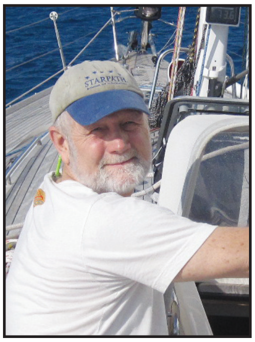
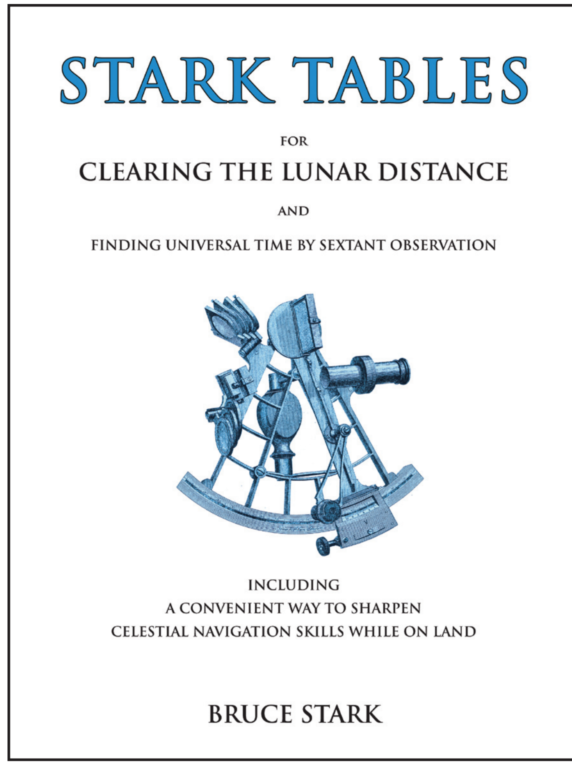


Burch at the Helm



Lunars!

For the celestial navigator who has everything: A challenge, that when met, will put you in the company of Bowditch, Cook and Vancouver

Back when I had more money and time than I do now, I took up the sport of flying. In the process, an instructor convinced me that to be a safe and versatile pilot, I should take training in aerobatics. This led to some exciting hours behind "the stick" of a Champion Citabria, strapped into a parachute with a cable at hand that would release the entire side of the plane with a single pull. It was a different kind of flying than I was used to, and it made me a better pilot.

The aerobatics of celestial navigation is called "the lunar distance method for finding longitude without time," or "lunars" for short. And now the instructor is saying that if you learn lunars, you will become a far better celestial navigator in your routine work. On top of that, you will be prepared for any of the various Doomsday scenarios (e.g. no more GPS, radio time signals, computers or iPhones). In fact, with a few special tables printed out and stowed, you could navigate—with sextant alone—to any point on earth for the next 20 years, even if there were no more civilization at all.

Granted, that may be overdoing it in the back-up department, even for a prudent mariner, but there is no doubt that your routine cel nav will shine in the light of your new skills as a "lunarian," with skills that can be mastered sitting in a chair in your backyard, without a view of the sea horizon. Lunar skills are universally considered the hallmark of the best celestial navigators.

THE REJUVENATION OF CEL NAV

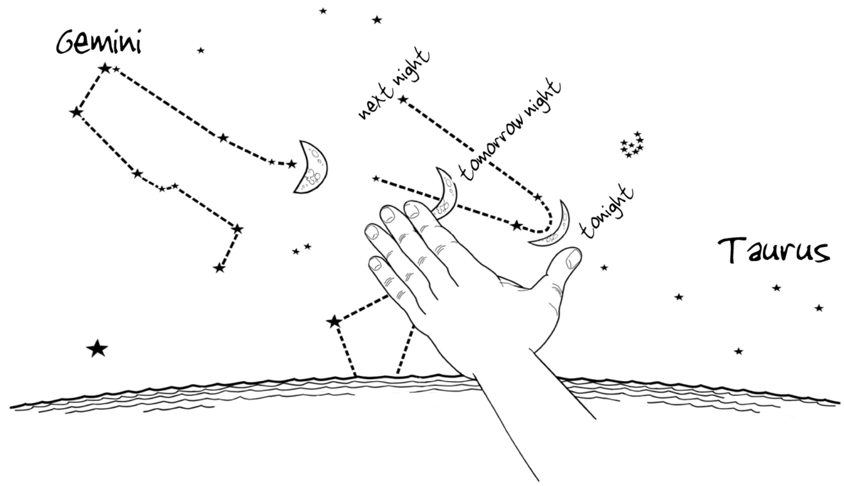
The opportunity to carry out this technique in the traditional manner without computers has recently become convenient with a new publication of the *Stark Tables for Clearing the Lunar Distance and Finding Universal Time by Sextant Observations—Including a Convenient Way to Sharpen Celestial Navigation Skills While on Land.* This book has rejuvenated this procedure worldwide, and with it, celestial navigation in general.

Celestial navigation is a way to find your latitude and longitude using a sextant to measure the angular heights of celestial bodies above the horizon. It has been used by mariners at sea and explorers on land for 300 years, and is still used as a dependable backup to modern electronic navigation. You cannot get an Unlimited Ocean Masters license from the USCG without knowing routine celestial navigation.

Routine celestial navigation relies upon accurate time (Universal Time) to find the longitude of a position (latitude does not require time). Advanced celestial navigators, however, can find longitude without knowing the time using the technique of Lunar Distance. In this technique, the sextant is used to measure the angular distance between the moon and another celestial body along its path. Since this distance slowly changes as the moon moves eastward though the Zodiac constellations, it can be used to find the time of day that is needed to complete the longitude determination.

There are several reasons this valuable technique has not been part of routine celestial navigation for over 100 years. First and foremost, it is not needed as long as the navigator has accurate time, which is readily at hand these days. The history of lunars is inseparable from the history of timekeeping at sea, because the achievements in astronomy needed to predict the location of the moon accurate enough for lunars came about at almost the same time as the invention of accurate seagoing watches—the mid 1700s. It is a famous story, made popular in Dava Sobel's book *Longitude*—a boon to the public knowledge of navigation history, despite some poetic license and struggle with details. But the invention alone did not make it a practical solution. It needed testing (Captain Cook did some of this), and most crucially, it had to be proven that someone other than the inventor (John Harrison) could manufacture them.

The production and dependability of the instruments was getting sorted out by the early 1800s, but they were still very expensive, especially since one was not enough to guarantee the right time. If it is wrong, you don't know it. Likewise, two are not enough. To know the time accurate to the second, over a long voyage away from civilization, you need at least three watches. This is still true if you want to be independent of radios and GPS.



The moon circles the earth (360°) in about 30 days, so viewed at the same time each night, it moves eastward through the stars at a rate of about 12°/day. The moon's path runs through the stars of the Zodiac. Drawing from *Emergency Navigation* by David Burch

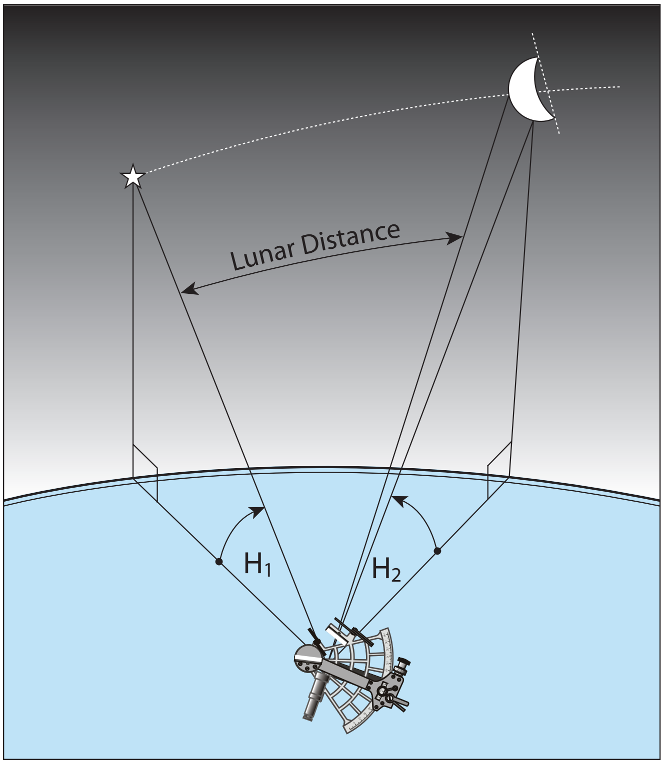
I say "watch," meaning a portable clock, but I should say "chronometer." A chronometer is just a watch that gains or loses time at a constant rate. The actual magnitude of the rate does not matter, so long as it is constant. With a known constant rate and date set, you can always figure the correct time. By the mid- to late-1800s, chronometers, though still expensive, were in reach of most ship's captains. Chronometers remained relatively expensive up to the days of the Bulova Accutron in the early 1960s, then the prices started down. Now, essentially any quartz watch is a chronometer, and three top-notch, waterproof models are less than $100. But they still have to be tested, preferably over the full temperature range expected. Put them inside an electric blanket and then inside a fridge for a couple of months as you monitor their rates.

BEYOND NORMAL

With good timekeeping practice, we should not lose accurate time *in normal conditions*, especially since we have accurate time from every GPS satellite, and there are numerous radio broadcasts of GMT, now called Universal Time (UT). But it is not unheard of, and prudent seamanship means considering things beyond normal conditions.

All electronics are vulnerable at sea. Watchbands are more vulnerable than watches in many cases, which can lead to the loss of a watch. Plus they take batteries. Do you know how long your watch battery will last? Do you take spare batteries when you go offshore? If your watch stops with a dead battery and you replace it offshore, what time do you set it back to? Does this turn your three chronometers into two?

And, there is always Doomsday. Those of us who thought Doomsday was somehow more remote after the fall of the Soviet Union are waking up to smell the coffee. The world has not evolved as we might have guessed it would. Two days ago, one nuclear power literally threatened a neighbor with total destruction after torpedoing one of its ships and killing 48 sailors. The concept of nuclear proliferation and its dire conse-



"Lunar distance" is the angle between the edge of the moon and another celestial body along the Zodiac. The sextant can reach out to almost 120°, though sights half this range or less are easier. The angular heights of the bodies perpendicular to the horizon are used in the analysis, but these values can be computed if an almanac is available. See www.historicalatlas.com/lunars for lunar computations and data. Drawing from *Celestial Navigation* by David Burch

quences are *more and more* a part of the daily news, not less. It is way too early to write off Doom.

WHAT YOU DON'T KNOW…

The main reason most navigators do not use lunars is because they do not need to; that is, if we rule out the even bigger reason—most navigators are unaware that the technique exists because it was not covered in any books they used.

Navigators who are aware of lunars and would like to learn them have other challenges. First, the special diagonal sextant sights are more difficult than normal cel nav sights, which are always measured straight up from the horizon, and the results must be more accurate. This requires learning to use the sextant to its very limits. But this challenge is part of the reward.

The practical limit to sextant accuracy is about ± 0.1' of arc. Without much practice or good instruction, navigators might average three or four times that limit, or even a bit worse. To be successful with lunars, however, you must practice until you can approach the instrument limit routinely, even using the sextant in the awkward diagonal manner. Higher-powered monocular telescopes help with this. Precomputing the lunar distance ahead of time is also helpful.

There are navigators who do lunars with plastic sextants, but this takes even more special care, and average results are not as good as with metal sextants. Put another way, it would make you even better if you could do them with plastic sextants, and in any event it is a way to see how the whole process works without the investment of a metal sextant. The author's booklet *How to Use Plastic Sextants* (starpath.com) is required reading for this endeavor, besides raising the general quality of all sextant sights, metal and plastic.

As an aside to celestial navigators, another great benefit is that you will learn a new technique for finding the sextant's index correction (what we call at Starpath the *solar method*). This is much more accurate than the conventional procedure using the horizon. Plus, it contains a self-consistency check because it measures the sun's semi-diameter, which can be looked up in the almanac. This correction measurement is not taught in modern textbooks that do not include lunars.

The other issue has been the challenge of analyzing the lunar distance to get longitude once it has been measured accurately. The government tables that used to do this went out of print in the early 1900s and it is essentially impossible to use old ones for modern sights. There are computer programs and Internet sites that have computed the solutions for many years, but reliance on a computer or an Internet service for a back up procedure is completely incongruous. Thus, there has not been a logical role for lunars outside of academic and historic study beyond a select group of sextant experts who use it to maintain their prowess. That is, until now.

AN INGENIOUS APPLICATION

The *Stark Tables* are a modern take on this venerable problem, but as lunar expert George Huxtable, FRIN, put it, "Captain Cook would have relished using the *Stark Tables*, had they been available to him then." They are an ingenious application of the same basic methods of the 1700s, but easier to use. Doing all the paperwork by hand, filling out custom forms, you can go from a measured lunar distance to the correct time and your longitude in about 15 minutes, without needing a calculator. You can measure the lunar distance any time of night that is convenient, since you do not need to see the horizon. The altitudes of the bodies above the horizon (which cannot be seen in the middle of the night) are needed in the process, but they can be computed from tables to sufficient accuracy from a DR position. Likewise, the sun and moon are frequently in good view for the sights throughout the day.

Robert Eno in a *Navigator's Newsletter* review said, "It is remarkable in this day when the very survival of celestial navigation seems in question, that an individual should suddenly appear on the scene and present to the world such a brilliant piece of work. Stark has rendered a great service to the celestial navigation community."

The accuracy achievable depends on the quality of the sights and the choice of bodies. The *Stark Tables* explain how to choose the best companion. You want one in line with the motion of the moon, so the change in lunar distance with time is the greatest. The sun is good just about any time it is in view with the moon and within reach of the sextant. At night you want bodies (star or planet) perpendicular to a line drawn across the horns of the moon. It can be on either side. The *Stark Tables* include a way to evaluate the quality of your choice in this regard, and they also provide detailed instructions on taking the sights.

TAKING BACK POWER

You can't expect to get lunar longitudes as precise as you can with accurate time, but they will be quite serviceable. A one-arc minute sextant error (1.0') in the distance measurement will cause about a two-minute error in the time when using the best companion bodies. If you can achieve 0.5' accuracy, you improve to one-minute error in time, which corresponds to a 15' error in longitude. This in turn corresponds to about 15 nmi in the Tropics or about 10 nmi at the latitude of Seattle. Navigators skilled in this method can generally get down to averaging closer to 30 seconds error in time.

If you surf around the Web looking into the topic online, you will find far more discussion on the details and complexities of the process than you will find discussion of its practical use today. And sure enough, there are many nuances to the process. These details, however, are all accounted for in the *Stark Tables*, so they can be treated like so many other navigation tables. Just use them for their practical value without worrying about the rigors of their physical and mathematical foundations.

In the end, the test is very simple: stand at a known place with a watch set to some unknown error, and see if you can find out where you are. If it works for you there, it will work for you at sea. This is one of the most rewarding navigation exercises you can do.

With the *Stark Tables* in your nav station, you no longer have to fear losing power to your electronic navigation aids, nor are you dependent on accurate time from any official broadcast. It is a small investment in time and energy that greatly expands your skills and preparation for the unexpected. For all we know, a volcano in Iceland might suddenly erupt and wipe out all of the air travel in Europe in a matter of days. ≈

David Burch is the director of Starpath School of Navigation, which offers online courses in marine navigation and weather at www.starpath.com. He has written eight books on navigation and has received the Institute of Navigation's Superior Achievement Award for outstanding performance as a practicing navigator.