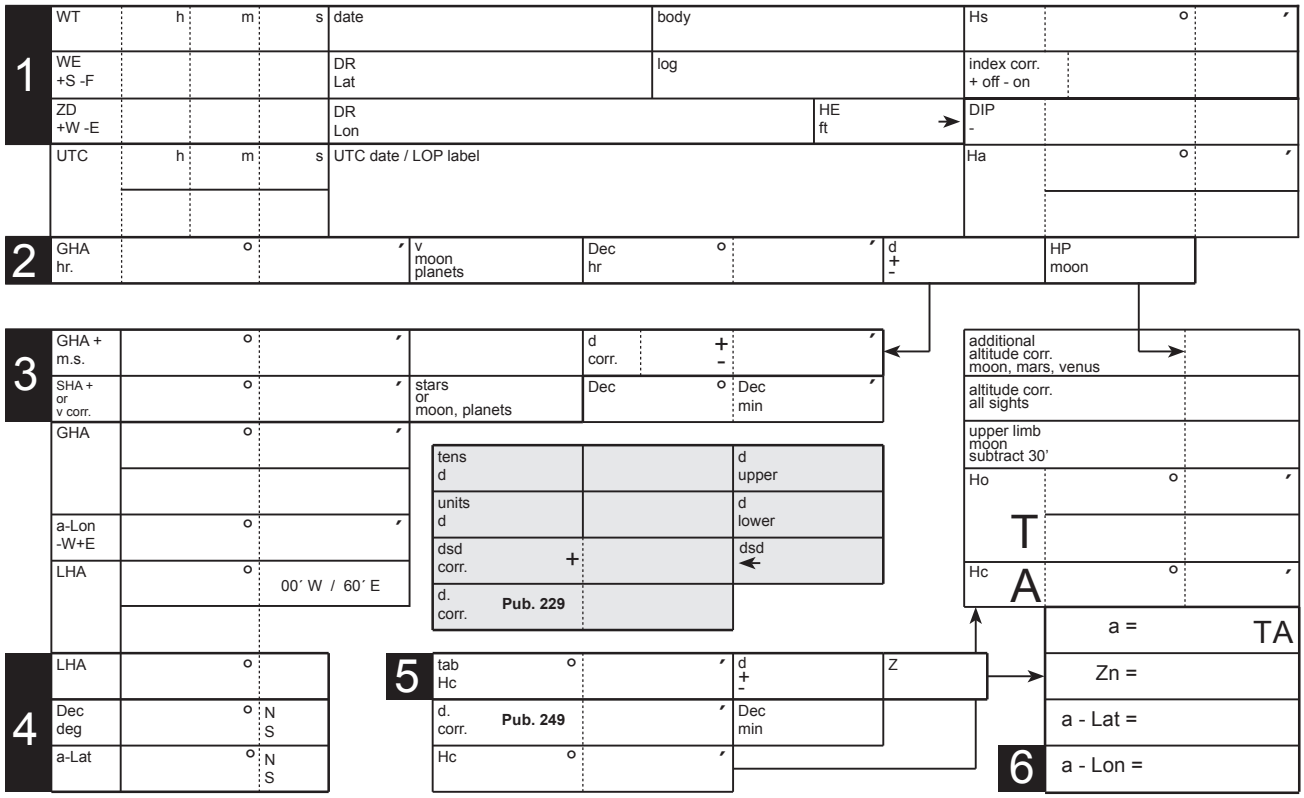


North Latitudes

LHA greater than 180° ..... Zn = Z
LHA less than 180° ..... Zn = 360° - Z

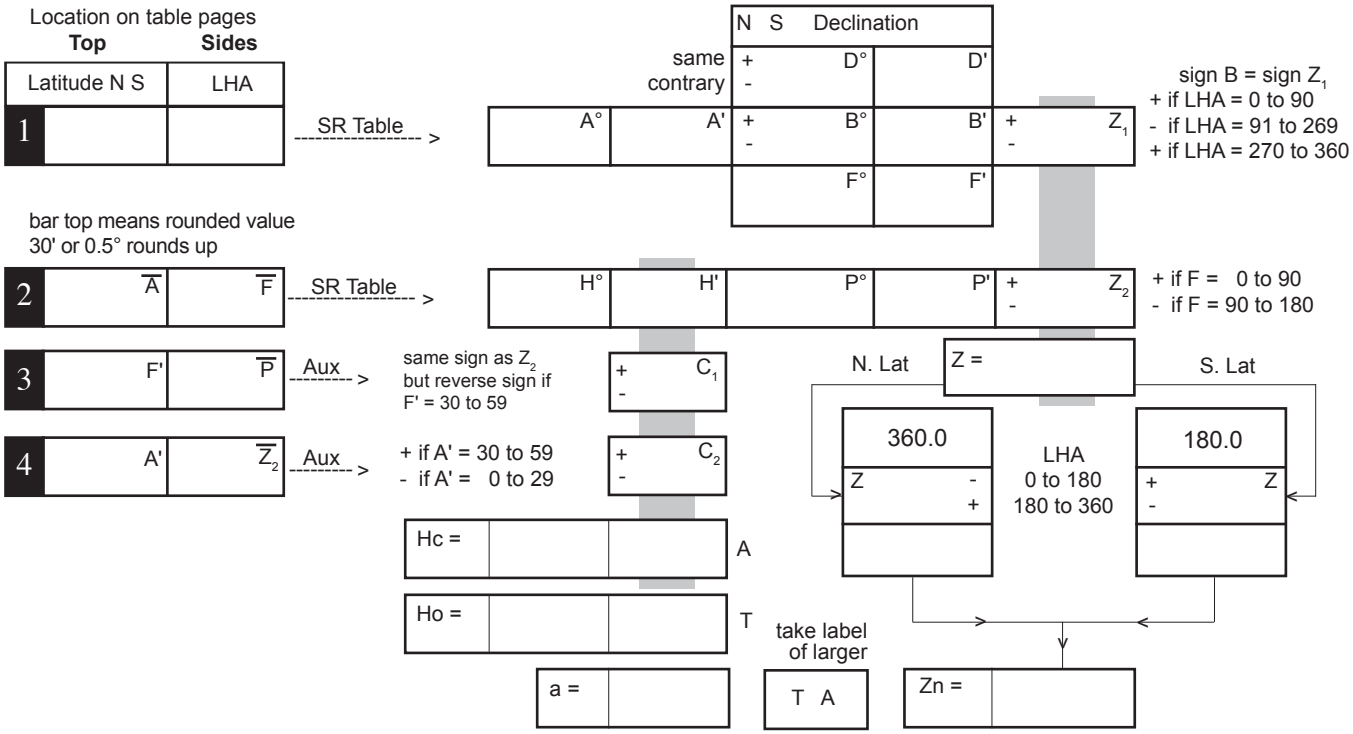
South Latitudes

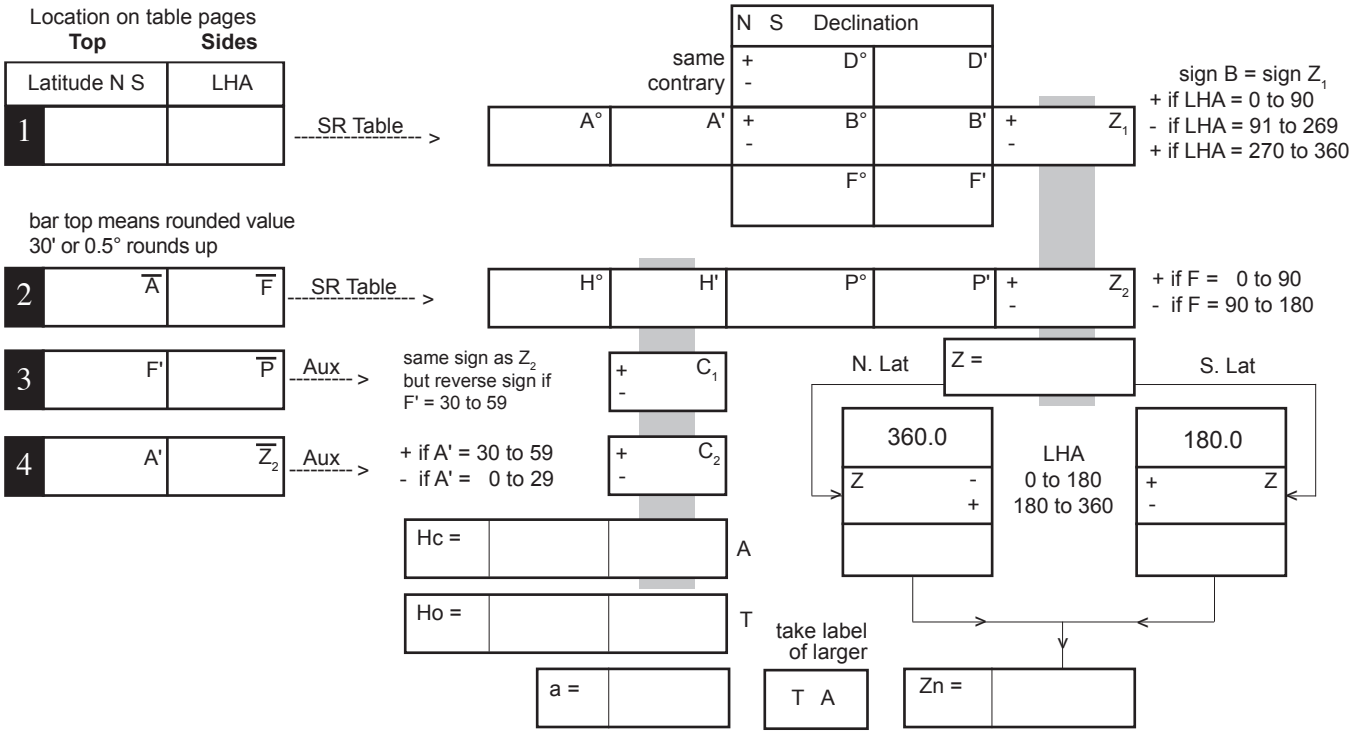
LHA greater than 180° ..... Zn = 180° - Z
LHA less than 180° ..... Zn = 180° + Z



Free, printable PDF forms available at www.starpath.com/celnavbook

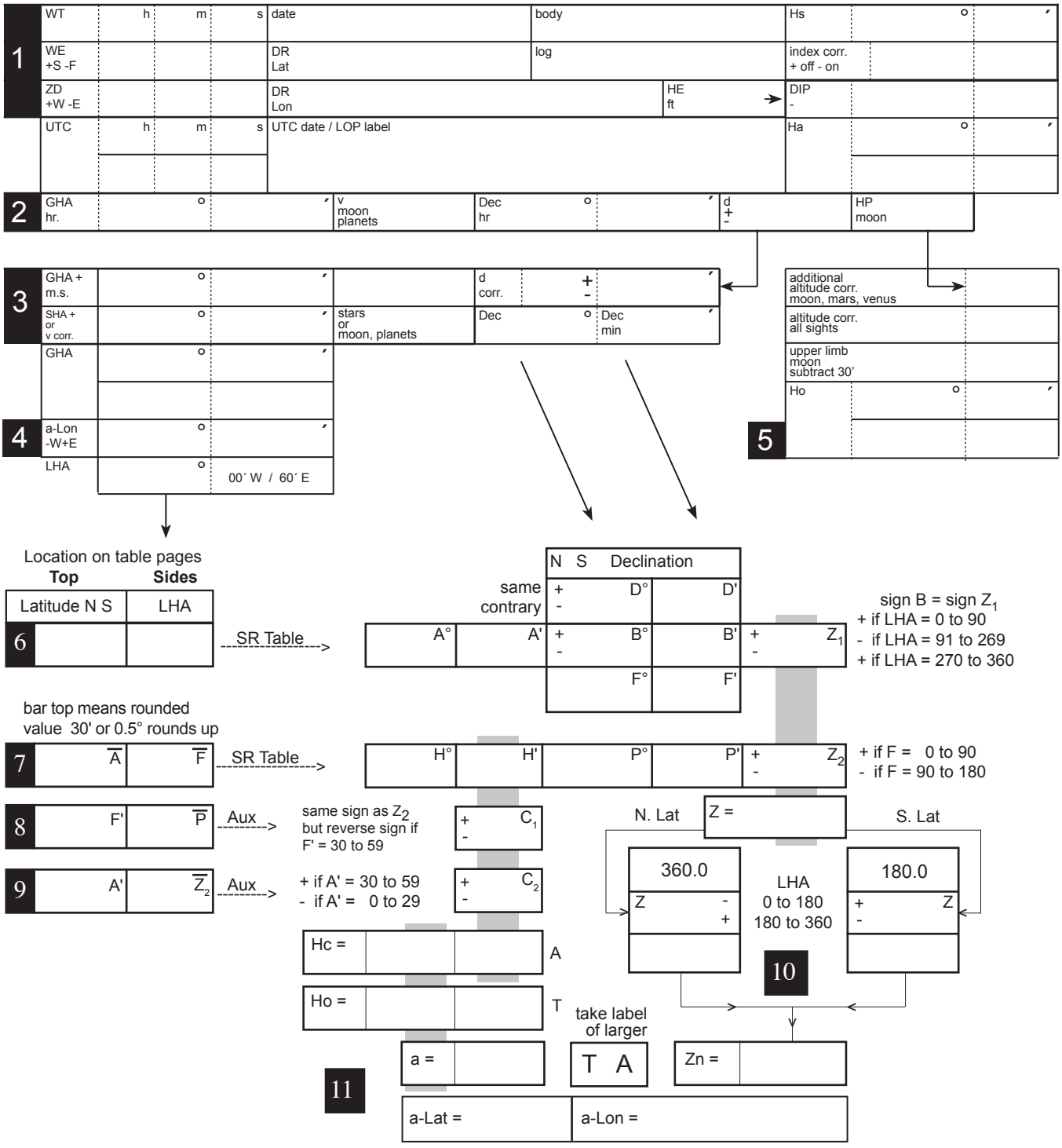
Form 106, All Sights, Using the NAO Tables





Free, printable PDF forms available at www.starpath.com/celnavbook

Form 108, All Bodies, Almanac, and NAO Tables



Form 109, for Solar Index Correction

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

Toward or Away		Date	
On	Off	Diff	Check SD
sight #	-	-	+
	=	= ÷2	= ÷4
SD=		=	=

This form covers 12 sights.

Form 107, for Latitude at LAN

Step 1 Correct Hs to get Ho

1-1	Record Maximum Sextant Height (Hs = peak height of the sun at noon), and mark limb	Lower / Upper Hs	°	'
1-2	Record Index Correction (mark sign + if off, - if on)	IC	Off / On + / −	'
1-3	Record eye height (HE) and Look up Dip Correction on the right-hand side of Table A2, front of the Almanac (correction depends on HE)	Dip / HE (ft)	−	'
1-4	Sum the above three numbers to get Apparent Height	Ha	°	'
1-5	Look up altitude correction on lefthand side of Table A2, front of the Almanac (correction depends on Ha, Limb, and month) (mark sign + for lower limb, - for upper limb)	Alt corr.	+ / −	'
1-6	Sum the above two numbers to get Observed Height	Ho	°	'

Step 2 Determine the Zenith Distance

					89°	60.0'
2-1	Record Ho from Step 1, above, and then subtract it from 90° to get the zenith distance		Ho		− °	'
2-2	Zenith distance		z		°	'

Step 3 Use the Almanac to Find Sun's Declination

GMT date =

3-1	Record the date and GMT of the sight (the time the sun reached its peak height)	GMT (hr) =		GMT (min) =	
3-2	Turn to the daily page of the Almanac for the date of the sight, and find the sun's declination (dec) for the hour of the sight (line 3-1) and record it here.	Dec (hr)		N / S °	'
3-3	Record the d-value from the bottom of the dec column in the Almanac. Mark the signs of the d-value and d-corr + if the dec for the next hour is larger, or - if it is smaller.	d-value =	+ / −	d-corr = + / −	'
3-4	Turn to the Increments and Corrections pages at the back of the Almanac (T-9 to 12, in the notes) and find the minutes table for the GMT minutes (line 3-1). On the right-hand side of the double line in the table, find the d-corr corresponding to the d-value of line 3-3.	Declination =		N / S °	'
		3-5 Apply the d-corr to the dec(hr) and record it above.			

Step 4 Find Latitude from Zenith Distance and Declination

Record DR Latitude to use as a guide, and then take the sum or difference of zenith distance and declination to find your true Latitude at LAN.

Declination or Zenith distance	°	'
Zenith distance or Declination	°	'
Latitude =	°	'

Form 110, for *Polaris* Sights

Step 1. Correct Hs to get Ho				
1-1	Record Sextant Height of *Polaris*	Hs	°	'
1-2	Record Index Correction *"If it's off, put it on; if it's on, take it off."*		Off + On –	'
1-3	Record height of eye (HE=_____) and look up Dip Correction on the right-hand side of Table A2, front of Almanac		Dip –	'
1-4	Sum the above to get the Apparent Height of *Polaris*	Ha	°	'
1-5	Look up the Altitude Correction (always minus)	alt corr.	–	'
1-6	Sum the above two numbers to get Observed Height	Ho	°	'

Step 2. Find LHA Aries (♈)		UTC Date =		
2-1	UTC Time in Hours, Minutes and Seconds	UTC Time =		
2-2	Find GHA ♈ on left-hand side of daily pages of the Nautical Almanac	GHA ♈ (hr) =	°	'
2-3	Find GHA Aries minutes and seconds correction from Increments and Corrections pages	GHA ♈ (m, s) =	°	'
2-4	Sum the above two numbers to get GHA Aries	GHA ♈ =	°	'
	Extra spaces to adjust angles as needed			
2-5	DR Lon: –West; +East	–W, +E	°	'
2-6	Combine 2-4 and 2-5 to get LHA ♈	LHA ♈ =	°	'

Step 3. Latitude Determination				
3-1	Ho from 1-6	Ho	°	'
3-2	Subtract 1°		-1 °	
3-3	Add a0 from *Polaris* Table (using LHA Aries)	+a0	°	'
3-4	Add a1 from *Polaris* Table (using DR Latitude)	+a1		'
3-5	Add a2 from *Polaris* Table (using Month)	+a2		'
3-6	Sum the above to find Latitude	Latitude =	°	'
Note that this procedure for finding Lat from Polaris *is explained in the Nautical Almanac.*				

Form 117, Short Forms for LAN and *Polaris* Sights

Lat at LAN			
Find Ho		degrees	minutes
Hs-max =			
IC (+Off, - On) =	±		
Dip (from HE) =	–		
Ha =			
alt corr (UL-,LL+) =	±		
Ho =			
Find z (90º-Ho)		89º	60.0’
Ho =	–		
z =			
DR (Lat, Lon) =			
Lat = sum or difference Dec and z			
Dec or z =			
z or Dec =	±		
Lat =			

Date	hr	min	sec
UTC LAN =			

Declination in Nautical Almanac at UTC of LAN				
		degrees	minutes	d-value (±)
Dec (hr) =	N S			
d corr =	±			
Dec =	N S			

Lon at LAN = GHA sun at UTC of LAN				
		degrees	minutes	
GHA (hr) =				
GHA (m.s) =	+			
GHA =				
If GHA between 0 and 180, Lon W = GHA				
If GHA between 180 and 360, Lon E = 360-GHA				

LAN Lat Rules: *For Contrary Name: Lat = z - Dec. For Same Name: DR-Lat > Dec, Lat = z + Dec; DR-Lat < Dec, Lat = Dec -z. But don’t forget the easy rule: add them, and if that is nonsense (compared to your DR Lat) then sub-tract them.* ***LAN Lon Reminder:*** *LAN Lon is only as accurate as the UTC you assign to the event. The Lon will be uncertain by 15’ for each 1 minute of time uncertainty in your choice of peak Hs time.*

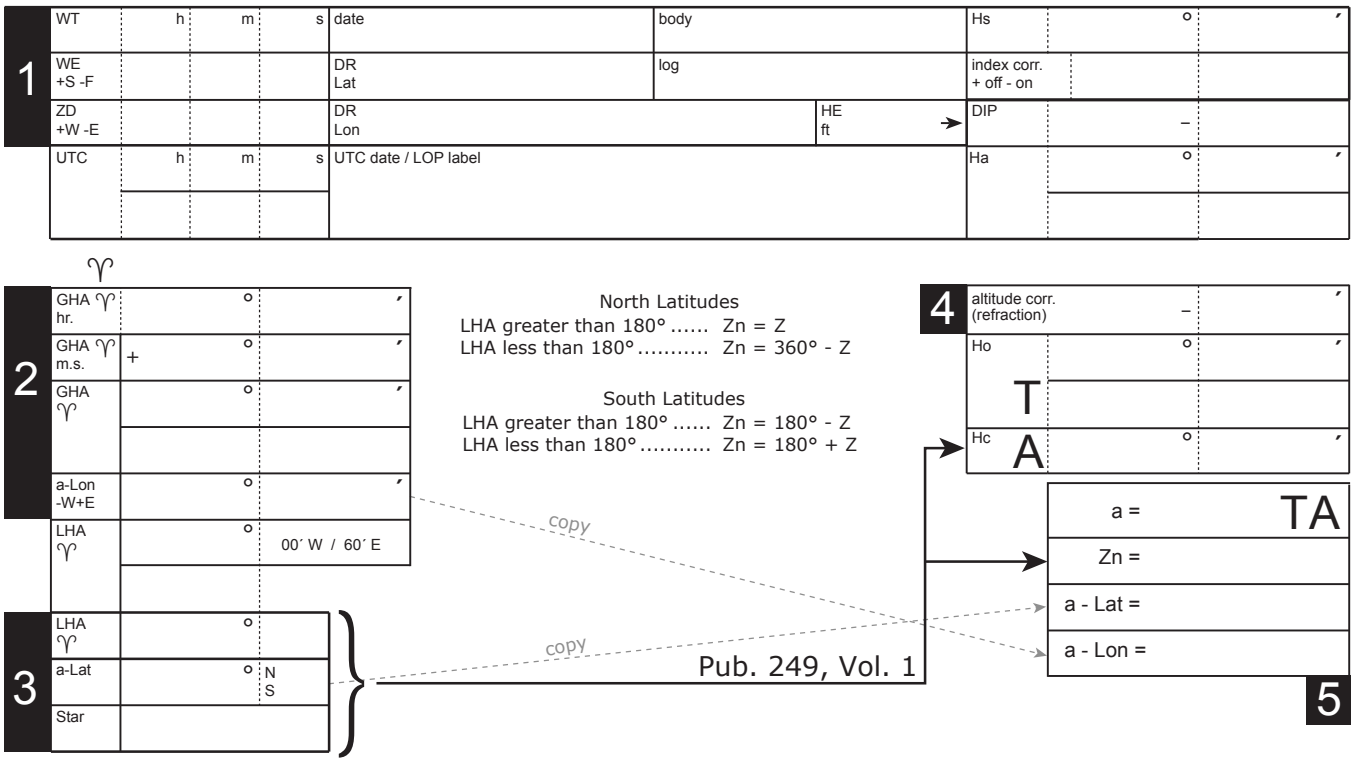
Find LHA ♈			
UTC *Polaris* sight	hr	min	sec
Date			
DR (Lat, Lon) =			

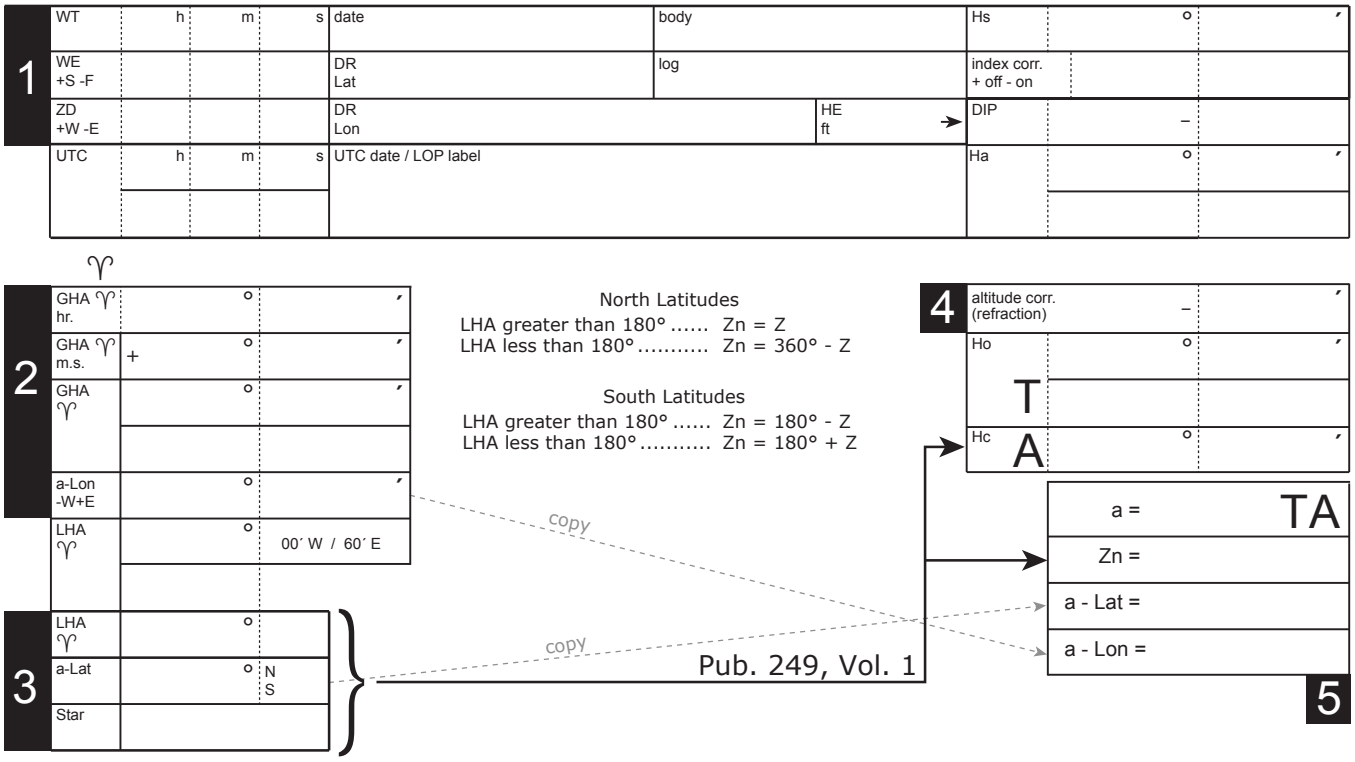
LHA ♈ = GHA ♈ - Lon W (or + Lon E)			
		degrees	minutes
GHA ♈ (hr) =			
GHA ♈ (m.s) =	+		
GHA ♈ =			
DR Lon (-W,+E) =	±		
LHA ♈ =			
Use LHA ♈ in Polaris *Tables to find a0, a1, a2*			

Lat by *Polaris*			
		degrees	minutes
Hs of *Polaris* =			
IC (+Off, - On) =	±		
Dip (from HE) =	–		
Ha =			
alt corr =	–		
Ho =			
subtract 1º	–	-1º	
+a0 =	+		
+a1 =	+		
+a2 =	+		
Lat =			

Free, printable PDF forms available at www.starpath.com/celnavbook

Form 111, for Pub. 249, Volume 1, Selected Stars





Save Time and Minimize Mistakes

Starpath work forms for sight reduction procedures in celestial navigation have been used by tens of thousands of navigators for over forty years. Designed to make the sight reduction of all celestial bodies flow in the same logical procedure that matches how data are presented in the *Nautical Almanac* and in the various sight reduction tables. There is always a place for adjusting angles to base values as needed, plus reminders on the signs of the values. Intermediate results are grouped for convenient entrance to the tables and for plotting the resulting lines of position.

Once a few examples have been worked, the forms alone guide you through the process. Even after being away from cel nav for long periods, the forms are a quick refresher that gets you back up to speed quickly.

Detailed instructions are included, with warnings about common errors. Forms included are:

Form 104 — Sight reduction of all bodies using Pub 249 (Vols. 2 and 3) or Pub 229 (all volumes). The workhorse of the Starpath approach to celestial navigation

Form 111 — Sight Reduction of stars using Pub 249 Vol.1 Selected Stars.

Form 106 — Sight reduction of all bodies using the NAO Sight Reduction Tables included in the *Nautical Almanac*. This form is a unique tool that makes these tables (that every navigator has) as easy to use as any other method.

Form 108 — A combination of Form 104 and Form 106 for those who choose the NAO Tables as standard,

Form 109 — For completing multiple solar index corrections and averaging them. This is a high-accuracy method, praised since the formative days of celestial navigation in the late 1700s, but not used as often as it could be these days.

Forms 107, **110**, and **117** cover latitude and longitude at noon as well as latitude by Polaris. These are basic procedures, but many new to cel nav find them helpful to get started... and they are instant refreshers after being away from the subjects for some time.

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