Celestial Project Advice

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Contents

1 Introduction

1.1 Ground Rules

If you are reading this, you are (probably) a CMA deckie on senior cruise or about to go. You're probably worried about completing the celestial project, and you may even have your eyes on the competition prize. To get you ready, you should know what you're biting into. I won the big prize in 2023, and I learned a lot of tricks for improving my rhythm and efficiency while taking my sights.

For the project itself, the self directed work is as follows:

For extra credit, there are 5(7) ways to get points.

Required Fixes	Required Azimuths	Single Lines of Position
Morning 3 Star Fix x2 Evening 3 Star Fix x2 3 Sun Fix x3	Azimuth of the Sun x3[1] Azimuth of Polaris Azimuth other than Sun or Polaris	Lat by LAN Lat by Polaris

Table 1: Required Submissions for Independent Work

1. Finish the project early.
   (a) 1st to finish gets 10 points
   (b) 2nd to finish gets 5 points
   (c) 3rd to finish gets 3 points
2. Extra Credit AM or PM 3 Star fix worth 4 points
3. Extra Credit Sun Sun Sun running fix worth 3 points
4. Great Circle or Mercator Sailing from one Ship Position to Another Ship Position worth 2 points
5. Extra Credit Azimuth or Amplitude of Any Body worth 1 point

For the Extra Credit Submissions outlines above, you are only permitted to submit 2 per day. In previous years, contestants who shot morning noon and night would get 11 points per day, but someone could beat them by submitting a Mercator sailing for the CMG and SMG between every hourly GPS fix from the CWO log and submit 48 points per day, which was deeply unfair. Now, only 4 points per day can be earned without a sextant, 2 sailings, and 8 points can be earned per day from fixes. I personally did 7 points per day with one 3 star and one Sun-Sun-Sun fix per day, and comfortably beat the runner up by 50 points.

The instructors are strict on formatting.

- Include the date of all submissions and the UT and LT time of each LOP
- Include the reference for your starting DR position, CSE, and SPD[2]

[1] One of these azimuths has to be an Amplitude, an Azimuth at Sunrise

[2] The best source of Starting `LAT, LON, CSE, SPD` is

1. The most recent Position Slip posted in the O4 Nav Lab, because he can check these.
2. A celestially reckoned position you obtained from previous work (useful for attempting a complete day submission)
3. The Instantaneous position from the GPS in the Nav Lab. He can't check these for accuracy.

1.2 Language and Equations

For this guide to make sense (and for you to be on this cruise), you had to pass Celestial Navigation class, so I will use the language with which I feel most comfortable. However, there are some distinctions between what I say and what you may have learned or what Pearson says. When I say Universal Time, that's Greenwich Mean Time; UT and GMT respectively. The modern Nautical Almanac gives all times in UT not GMT. I may say Ship Time or Local Time to mean Zone Time. Zone Time is respective only to geographic meridians; not to the ship, daylight savings time, or political boundaries. If you calculate the Zone Time of Begin Morning Nautical Twilight, you may not wake up at the right time because the time zone being observed on the ship is not always the time zone that your longitude indicates, so I say Local Time (LT). The formatting in the projects on the board in the Nav Lab use `Advance/Retard` but I write `Run` with a positive (+) run indicating that the ship has moved forward between the sight time and the desired fix time, or a negative (-) run indicates that the sight was taken after the desired fix time. I always move all of my lines to a convenient hour. Daytime running fixes should always yield a 1200 position, but since the twilight move around so much, I can't give a hard and fast rule that the AM fix is always at 0600 or something.

$$\mathrm{Hc} = \sin^{-1} \cos \mathrm{L} \cos \mathrm{d} \cos \mathrm{LHA} + \sin \mathrm{L} \sin \mathrm{d} \qquad \texttt{Height Computed} \qquad (\mathrm{Hc})$$

$$\mathrm{Z} = \tan^{-1} \frac{\sin \mathrm{LHA}}{\cos \mathrm{Lat} \tan \mathrm{d} - \sin \mathrm{L} \cos \mathrm{LHA}} \qquad \texttt{Azimuth Angle} \qquad (\mathrm{Z})$$

$$\Delta \mathrm{h} = \mathrm{Run} \times \cos(\mathrm{Zn} - \mathrm{CSE}) \qquad \texttt{Motion of Observer} \qquad (\mathrm{MOO})$$

$$\mathrm{A} = \sin^{-1} \frac{\sin \mathrm{d}}{\cos \mathrm{Lat}} \qquad \texttt{Amplitude} \qquad (\mathrm{Amplitude})$$

Amplitude, from Bowditch Volume 2 page 6[3]. Z and Hc from Bowditch Volume 2 page 235[4]. MOO is given in Ho 249[5].

Z Keystrokes: RCL 3 SIN ÷ (RCL 1 COS × RCL 2 TAN − RCL 1 SIN × RCL 3 COS) = 2nd TAN

Hc Keystrokes: RCL 1 COS × RCL 2 COS × RCL 3 COS + RCL 1 SIN × RCL 2 SIN = 2nd SIN

2 Scheduling

2.1 Sight Planning

A not inconsiderable part of your celestial Routine will consist of creating sight plans for you and your fellow cadets. Live and die by these. Don't shoot a body that's not on your sight plan and identify it afterwards. Use the sight plan to set your alarm in the morning, remember to take your breaks during the day to take your sun lines at the optimal time, and

[3] United States National Imagery and Mapping Agency and United States National Geospatial-Intelligence Agency, 2017, vol. 2, p. 6.

[4] United States National Imagery and Mapping Agency and United States National Geospatial-Intelligence Agency, 2017, vol. 2, p 235.

[5] United States National Imagery and Mapping Agency, 2020.

stay awake long enough in the evening to make the morning sight plan and communicate it to your peers. Half a dozen otherwise competent and intelligent men I know failed their senior cruise in 2023 because they did not. You may find my detailed instructions for sight planning **HERE**.[6].

2.2 Your Routine

There are a few celestial events that happen each day, and if you want to finish the project quickly or stack up extra credit, you can try to observe as many of them as you can. Of course, no time numbers here because the times of these events is the definition of Ephemeris. You are a senior, which grants you some right and liberties, but unfortunately you are a senior, which requires some duties. Observe which of these you can. If you have day work you're allowed to take a break to whip out the sextant and take observations. If you're on watch, you are required to take observations, don't forget to take a picture with your phone to give to submit to the teacher or to copy your work for later. If you're in the classroom or the simulator or practical training, the breaks might not line up with when star stuff is happening. You will have many days to catch all of it, especially on the long Pacific passage.

1. During True Night Time, only azimuths are possible.

2. `Begin Morning Nautical Twilight.` AM Star Time Begins. Take a fix using 3 different stars for lines of position. If one of them is Polaris, then this submission checks off your requirement for a Polaris LOP.

3. `Begin Morning Civil Twilight.` AM Star Time Ends, only planets remain visible after this time. Stars get harder to see, but the horizon becomes easier to sight.

4. `Sunrise.` At such a low altitude, it is important to take the barometer and temperature corrections for the sun if you choose to sight it, and you can even get an LOP without a sextant by marking the time that the upper limb breaches the horizon or that the lower limb stops touching the water. Enter $\mathrm{Hs} = 0, \mathrm{IC} = 0$. Within a few minutes of Sunrise, the center of the Sun will be at the Celestial Equator, or about 1 Sun above the horizon. Use the Gunsight of the Azimuth Circle to take an Amplitude of the Sun.

5. Daytime. Use the Mirror of the Azimuth Circle to take an Az Sun at any time. The procedure for bridge azimuths will be expanded on in Subsection 4.4.1. Before LAN[7] take an altitude of the Sun for a single LOP, record the information for later, save the calculation until after the PM sun line.

6. `LAN.` I warn you now about Daylight Savings Time. On my freshman cruise I stepped out on the deck a whole hour early because I forgot about DST. We were not observing zone time, we were observing ship time, and the sun kept getting higher and higher

[6] Simone, J. (2024). *Operational level celestial sight planning.* https://www.csum.edu/tutoring/media/celnavjoey.pdf.

[7] an amount of time you can estimate with the rules in my Sight Planning Guide

until it stopped at 1300 on the dot. Sun Sun Sun fixes are not counted unless they include a Lat by LAN, but this can be substituted with an Ex-Meridian.

7. In the Afternoon, you can do the same thing as the morning and take a mirror azimuth or a Sun LOP. Maybe you'll get lucky and shoot the moon during the day to have a 4$^{\text{th}}$ LOP.
8. `Sunset. Observe amplitude. Planets Available.`
9. `End Evening Civil Twilight. Star time begins. Observe 3 star fix.`
10. `End Evening Nautical Twilight.` Star time ends when the ocean is too dark to see in the sextant.
11. `Night Time, azimuths only.`

3 Taking Sights

The instructor and the LWOs will cover with you how to adjust your instrument for error, record non adjustable error, and even possibly how to shoot a body. Here are some tips that may not be covered or may not be obvious for helping improve your efficiency, especially by yourself.

When adjusting error out of your sextant, the goal is that when the arm and micrometer are set to 00°00.0',that when you look through the scope, the image is unbroken and not distorted, much like through a telescope. [8] Once you've removed the adjustable error, you may think that your index error is zero, but it is not. Set the sextant to 5 degrees and look through the sight. Use the micrometer drum to walk the scope down until the sextant appears unbroken. Read the altitude on the index arm and the result is your true index error. Detailed and useful instructions for reading the sextant are to be found in Bowditch 1. You may have a negative value of altitude, meaning your index error is *Off The Arc*. In this case, "Negative readings […] are made in the same manner as positive readings; the various figures are added algebraically. Thus, if the three parts of a micrometer drum reading are $(-)1° + 56' + .3' = (-)3.7'$." (United States National Imagery and Mapping Agency & United States National Geospatial-Intelligence Agency, 2017, vol. 1, p 269). If your altitude is positive, this is your index error and it is *On The Arc*, and it is subtracted from all sights. It helps me to conceive as the index correction as the offset to apply to shoot altitude -0-.

4 Sight Reduction

4.1 Time

Some thought must be given into how you record the time for sights. I make my observations in UT (universal time, or GMT), and I convert to ship time afterwards. I have a two time-zone watch so switching is easy, and I keep that second time zone synced by heading to the

[8] More detailed instructions for removing and diagnosing sextant error can be found in Bowditch 1 page 272.

radio room to listen to the time tick, or using the time on the ECDIS. To take the time of an observation, I have a few principal strategies. These are from some advice I've given on Facebook, so these will have a more conversational tone than the rest of this manual.

Manual Solo

I turn my watch to face the inside of my wrist, keep constantly adjusting the instrument to keep the body on target, say mark and look at the wristwatch. I say the seconds out loud, then the hour and minute. "Shooting the lower limb of the sun, steady steady steady mark twenty two. UT time 17 46 22." I write the time in my pocket notebook, if I'm getting an LOP I'll then inspect the sextant arc and micrometer for Hs. For an azimuth, I'll keep the body sighted or keep the compass illuminated until I see the reading. I say mark when I see the number and I'm sure, and then look at the watch.

Two Player Method

The two player method is to have someone hold your watch and they mark the time when you call it. Requires a buddy.

Stopwatch Method

this method is very good. I have a sports stopwatch with laps and splits, so if I start the watch at the top of the hour (sync to tick or to ship chronometer or GPS clock) I can push the button once for each sight. In split mode, starting at 1800, I might have

Split	Time
1	07:42.3
2	10:03.8
3	14:31.0

Meaning 180742, 181004 and 181431 respectively. The lap mode is less useful, but the same numbers would be

Lap	Time
1	07:42.3
2	02:21.5
3	04:27.2

Which is less convenient than having the minutes and seconds read to you directly off of the face of the watch, but the addition of the times is not so bad.

4.2 Azimuth

The most important piece of equipment for your azimuth observations is the gyrocompass repeater. The bridge wings, the nav lab wings, and the 4 on the roof of the nav lab are suitable for use. It's not good to use the standard magnetic compass. The gyrocompass repeater should be operational. Before shooting, check that the card is moving when the ship turns, otherwise your reading will be wrong. The body you're observing will determine what attachment you should use for taking the sight. For the moon (or conspicuous land objects) or the sun at a very low altitude with powerful sunglasses, use the "gun sight." On the regular bearing circle (not the one with the telescope), the two flip up sights, one is a metal tab with a slot cut out, the other is a long meta loop with a string. Look through the metal cutout and through the loop, getting the string through the middle of the body. Once the body is sighted, look down a little at the mirror below the metal loop. There will be an indicator showing you the gyro azimuth of the body.

For stars and planets, use the telescope attachment. The view in the telescope attachment has a vertical crosshair for centering on the star, and below that will be a mirror pointing down at the compass to show the star's bearing at that instant. It is difficult to manage the illumination of the compass card correctly so that the number can be seen at the same time as the star. The light must be dim enough to not destroy the observer's night vision, but bright enough to make out the number on the card in the little slot in the sight.

The azimuth of the sun is the most frequently observed but the hardest to do or describe. The bearing circle has a mirror on it, and across the circle is a coin slot. The goal of the game is that you catch the reflection of the sun in the mirror and adjust the circle and the angle of the mirror so that the reflection goes into the coin slot, where another mirror shines the light from the sun down onto the compass card. Once you read the number illuminated by the sunlight, mark the time.

There is a secret method for shooting bodies of medium brightness at altitude higher than 40°. Attached to the string side of the Gunsight, there is a piece of black reflective glass. Looking through the metal slot, catch the reflection of the object in the black mirror, and align this with the string. A reflection of the sun dimmed by the dark glass will not burn the eye. This reflection can be used to observe the Moon at a high elevation, or painfully bright stars.

Taking an azimuth for the project is simpler and easier than taking an azimuth on the bridge. You are only required to find gyro error. This means you do not need to record the ship's heading at the same time that you take the gyro bearing, you do not need the local variation, you don't need the steering and checking information from the helmsman, and more tolerance is given to DR position. Simply observe the body of your choice and record the gyro bearing and the time. Find the DR Lat and Lon with the most recent POSN slip and the mid lat sailing, then use Z to get true bearing, and submit determine GE.

Rules for Converting Z to Zn

1. If the Observer is in the North, Z is prefixed N.
2. If the Observer is in the South, Z is prefixed S.
3. If LHA > 180, Z is Suffixed E.
4. If LHA < 180, Z is Suffixed W.

Z NE; Zn = Z

Z NW; Zn = $360 - Z$

Z SW; Zn = $180 - Z$

Z SE; Zn = $180 - Z$

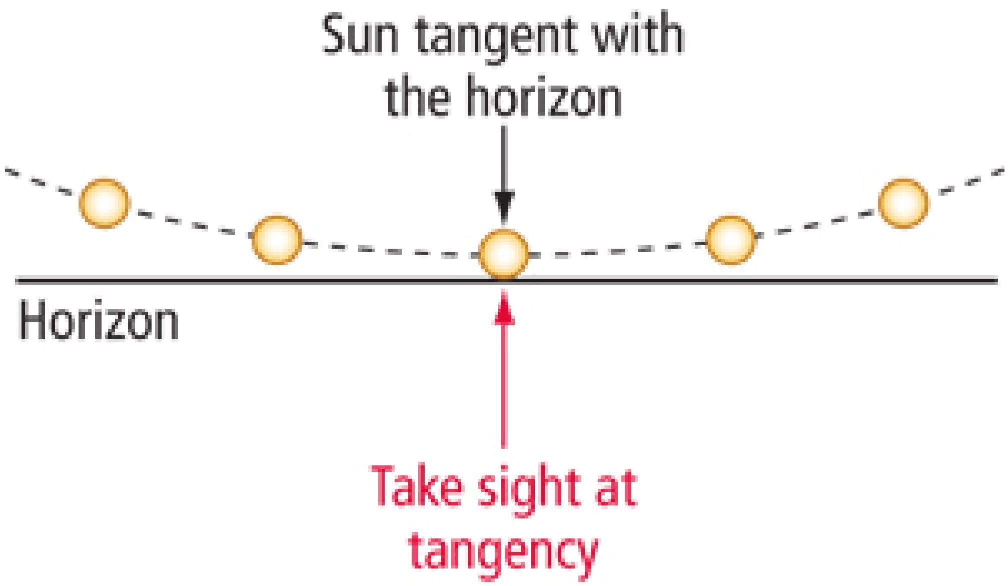

Figure 1: "In order to ensure that you are bringing the sun directly down to the horizon, the navigator needs to "swing the arc." This means gently rocking the sextant back and forth. As you do this, the sun will appear to describe an arc in the sky. The sight is taken when the sun is at the lowest point of its arc and rests on the horizon."From "Celestial Navigation Series, Part 5 - Ocean Navigator," by Navigator, O., 2019, February, , ()

4.3 Fix

The Celestial Fix is the hardest thing you will have to do for this project, but it is very rewarding, and you can tell very quickly when something has gone wrong. If three lines of position are closely intersecting somewhere near the DR, you have most likely been successful. Effective sight planning is also crucial. Consider studying Bowditch's chapter on "Sight Planning".(vol 1, p. 308). Not to toot my own horn but you should also have a copy of my sight planning manual, which can be found in the bibliography of this document.

Sun Fix

For shooting a line of position other than LAN involving the sun, the process requires no special technique. Stand out on deck with your pocket notebook, pen, sunglasses, and sextant. Face your shadow and turn all the way around to face the sun directly. Apply the shade filters to your sextant, and set the altitude to 0°0.0'. Look through the sextant with one eye and close the other eye. Look for the sun, feel the warmth on your face, try to find what direction in the scope is becoming brighter, and a sweeping scanning motion until the sun is in the center of the telescope's vision. When the sun is dim, as through clouds or at low altitudes, it is sometimes necessary to remove some of the shades. You want the image of the sun to be as bright as it can be without hurting your eyes. Different combinations of filters provide different brightnesses. Use the left hand to pinch the two triggers on the bottom of the sextant arc together, and use a crawling motion with the fingers and thumb to slowly slide the image of the sun downwards in the scope. If the sun does not move when you move the arc, you have not sighted it correctly. Consider starting by moving the micrometer drum to see if the sun moves up or down when you turn it. Slowly bring the sun downwards. Once you believe that you are near the horizon, remove the shades from ***The Horizon Glass.*** **The shades which are level with your eye, not the ones in front of the mirror. If you move the shades in front of the mirror, you may suffer permanent eye damage**.

Use the micrometer drum to walk the sun the rest of the way down to the horizon. Let the bottom of the circle just kiss the surface of the water. Rock your sextant by twisting it in your hands or by shifting your hips left to right. The sun should make an arc whose lowest point is on the top of the water, as in Figure 1. Keep the sun steady there, note how as you wait, it rises in the morning and sets in the afternoon, and you have to make small adjustments to the micrometer drum to keep it in position on the horizon.

Look at your watch first; then look at the sextant. For daytime sights, note the deck you were standing on, the index error at sight time, the UT of the sight, and the Hs of the sextant. All other information can be calculated later.

For LAN, the key is to be patient. If LAN is at 1222, I may take a traditional sight at 1215 as insurance so I may evaluate an Ex-Meridian if clouds obscure the sun. Don't do something like setting a timer for 1222 and recording what the sextant says at that time. You must watch the sun get higher and higher on the arc, keeping the sun on the horizon from 1218-1226 for instance, until you notice the moment that you don't have to keep adjusting the micrometer. Consider making a reading and noting the time, and then continuing to observe and seeing if the sun begins to lower in the scope. Once it has, LAN has occurred.

Putting together the lines of position for the 3 LOP Sun-Sun-Sun fix requires you choose a sight time. Some choose to advance the morning sun line and retard the evening sun line to LAN time to avoid having to move the LAN time. I find this to be unsatisfying, and prefer to move all 3 lines to 1200. In the fiction of celestial navigation, where we pretend it's 1983, we take this 1200 fix of the sun to fill out the noon slip and determine the day's run. Academically, you can take your 1200 RFIX and compare it to the Cadet Second Mate's noon slip to see how your accuracy is doing. The most common source of error in a sun running fix is incorrect compensation for the vessel's motion, often from incorrect information regarding her course. Usually the most satisfactory information is in the 0800 POSN slip, regarding the 0800 DR information to plot from, the CSE and SPD of the ship, to be used for advancing and retarding your lines of position. You are free to do it graphically, but the sun running fix becomes a lot easier with the equation for MOO.

Star Fix

Star identification is a common stumbling block for those beginning celestial. In the celestial class, you learned that if you observe an unidentified star and its bearing simultaneously, that you can identify it. *Do not do this.* Shooting a random star does not guarantee that you have observed one of the Major Navigational Stars, or even one of the minor stars in the same constellation. The margin for error for starfinders is greater than the tolerance permitted. It is better to know what body you intend to shoot, least of all because choosing stars at random in the sky also does not mean that you will have a good crossing angle between your LOPs. You don't have to think about star maps if you are a good hand with the precomputation of the altitudes and relative bearings of the stars and planets you will see on any given morning or evening. However, knowing some constellations is better than none for the nights where it is easy to misidentify a star, or shoot the wrong star in a constellation. Thankfully, there are resources available to us. Pages 266 and 267 of the Nautical Almanac have 4 "Star Charts" which show some projections with dotted lines connecting stars in some of the more famous and useful constellations, as well as the names and Bayer designations of those stars.(United Kingdrom Hydrographic Office & United States Naval Observatory, 2023). The use of these charts is often unintuitive, and because most star charts are meant to represent a view with the chart being held above the navigator's head while they look up, many people will get their left and right confused. An exercise that I practiced when making my sight plans was to draw the constellation that contained a star mentioned in my sight plan, so that when I go outside, I know "Okay. I need to find the Whale 'Cetus' which to me looks kinda like the lamp from Aladdin. His right flipper is Menkar (α, so it's brighter) but I want Diphda, the whale's chin, which is β"

Other Star Charts exist. The Nav Lab has a very large one on the wall by the cork board, and it is worth studying, as between the constellations there are arrows, clues, and mnemonics; how a navigator can find a constellation if they see a familiar one, how to avoid confusing two similar groupings, etc. Also take a look at the charts in the Navigational Astronomy section of Bowditch, pp. 256-257 in Vol 1, 2019 ed.

Once you know what time you need to be shooting, about where the stars you must shoot are, and you're outside with a pen, pocket notebook, red flashlight, and sextant, you will need to act quickly. Twilight lasts much longer at higher latitudes, but the Bear likes to steam through the Tropics much more than the Poles. Therefore, usually you will have no longer than 20 minutes between BMNT and BMCT, or between EECT and EENT. In the mornings, you will lose stars in the east first. In the evenings you will gain stars in the east first. Shoot stars in order from east to west, and when you are new you'll want to take multiple readings of each. Bowditch espouses taking many redundant sights to reduce error and increase certainty.

> It is preferable to take observations in a round-robin fashion when taking sights of more than one body at a session. Taking consecutive observations of different bodies helps assure that all the bodies are observed at least once should a sudden change in weather put an end to the observation of one or more bodies. Taking non-consecutive observations of a body helps to remove systematic errors in its observations by adding a randomizing factor to the sight taking. Taking sights of more than two bodies can significantly reduce the random error of a fix just as taking more than a single observation can reduce the random error in an LOP.
>
> There are two parameters to be determined, latitude and longitude, involved in a fix. So the random error of a fix is reduced by the square root of the number of sights minus two. Determining a fix from five or six sights is about optimum to reduce the random error in a fix.
>
> By averaging a number of observations into a single sight and then combining it with other sights into a single fix, the navigator can significantly reduce the uncertainty of the vessel's position. The difference of a course of advance and

the track made good for a running fix results in a less accurate fix than one made from taking sights of two bodies at a single observing session. The best method for reducing error in a running fix is to average together multiple observations, particularly those of the latter observing session, to improve the accuracy of the LOP. (United States National Imagery and Mapping Agency & United States National Geospatial-Intelligence Agency, 2017, vol. 2, p. 311)

Say you or a friend makes this sight plan (See Table 2):

June 26 AM Sight Plan
ZD=+9, CSE 042, SPD 15.2, Reckoned from 25 Jun 2023, 2000 POSN SLIP
UT BMNT 1342, LT BMNT 0442, 0442 DR Posn: L31° 26.4′N, λ146° 43′W

Symbol	Name	Hc	Zn
⧫	Mirfak	30°16′	047
⧫	FOMALHAUT	28°29′	168
⧫	VEGA	46°01′	295
⋆	Hamal	37°31′	083
⋆	Diphda	28°54′	138
⋆	ALTAIR	50°41′	243
⋆	Kochab	24°25′	344
☽	MOON	NOT	AVAILABLE
♀	VENUS	NOT	AVAILABLE
♂	MARS	NOT	AVAILABLE
♃	JUPITER	30°	090
♄	SATURN	48°	171

Table 2: Created from a real sight plan I made on the TSGB

If you decide to shoot only the 3 selected stars at the top, then I would recommend this: Go out on deck with the sextant at 0430 to let your eyes adjust. At 0440, start trying to make out Mirfak, in the constellation Perseus, in the spot that you think is his groin. You try to sight it, but the horizon is still too dim to see in that spot. You already know where VEGA is, because it's so close to Cygnus the Swan, which is really easy to spot. While you wait for Nautical Twilight to give you enough horizon to accurately sight Mirfak, you try pick out FOMALHAUT, and note that it's the fish's nose. You turn back to the east and your eyes can start to see where the black ocean is beginning to separate from the deep dark blue sky, you set your sextant to 30° and start to sweep the horizon to the Northeast to find Mirfak. You spot it, adjust the micrometer to get the center of the star on the horizon, and mark the time and Altitude. A you sight FOMALHAUT just before a small cloud passes in front of it, and you record the time and altitude. You zero the sextant, look at Cygnus and come over to VEGA, which is painfully bright. You pull VEGA down to the water and mark the time and the altitude. You sight Mirfak again, FOMALHAUT again, VEGA again. Repeat one more time but FOMALHAUT is gone for sure.

The Horizon turns golden as the stars wink out and become harder to see, VEGA is the last one to leave. When you go inside to check your notes and start your calculations, you find that your second observation of Mirfak is different from the 1$^{\text{st}}$ and 3$^{\text{rd}}$ by about 9 degrees, so you discard that sight. You decide which three LOPs you want to plot, reduce Hs to Ho, convert time to Hc and Zn, run all 3 observations to 0500, enclose and label the fix, and submit the papers. You grab a shower before heading to breakfast, then formation.

Advanced method for 3 star fix

Evening civil twilight begins at 1840 ship time, desire 1900 fix. Requires pub 249 (sight reduction table for air navigation).

1. Take a stop watch with a repeating timer function (every 4 minutes and 0 seconds, beep and then restart the timer).
2. At 1840, start the timer so it beeps at `1848, 1848, 1852, 1856, and, 1900,`
3. When the watch beeps at 1844, record UT base.
4. By 1848, be outside and identifying your bodies.
5. Observe Star 1 and keep it on the horizon until the watch beeps at 1852. Record Hs1
6. Observe Star 2 and keep it on the horizon until the watch beeps at 1856. Record Hs2
7. Observe Star 3 and keep it on the horizon until the watch beeps at 1900. Record Hs3
8. Go inside and stop your watch.
9. Sight time is UT base +4x minutes. T_1 is Base Time +8 minutes, T_2 is Base Time +12 minutes, T_3 is Base Time +16 minutes.
10. Calculate the LHA of Aries, establish an AP on the plotting sheet.
11. Use the MOO and MOB tables to adjust the HC of the bodies used for sights 1 and 2, and the correction for sight 3 is zero.
12. Because the earth turns at 1° per 4 minutes, LHA♈ increases 1° between shots, so AP longitude stays the same.

All 3 lines of position are then run out from the same AP, with no need to advance the AP for ship run or time because of the corrections from tables 1 and 2 of the pub 249. With some effort, the corrections can be applied to Hc in advance, so I spent a part of my lunch break doing my sight plan and finding the adjusted precomputed Hc of all 3 stars, so when I shot my last star at 1900, I came back in the house, corrected Hs to Ho 3 times, and had my 3 star 1900 fix on the plotting sheet by 1915. The time burden is the same, but I felt cool.

4.4 Bridge Watch

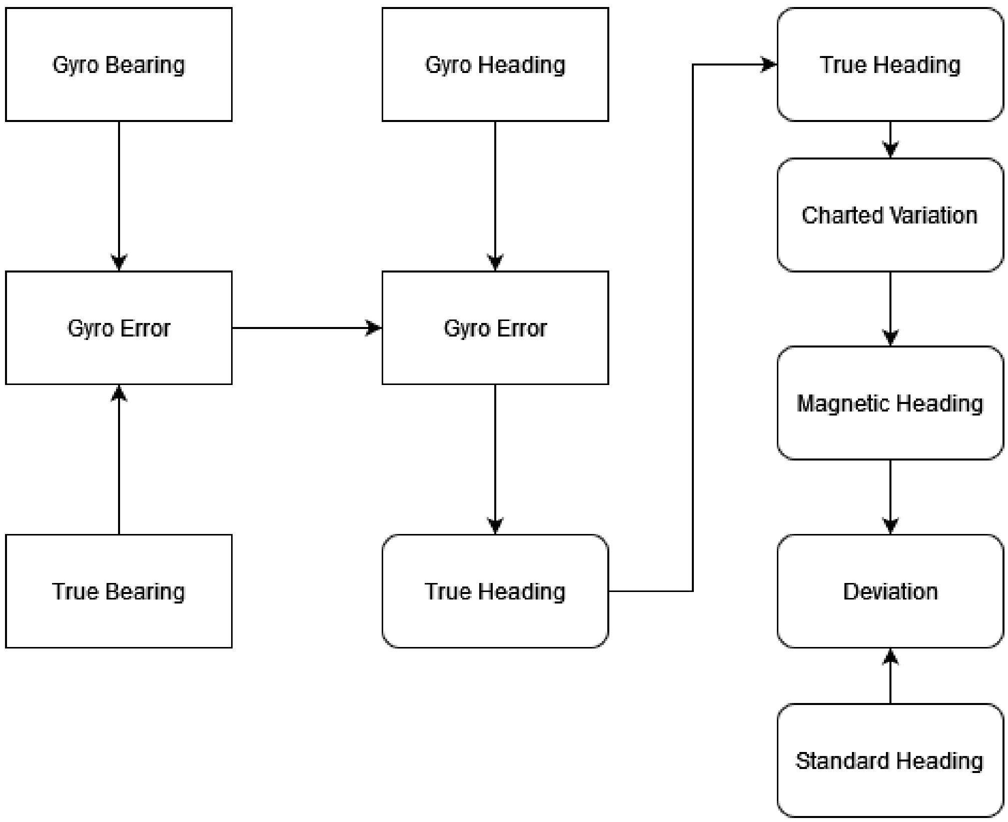

Figure 2: A common way to organize the calculations for calculating Gyrocompass Error, Variation and Deviation of the Standard Compass, as required for all watches.

4.4.1 Azimuth

It is important to get into a good routine for taking an Azimuth on your bridge watch. The CWO is required to complete one on all watches on the Bear, and azimuths are some of the only practical industry celestial. You are required to log information in the Ship's Log and the Compass Observation book. The Ship's log wants the gyro course, standard course, GE, VAR, and DEV, True Heading, and the CWO's signature. The Compass record book wants time, date, Lat, Lon, gyro CSE, standard CSE, gyro bearing, true bearing, GE, VAR, and DEV, True Heading, repeater used, and the CWO's initials. To successfully complete your azimuth, you need 4 pieces of information simultaneously.

1. Ship's Position
2. Time (UT and LT) of Observation
3. Observed Bearing
4. Ship's Heading (Steering and Checking)

Information on the ship's heading can always be had by asking the helmsman what they are steering and checking, and if they are any good they will still be on mostly the same course when you ask as when you were when you made the observation. You may ask your BTM to record the Ship's Position off the GPS at the moment you take your observation, but if you do that, he can't be standing next to your to hold your wristwatch. At the very least, you have to make the shot yourself. If you know the ECDIS logbook frequency, you can kill birds 1 and 2 (and half of bird 4) by timing your shot to land on a time that the ECDIS records information, like at the top of the hour, as that ECDIS log entry will have Lat, Lon, Gyro Head, and (zone and Greenwich) time. You still must observe your shot and ask the helmsman what she is checking. As far as calculating GE and DEV, consider the format in Figure 2. Fill in the steering and checking headings as reported by the helmsman, the observed gyro bearing you saw, and the variation off the chart. Use the Z Equation to get Azimuth Angle, convert to true bearing, and find the Gyro Error. Apply the Gyro Error to the Gyro Heading to get True Course. True Course $^{+W}{}_{-E}$ Variation = Magnetic Heading, and the difference between magnetic and standard headings is the deviation.

4.4.2 Fix

The important thing to note about taking Celestial Fixes on your navigational watch is the use of the communal plotting sheet. This is in some ways easier, because you no longer have to set up your longitude lines on your own and you have a trackline. On the other hand, you must share this chart and you cannot take it to the nav lab to submit for your credit. To submit a fix, take a photograph of the plotting sheet and submit your work separately with a note to see the photo you will provide the instructor. When making your fix, you may initial the lines of position that you have constructed, as well as the running fix if it is on your watch. This note is the most important when daytime running fixes of the Sun are required. The BTM of the 08-12 watch creates an LOP from the sun at 0903, marks the AP and leaves a dashed construction line to the LOP, initials the LOP, and also creates an 0903

DR. You are the CWO of the 12-16 watch, you observe LAN at 1222, and a post meridian LOP ⊙ at 1541.

1. Make 1222 and 1541 DR
2. Draw 1222 LAN Lat and sign
3. Place 1541 AP, dashed construction line, and 1541 LOP and sign
4. Decide what time you want the fix to reflect, (I would recommend 1600 in this case, to provide the oncoming bridge watch the most up to date position information)
5. Advance/Retard AM and PM APs to the desired fix time, and move the 1222 LAN Lat LOP directly
6. Enclose and sign the running fix
7. Take a picture.

An important aspect of the morning or evening fix of the stars is not neglecting your watch duties. An experienced navigator can spend 6 minutes finding and shooting the stars, and then 5 minutes each converting that information into LOPs, and a final 2 minutes each plotting them. However, even though I am fast enough to spend only 30 minutes shooting, reducing, and plotting a fix, that's a lot of time not spent doing your mandatory duties, maintaining a good lookout, and standing a good watch. Take care to not spend long with your nose in the book. Take a sight, back to watch, sight, watch, sight, watch, calculate, watch, calculate, watch, calculate, watch, plot, watch, plot, watch, plot, enclose and sign, watch. On my cruise the 04-08/16-20 LWO was very strict about this. Delegate what you can to your BTM.

5 Closing Remarks

The most important advice I can give you is to get in the routine. Nobody does average, people do the minimum or the maximum, and if you're reading this I hope you'll do the most. The more you do, the better you get, the easier the process becomes, the more you can do. It is far easier to stay in the habit than to get in it. Commit early to waking up for Nautical Twilight every morning, taking your breaks during the day for Sun observations, not going to bed until your evening twilight fix is reduced, plotted and submitted. Compare measurements with your friends on the top of the Nav Lab, making sure that you've correctly identified the bodies and set your watches accurately. Your fix triangles will get tighter and tighter, and then you'll be golden. Best of luck.

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