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TD2LL: Loran-C Time Difference to Latitude-Longitude Coordinate Converter

Version 1.31

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1. Introduction

TD2LL is a Microsoft Windows™ based tool for the conversion of Loran-C Time Differences to geographical (latitude and longitude) positions on the surface of the earth. The geographical location is referred to the WGS-84 ellipsoid representation of the surface of the earth, allowing compatibility with the Global Positioning System (GPS).

The user may select from a number of Loran-C chains, directly enter the TD reading as provided by a legacy hyperbolic mode receiver or from a set of waypoints, and convert to geographical location with the click of a button. There is also the option to convert data collected from a Locus™ LRS III Loran receiver into a list of geographical locations.

In addition, the tool allows the inverse calculation; given a geographical location in latitude and longitude format the equivalent Loran-C Time Difference may be computed for a given chain.

A summary of the features of TD2LL follows:

- Non-iterative conversion algorithm – no need to enter an initial estimated position, and convergence is guaranteed every time.
- Direct (TD2LL) and inverse (LL2TD) computation.
- Chains are expandable and configurable using a text file with a simple format.
- Compatible with the output from a Locus™ LRS III receiver.
- Simple and flexible Additional Secondary Factor (ASF) entry system – Time Difference (TD) ASF or Time of Arrival (TOA) ASF format available.
- Display in decimal degrees, degrees and decimal minutes, or full degrees-minutes-seconds.

Note: TD2LL Version 1.3 comes with both iterative and non-iterative options available, selectable using the radio buttons at the lower left of the control panel. The non-iterative technique does not need to be provided with an initial position estimate. Using Bangor as a test location we found a difference of about 3 metres between TD conversions using the non-iterative and iterative solutions. We have included both options for the experimenter to test the algorithms on their own data. Any comments and notes on accuracy are welcome as we try to improve the non-iterative algorithm in future updates.

1.1 Version History

V1.0 - Original iterative algorithm implementation

V1.1 - Inclusion of non-iterative algorithm

V1.2 - September 2003 - Improved accuracy of non-iterative algorithm

V1.3 – September 2003 –output result format option included (degrees, minutes, seconds)

V1.31 – 30 September 2003 – Fixed a bug when reading Lat/Lon edit box when converting Lat/Lon to TD using Degrees Minutes Seconds compatibility.

2. Installation

The TD2LL application and associated files are distributed in a Zip file: td2ll.zip. The Zip distribution contains the following:

1. TD2LL.exe – The tool.
2. TD2LLGuide1.31.doc – This user guide.
3. Loraninfo.dat – Loran-C transmitter chain database

These three files should be extracted into a folder on your hard drive.

3. Using TD2LL

Double click the td2ll.exe application, or create a shortcut to the application on your desktop and double click that. The screen shown in Fig. 1 should be displayed.

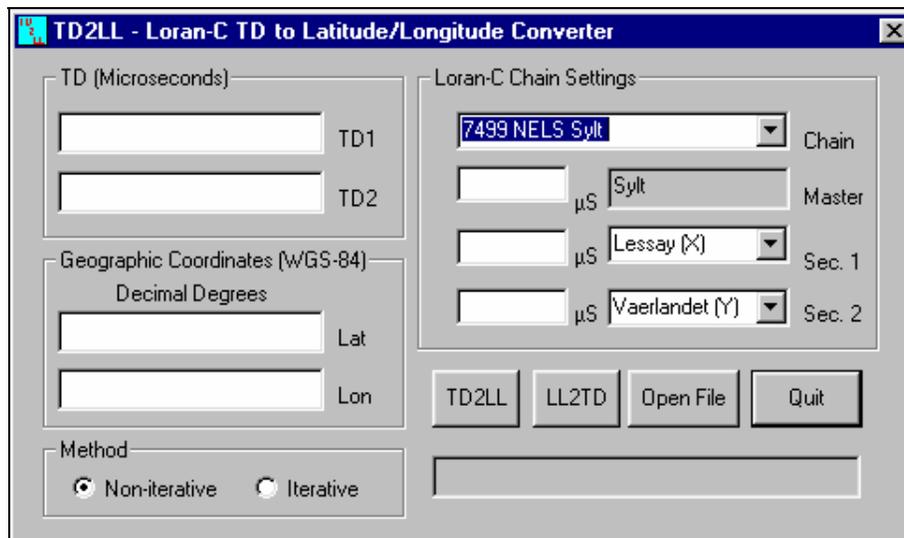


Fig. 1 – The TD2LL dialog box.

3.1 Time Difference to Latitude - Longitude

Select the appropriate chain from the “Chain” drop-down list. Select the appropriate pair of secondary stations from the relevant drop-down box (“Sec.1” and “Sec.2”). Ensure that two separate secondary stations are selected as appropriate for the TDs you wish to convert. Select the conversion method using the radio buttons at the lower left of the dialog. Both iterative and non-iterative methods have been implemented for demonstration purposes in the full version of the software. The non-iterative technique

does not require a position estimate to be entered. With the iterative method, you need to enter a position estimate into the “Geographic Coordinate” edit boxes before clicking the “TD2LL” button.

Enter the TD values in microseconds in the edit boxes on the top left hand side of the TD2LL dialog box. The upper edit box is for the first “Master - Secondary” pair (Sec.1-Master), and the lower edit box is for the second “Master – Secondary” pair (Sec.2-Master). Click the button labelled “TD2LL”. The geographical location will appear in the lower pair of edit boxes in decimal degrees.

Example 1:

Using the NELS Sylt Chain (GRI 7499), at the School of Informatics in Bangor, we measure the following TDs:

Lessay(X)-Sylt(M) = 12960.60 μ s
Vaerlandet(Y)-Sylt(M) = 30204.04 μ s

If you are using the iterative method, you will need to enter a position estimate into the “Geographical Location” edit boxes. For this example entering “50” in the latitude box and 0 in the longitude box should suffice.

Entering these values into the appropriate edit boxes and selecting the Sylt chain results in the following geographical location when the “TD2LL” button is clicked:

Latitude: 53.237986°N
Longitude: -4.120838°E

Longitudes west of Greenwich (0°E) are represented as negative East values.

3.2 Latitude – Longitude to Time Difference

Select the appropriate chain from the “Chain” drop-down list. Select the appropriate pair of secondary stations from the relevant drop-down box. Ensure that two separate secondary stations are selected as appropriate for the Latitude – Longitude pair that you wish to convert.

Enter the Latitude – Longitude values in the edit boxes on the bottom left hand side of the TD2LL dialog box. You may use any of the three formats Degrees Decimal, Degrees DecimalMinutes or Degrees Minutes Seconds. You must separate the Degrees, Minutes and Seconds values by a space.

The upper edit box is for the Latitude, and the lower edit box is for the Longitude. The convention in the program is to use positive values to represent longitudes east of

Greenwich, and latitudes north of the equator; and negative values to represent longitudes west of Greenwich and latitudes south of the equator. In DMS (and Decimal Minutes) format you only need to type the negative sign before the Degree value.

Click the button labelled “LL2TD”. The Time Differences will appear in the upper pair of edit boxes in microsecond (μs).

3.3 Processing a Data File

Ensure that any files collected from the Locus receiver are saved with a “.loc” extension and that the TDs are in nanoseconds, **not tenths of nanoseconds**. Click the button labelled “Open File” and browse to the location of the “.loc” file. Click “Open” on the browse dialog. Click the TD2LL button. The message box will display “Processing...”, while the file is being processed, and “Done” when processing has finished. Once processing has finished, a new file will be found in the data file folder with the same pre-extension filename as the “.loc” file, but with the extension “.lln” (Latitude-Longitude Non-iterative). This file will contain a list of Latitude – Longitude pairs corresponding to the TDs for the selected chain and secondaries in the Locus™ data file.

3.4 Entering ASFs

You may enter Additional Secondary Factor (ASF) values in microseconds (μs) in the edit boxes supplied. Two modes of ASF are available:

1. TOA ASFs – A Time of Arrival ASF is a value, which corresponds to the individual propagation path from a transmitter to a receiver. They are the propagation delays due to propagation over land rather than the sea-water only assumption generally assumed by Loran-C receivers. They are applied to individual pseudoranges in rho-rho (circular mode) navigation or in the navigation mix with the GNSS (Global Navigation Satellite System, i.e. GPS, Glonass, Galileo etc.).
2. TD ASFs – Time Difference ASFs are values, which correspond to transmitter pairs and are applied to time differences used in hyperbolic mode navigation. They may be computed from TOA ASFs thus:

$$TDASF_{X-M} = TOAASF_X - TOAASF_M$$

If you leave the ASF entries blank, the ASFs will all be assumed to be zero. In order to use TOA ASFs enter individual ASF values corresponding to each of the stations (Master, Secondary 1, Secondary 2) in the edit boxes provided.

To use TD ASFs leave the Master station ASF box blank, and just enter the TD ASF values for the two secondary stations in the appropriate box.

Example 2:

Using Example 1, we can include ASFs in our position solution. The TD ASFs for the station pairs are:

Lessay-Sylt: 4.19 μ s

Vaerlandet-Sylt: -1.61 μ s

The measured TDs for the station pairs remain the same:

Lessay(X)-Sylt(M) = 12960.60 μ s

Vaerlandet(Y)-Sylt(M) = 30204.04 μ s

Entering these values into the appropriate edit boxes and selecting the Sylt chain results in the following geographical location when the “TD2LL” button is clicked:

Latitude: 53.229420°N

Longitude: -4.123406°E

Longitudes west of Greenwich (0°E) are represented as negative East values.

3.5 Latitude and Longitude Output Format

The default output format of the converter is in decimal degrees. By **clicking** the label “Decimal Degrees” positioned above the “Latitude” and “Longitude” display boxes you may cycle through the following output display formats:

Degrees Decimal-Minutes
Degrees Minutes Seconds
Decimal Degrees

4. Support

TD2ll has been tested on the following platforms:

Microsoft Windows 98

Windows 98 Second Edition

Windows XP

Windows 2000

Please report any bugs and make suggestions using the Guestbook on the Web site at www.informatics.bangor.ac.uk/Loran-C or e-mail Paul.Williams@gla-rad.org

The website can also be reached by using the “Go to URL” button on the tools “About” dialog box.

Updates will be made available for registered users of the software at the above site in the future.

The Radionavigation Systems Research Group and the University of Wales, Bangor, accept no liability for the use of the TD2LL tool for navigation and safety critical applications.

NEVER RELY ON A SINGLE NAVIGATION SYSTEM!