The USPS® LHA Aries Calculator

Purpose

JN and N students and practicing navigators will find the Calculator particularly useful to set the USPS Star Finder (formerly HO 2102-D) as LHA Aries is much more easily and quickly found than by arithmetical computation. It is also useful for pre-set star sights in combination with Volume I of HO 249. The Calculator is quite accurate enough for these applications as it has a maximum error of about ±1°. For those with interests in astronomy, an added step will give local sidereal time, LST, to comparable accuracy.

Design

The Calculator is a circular slide rule with three concentric discs and a transparent cursor. It can be stored in the same case with the Star Finder. Each disc adds a fraction of 360° of LHA Aries equivalent to a fraction of a year plus a fraction of a day plus (or minus) a fraction of 360° of longitude; the sum of these is LHA Aries.

How to use

If the time, date, and observer's longitude are known, the three steps required to find LHA Aries, briefly noted on the face of the instrument, are: (1) The date (calendar scale) is set opposite 00h (hour scale), (2) the time of the sextant observation (hour scale) is then set opposite the reference zone meridian, ZM (meridian scale), for the time zone, and, finally, (3) the value for LHA Aries (LHA Aries scale) is read opposite the DLo value (meridian scale) for the DR or the known position. Only the last step requires the use of the cursor.

Time Used: Standard Time may be used just as well as Zone Time as the meridian scale will encompass the large DLo values sometimes required in the more irregular Standard Time Zones.

Accuracy: The Calculator should be read only to the nearest degree of LHA Aries as there is an inherent instrument error of about this magnitude. The error is irregular so that no attempt should be made to interpolate for the time of day on the calendar scale: Just set 00h opposite the line representing the date, no matter the time of day.

LHA Aries at Twilight: To locate the star positions for twilight sights, LHA Aries is needed for the time of civil twilight that is listed in the Nautical Almanac. The listed time is the UT of the event at Greenwich, but, to sufficient accuracy, it is also the LMT of the event at the observer's meridian. So, DLo is not needed and step 2 in setting the Calculator may be omitted: LHA Aries is read opposite the time of listed civil twilight (interpolated for latitude) without reference to the meridian scale. (If the ZT of the event is wanted as well, set LMT opposite DLo and ZT will be opposite ZM.)

Local Sidereal Time: After finding LHA Aries, 00h on the hour scale is placed opposite 0° LHA Aries and LST read on the hour scale opposite LHA Aries. As the two quantities are identical except for the units involved, the instrument's scales are used to make the conversion.

Instrument Error

This instrument is an analog calculator and equates: 360° of hour angle of Aries = 24 hours of mean time = 365 mean solar days. But these relations are not entirely correct due to (1) the "additional" sidereal day in the calendar year, and (2) the difference in the length of the calendar (365 mean solar days) and tropical year (equinox to equinox).

The "diurnal" error results from the fact that LHA Aries increases very nearly 361° during a 24-hour period, rather than 360°, due to the "additional" sidereal day each year. Consequently, the calculator will have essentially no error on this account at 00h but it will steadily approach -l° at 2400.

The "calendar" error results from the difference in length of the calendar and tropical year which approaches -1° in four years when it is largely corrected by the addition of an extra (intercalary) day in leap years.

4-year increase of mean value of Aries	-0° 57.2936'
Addition of intercalary day	+0° 59.1388'
Residual 4-year discrepancy	+0° 01.8452'

By choosing 21.0 September as the point at which LHA Aries is 0° on the Calculator, the calendar error will vary from approximately 0° to +1°. Thus the combined effect of diurnal and calendar errors will not exceed about ±1° at any given time and, as the two errors are of opposite sign, they will tend to be compensatory so that the error will generally be less than 1°.

The residual 4-year discrepancy which appears in the above computation is small, but, as the Gregorian calendar compensates for this remaining discrepancy by omitting the intercalary day every 100 years except those centurial years divisible by 400 (the residual error after this maneuver amounts to one day in 3300 years), the Calculator will develop a gradually increasing error on this account which will amount to 0.2° in the year 2000 and will reach 0.5° about the year 2050.
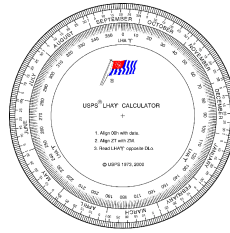
Assembly

Cut out Templates #2, #3 and #4 and paste them onto cardboard, thin stiff plastic, or other durable material. Punch a hole in the center of all three templates using the cross marked on each template, and attach them together at the centers with a screw and nut, a rivet, a paper fastener, a round head brass nail cut to length and glued at the bottom (#4) disk, or other similar device. Template #1 is a cursor that should be added to make reading the calculator easier. Copy Template #1 onto a sheet of transparency film, cut out the cursor outline from the transparency film, punch a hole in the cursor at the cross, and fasten it on top of the other three templates.

Assemble the calculator in layers as follows:
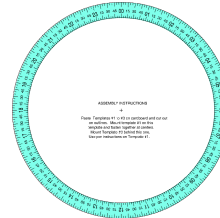
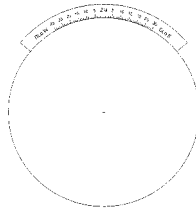Top: Template #1, transparent cursor
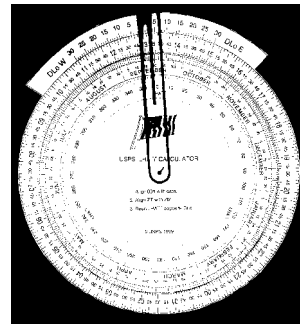
2nd: Template #2, main dial with USPS Ensign
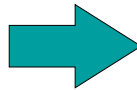
3rd: Template #3, outer ring with assembly instructions

Bottom: Template #4, ring with DLo, ZM

Completed calculator should look like this:

Abbreviated Operating Instructions

This calculator gives the LHA Aries within 1.0°. Use it for setting a star finder, but do not use it for a sight reduction, except as a check.

To obtain LHA Aries:
1.   Align 00 hours (00h) with the date
2.   Align zone time (ZT) with zone meridian (ZM)
        For daylight time, subtract 1 hour to obtain ZT
3.   Calculate DLo from zone meridian
4.   Read LHA Aries opposite DLo

Examples

Standard Time. Find the LHA Aries for 2 Mar at Lo 70° W at ZT 1820.

By LHA Calculator:

1. Set the date 2 Mar on Template 2 opposite 00h on Template 3.

2. Set the ZT 1820 on Template 3 opposite the Zone Meridian ZM on Template 4.

3. Read LHA Aries on the inside arc of Template 2 opposite the DLo of 5° east. The cursor of Template 1 is useful for this reading. Note that 70° West Longitude is 5° east of the Zone Meridian which is at 75° West. From the LHA Calculator, LHA Aries is 080°.

By Nautical Almanac excerpts:

ZT	1820 2 Mar	
ZD	+5	
UT	2320 2 Mar	
GHA Aries 23h	145° 49.5'	
20m	5° 00.8'	
GHA Aries 2320	150° 50.3'	
Lo (West)	+70° 00.0' (Rev)	
LHA Aries	80° 50.3'	
LHA Aries	80.8°	

Daylight Savings Time. Find the LHA Aries for 24 Jun at 70° W at ZT 2006.
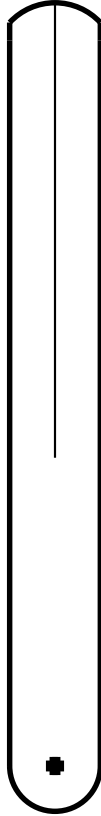
By LHA Calculator:

1. Set the date 24 Jun on Template 2 opposite 00h on Template 3.

2. Set the (daylight savings) ZT 2006 on Template 3 opposite the Zone Meridian ZM on Template 4.

3. Note that 70° West Longitude is 5° east of the Zone Meridian which is at 75° West. In addition, daylight savings time essentially sets your local meridian 15° further east than your actual zone meridian, so your DLo is computed as 15° west (to get to your actual zone meridian) plus 5° east, which gives a net DLo of 10° west.

4. Read LHA Aries on the inside arc of Template 2 opposite the DLo of 10° west. The cursor of Template 1 is useful for this reading. From the LHA Calculator, LHA Aries is 204°.
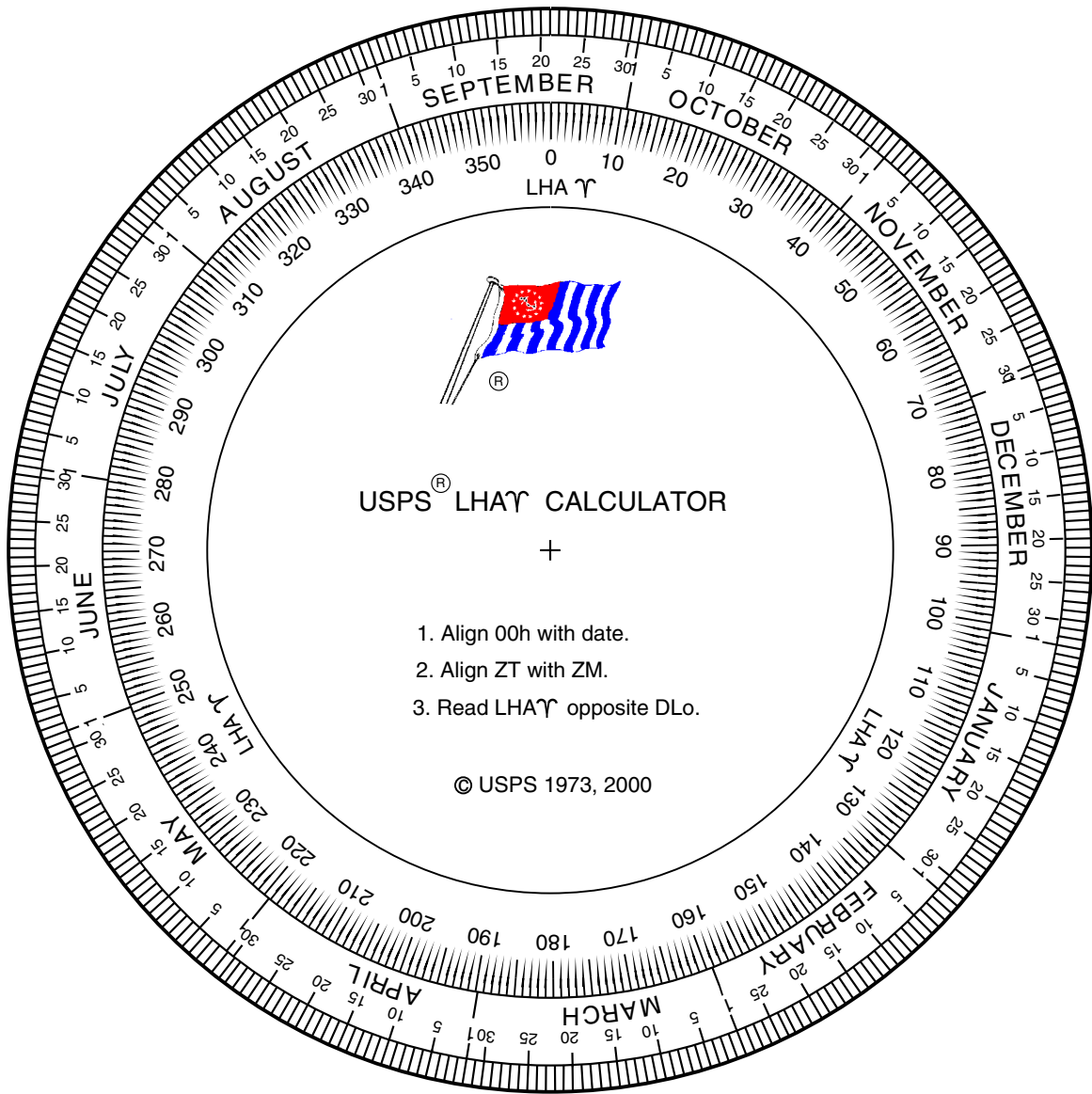
An alternative procedure is to set the ZT for the equivalent standard time (ZT 1906), and then follow the procedures for standard time.

By Nautical Almanac excerpts:

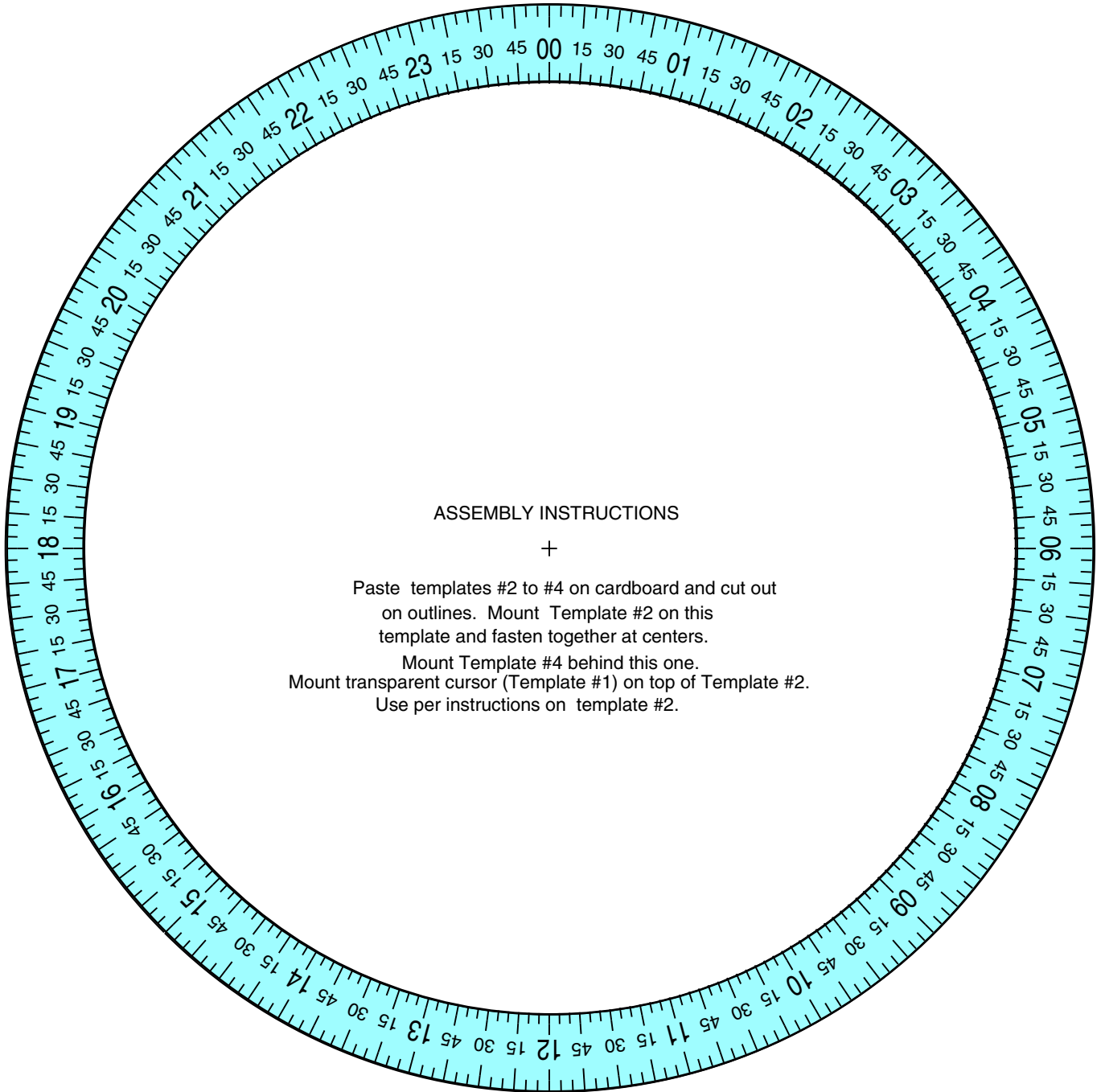|		
ZT	2006 24 Jun	
ZD	+4	
UT	0006 25 Jun	
GHA Aries 00h	273° 13.8'	25 Jun
06m	1° 30.2'	
GHA Aries 0006	274° 44.0'	25 Jun
Lo (West)	+70° 00.0' (Rev)	
LHA Aries	204° 44.0'	
LHA Aries	204.7°	

INSTRUCTIONS
Copy to transparency stock and cut out.
Insert over LHA Calculator, Template #2,
with cross at center of calculator.

Template #1

USPS® LHA♈ CALCULATOR

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1. Align 00h with date.
2. Align ZT with ZM.
3. Read LHA♈ opposite DLo.

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LHA ♈

Template #2

ASSEMBLY INSTRUCTIONS

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Paste templates #2 to #4 on cardboard and cut out
on outlines. Mount Template #2 on this
template and fasten together at centers.
Mount Template #4 behind this one.
Mount transparent cursor (Template #1) on top of Template #2.
Use per instructions on template #2.

Template #3

DLo W 30 25 20 15 10 5 ZM 5 10 15 20 25 30 DLo E

Template #4