Waypoint Conversions

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Abstract

Many coastal navigators have good, measured Loran-C waypoints of underwater features such as wrecks and reefs, and want to enter them in a GPS receiver. But Loran-C waypoints are best described by time delay (TD) readings, while the GPS receiver uses latitude and longitude. A Loran-C receiver calculates latitude and longitude, and you can enter TDs in many GPS receivers, but doing so introduces errors of a few hundred yards or more. We frequently get requests from people who want to convert TDs to latitude and longitude with minimum error. This paper describes practical ways for a navigator having Loran-C and GPS receivers to determine the corrections to apply to achieve minimum error when finding the latitude and longitude from waypoint TDs. It describes methods using the receivers and another using computer programs to do the calculations, and how to determine and use corrections.

We frequently are asked how to determine the latitude and longitude of positions from previously measured Loran-C time delay readings, for use in GPS receivers. This is particularly important for underwater objects such as rocks, reefs, wrecks, well terminations, and net hangs with positions that are known only by their Loran-C waypoint data.

There are several methods of finding the desired coordinates: latitude and longitude. These methods vary in both accuracy and complexity. People who need to convert Loran-C TDs (time delay readings) to latitude and longitude should first determine their accuracy requirements. For clear-weather navigation, for example using a waypoint to find a large offshore buoy, accuracy needs are low—around a quarter of a mile is adequate. Navigation in the fog requires high accuracy, as does finding (or avoiding) underwater objects.

Moderate-accuracy Methods

For clear-weather navigation using both electronic and visual aids to navigation, it is best to use a simple method. All Loran-C receivers except ancient ones can convert TDs to Latitude and Longitude. If you have a Loran-C receiver, just call up the waypoint and change the display from “TD” to “L/L.” Many GPS receivers can make the same conversion by entering a waypoint in Loran TDs and then displaying it in latitude and longitude. However, the errors in these conversions are up to 500 yards or so.

Occasionally the errors are greater. A few models of Loran-C receivers do not have “Additional Secondary Phase” corrections in their programs. These receivers show much greater errors, occasionally well over a mile, in calculating latitude and longitude. In order to determine if the receiver incorporates ASF, check the manual to find if there is a procedure to turn ASF on and off.

GPS receivers show variations in the accuracy of their calculations of latitude and longitude from Loran-C TD entries. Some manufacturers who previously made Loran-C receivers now have more accurate TD to L/L conversions than those that lack such experience. For example, Trimble has a reputation of making the calculations with small errors.

Don't confuse the GPS receivers that *calculate* latitude and longitude from TD data with ones that *measure* Loran-C TDs with an internal receiver. Trimble, Raytheon, and a few others have in the past produced units that include both Loran-C and GPS receivers. Since they combine a GPS receiver and a Loran-C receiver in one unit, they give TDs as accurate as any stand-alone Loran-C receiver.

It is straightforward to plot Loran TDs directly on coastal charts to find the latitude and longitude. The 1:80,000 and smaller scale NOAA charts show Loran TD lines. Plot the positions in TDs using the interpolator on the chart, or an interpolator card. My book "Boat Navigation for the Rest of Us" published by International Marine has a thorough discussion of this, as do many others.

Both of the above simple methods are fine for clear-weather navigation, but not for foggy weather or for finding underwater objects.

Visiting and Measuring

The Coast Guard suggests visiting each Loran-C waypoint while using a Loran-C and a GPS receiver simultaneously, and saving a new waypoint with the GPS receiver. While correct in theory and practice, this method does require extensive steaming time. This is particularly so when the navigator has saved hundreds of waypoints for small underwater objects. In addition, fishermen have saved many hundreds of waypoints to avoid: snags, hangs, and rocks. It is impractical for a trawler to visit these locations.

Computer Calculations to Determine Latitude and Longitude

People often request “the formulas” to find latitude and longitude from Loran-C TD readings. As members of this Association know quite well, the calculation of latitude and longitude from Loran TDs is complex. The highest accuracy requires ground conductivity data that is not easy to apply.

Fortunately, there is a public domain NOS (NOAA) computer program to make these calculations. It is available on the International Loran Association home page at http://www.loran.org/ Go to the FTP site and get “gptotd.zip”

The U.S. Coast Guard Research & Development Center has another program at http://www.rdc.uscg.mil/rdcpages/soft-posaid2.html

The NOS and USCG programs run under DOS, and do not include ASF corrections. Thus they produce relatively large errors. There are two ways to correct the calculations. The International Loran Association and NOS have posted the ASF tables on their web sites. These data are arranged by Loran-C chain, rate, and geographic position. The corrections are given for each five-minute square of latitude and longitude. In order to calculate reasonably accurate latitude and longitude from TD readings, it is necessary to apply the ASF factors prior to entering the TD data in the program.

Use the ASF tables for the appropriate Loran-C chain, rate, and geographic position to determine the ASFs for each TD. Then add the corrections to the actual readings, and use the “corrected” TDs as entering arguments in one of the computer programs. Positions calculated in this manner are accurate within +/- 200 meters in the open ocean, according to NOS, but their accuracy decreases near shore.

There is a good commercial program to convert Loran TDs to latitude and longitude with reasonable accuracy, and is easier to use than the above programs. The program also stores waypoint data and prints charts showing the waypoints. It runs on the Windows operating system, and is available from:
ANDREN SOFTWARE CO.
906 S. Ramona Ave.
Indialantic, FL 32903-3435 USA
(321) 725-4115
http://www.andren.com/

Improving Accuracy

Any one of these computation methods can be improved dramatically by taking simultaneous data with a GPS, DGPS, or WAAS/GPS receiver and with a Loran-C receiver, and determining the corrections. This procedure is far more reliable now that Selective Availability for GPS has been set to zero. Prior to May 2000, the +/- 100 m, 95% accuracy of GPS was a limiting factor in determining an accurate latitude and longitude starting point. Now GPS, with reported accuracy of +/- 5 to 20 m, 95% of the time, is more precise than Loran-C in nearly all areas.

To obtain simultaneous positions, go to a convenient position clear of obstructions, and anchor the boat. It's best to be in open water rather than in the marina. Large bridges can distort the Loran-C signals, and big buildings can reflect the GPS signals. You want to make a comparison free of such disturbances. Check both Loran-C and GPS receivers to be sure that the numbers aren't ``jumping around." Check that the Loran-C is locked on the usual TDs, that the SNR is high, and that the GPS has low PDOP and high signal quality. If your GPS receiver can be augmented by Differential or WAAS, be sure that it is using the corrections. Save a Loran-C and a GPS waypoint at the same time. At this point, there are two workable methods.

Latitude and Longitude Corrections

The first method determines corrections to apply to the latitude and longitude calculated from the Loran-C TDs to agree with the GPS position. Shift the Loran-C receiver to indicate latitude and longitude of the waypoint, and compare them with the GPS position at the ``common waypoint."

This is sample data taken in our area:

GPS	N 34° 42.04’	W 76° 59.172’
Loran-C	N 34° 41.97’	W 76° 59.13’
difference	.07’	.042’

With these two receivers, in this area, *adding* these differences to Loran-C waypoints gives the latitude and longitude to be entered into the GPS receiver. It has shown good accuracy.

There are some precautions. First, use your own receivers. Two other receivers at the same spot gave different corrections. Second, the corrections are valid over relatively short distances. As a rule of thumb, they will be most accurate within the one-degree square containing the common waypoint. In the example above, the latitude and longitude corrections are valid from 34° N to 35° N, and from 76° W to 77° W. Only a few hundred yards to the west, beyond 77° W, new corrections are necessary for the highest accuracy. For a better assessment, examine the ASF tables to determine how quickly ASF varies for each TD. Third, when you do go to each waypoint, save it in the GPS receiver. That is the most accurate GPS data.

Local TD Corrections

To use the other method, that of determining local corrections to apply to Loran-C TDs, enter a waypoint in the Loran-C receiver using the latitude and longitude of the GPS waypoint. Next, have the Loran-C receiver calculate and display the TDs of the waypoint, and compare them with the TDs *measured by the Loran-C receiver* at the common waypoint. This gives corrections to be applied to each Loran-C station pair (each TD).

The reverse method of calculating TDs and comparing the calculated values with the Loran-C TD readings also works with the two public domain computer programs. Proceed the same way; enter the *measured* GPS position and calculate the TDs. Compare these TDs with the TD readings that you obtain from the Loran-C receiver at the common waypoint. Then you can apply the corrections to observed data to calculate nearly correct latitude and longitude. Again, the values are most accurate within a one-degree square. For highest accuracy, obtain corrections within each five-minute square.

The Andren computer program includes instructions for methods of "calibrating" local ASF corrections with local position and TD data for high accuracy. It works well and provides good results.

These calculation/measurement comparison methods are practical, designed for ease of use. They avoid the problems of datum conversions when used within a relatively small area. They are much more precise than any known calculations that do not include local corrections, but they are subject to errors if they are used over large areas. Of course no method is as accurate as finding the physical feature with the previously measured Loran-C TDs, and then saving a GPS or enhanced GPS waypoint.