F1

Introduction
This chapter discusses Loran-C overprinted charts and related Loran-C information available from the various agencies of the U.S. government. Relevant information includes the Loran-C charts, DMA published manuals on ASF corrections (discussed in Chapter II), and material furnished by USCG, including the Local Notice to Mariners and related information. This chapter is principally of interest to mariners.

Loran-C Charts: Third Vital Component of the System
As noted in Chapter I, the Loran-C system consists of land based transmission and control systems, a receiver to measure TDs, and Loran-C overprinted charts, used for navigation and for plotting and converting the measured TD data into latitude and longitude. (These charts are not used by aviators. As noted, aviation users work in latitude and longitude units exclusively.) For U.S. waters, these charts are prepared and published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS). For other parts of the world, the Department of Defense (DOD), Defense Mapping Agency, Hydrographic/Topographic Center (DMAHTC), publishes nautical charts, many overprinted with Loran-C TDs. Additionally, several other countries of the world publish Loran-C overprinted nautical charts. Canada, for example, publishes excellent Loran-C charts of both Canadian and adjoining U.S. waters.

The focus of this discussion is upon charts of U.S. waters, therefore, the charting conventions of NOS will be emphasized. Chart conventions generally agree among the various countries, although there are some minor differences. Readers wishing information on chart conventions employed in other countries should write directly to the NOS counterpart in the country of interest. Useful material on NOS conventions can be found in Stuart (1986, 1991) or obtained directly from NOS.

Loran-C Overprinted Charts
Charts available from NOS are identified in the NOS Chart Catalog, issued in five volumes, including: the Atlantic and Gulf Coasts (Volume 1); the Pacific Coast, including Hawaiian, Mariana and Samoa Islands (Volume 2); Alaska, including the Aleutian Islands (Volume 3); the Great Lakes and Adjacent Waterways (Volume 4); and finally a fifth volume covering Bathymetric and Fishing Maps, including Topographic/Bathymetric Maps. These chart catalogs are available at no charge from authorized NOS sales agents, or directly from NOS at 6501 Lafayette Avenue, Riverdale, Maryland 20737. The catalogs contain a small scale chart of the applicable areas of U.S. CCZ waters with coded rectangles (outlining the area covered by each NOS chart) superimposed. These rectangles contain the chart number, and are also color coded to reflect the scale of the chart. Harbor charts, for example, at a scale of 1:50,000 and larger are printed in a purple outline, while coast charts, with scales of from 1:150,000 to 1:50,000 are outlined in blue. Inset panels provide more information on the various charts, including the chart number, title, and scale. Charts prefixed with a
C inside a circle (similar in appearance to a copyright mark) are overprinted with Loran-C TDs. Although the catalog enables the identification of which charts are overprinted with Loran-C TDs, this catalog does not ientify which rates are shown on these charts. Loran-C overprinted charts are available for the entire CCZ and many other areas as well. Loran-C overprinted bathymetric maps1 are also available for selected areas, and loran overprinted transparent mylar overlays can be obtained upon special request (and at additional cost) from NOS. These loran overprinted bathymetric maps are much used by fishing vessels.

With very few exceptions, Loran-C TDs are not printed on any chart with a scale larger than 1:80,000 (1:75,000 in Canada). For the present, this is a deliberate NOS (also USCG and DMAHTC) policy, made because the ASF data presently available are not accurate enough for presentation at larger scales.

Other navigational systems (e.g., radar, visual fixes, depth information) are available for inshore piloting and are almost always adequate.

Absolute (geodetic) accuracy limitations of Loran-C in near shore and harbor areas are explained in Chapters II and III and arise from the sometimes unpredictable effects that land has on loran signals. To some degree, this limitation could be removed by gathering extensive and costly survey data. However, the ready availability of satisfactory alternatives to the use of Loran-C for navigation in these waters and the high cost of such surveys have resulted in the policy decision not to print loran LOPs on large-scale charts.

As well, it is NOS policy not to show Loran-C TDs for inshore waters, bays, rivers, protected harbors (nor over land areas) on smaller scale charts which include these areas. As a point of interest, these LOPs are actually calculated throughout the area covered by the chart by the computer programs used by NOS, but
painted out over these regions on the photographic negatives prior to printing the chart.

Rates Printed on NOS Charts
Rates (GRI and secondaries) shown on each overprinted chart are specifically identified in the Loran-C notes on each chart (see below). NOS loran overprinted charts include at least the recommended rates shown in the coverage diagram, but not necessarily all rates that can be received in the waters covered by the chart. If the spacing between LOPs is excessive (poor gradient), or the crossing angle is too small (see Chapter III), a rate may be not be shown on the chart. In particular, LOPs in the fringe area of ground wave coverage, or in the baseline extension area for a specific rate, are usually deleted from the chart. The decision to omit a rate depends upon several factors, including chart clutter, and is made jointly by USCG and NOS. However, if a particular rate is shown on the coastal series charts in an area, it will also be shown on smaller scale charts of the same waters.

Intervals Between Adjacent TDs and Spacing
As noted in earlier chapters, it would be impractical to print LOPs on nautical charts corresponding to each possible TD. Therefore, only selected TDs are printed. The interval spacing (in microseconds) between the adjacent TDs printed on the nautical chart depends upon the gradient (see Chapter III) and the chart scale. The overall objective of the cartographer is to select an interval (difference in microseconds between adjacent TD lines) that will result in lines of position spaced approximately 3/4" to 1 1/4" apartin any event not closer than 1/2", nor farther apart than 2". Table VI
1 shows the interval between adjacent charted TDs (in usec) and the chart scale and gradient (ft/usec) necessary to achieve a chart spacing of 0.5 in, 1.0 in, or 2.0 inches. For example, charting an LOP near the baseline (gradient approximately 500 ft per usec) at a 1:80,000 scale (typical of coastal charts) would require an interval of 6.7 usec to achieve a spacing of 0.5 in or 27 usec to achieve a spacing of 2 in between adjacent TDs. An interval of 10 or 20 usec might be used. However, if the gradient were as large as 2,500 ft/usec, a smaller interval, such as 2, 4, or 5 usec would be appropriate. Too small an interval results in a cluttered and unusable chart, while too large an interval complicates the task of interpolation using a plotter (see below).

Mcrosecond intervals between adjacent TDs are usually selected as multiples of 5 or factors of 100 (e.g., 5, 10, 20, 25, or 50). On larger scale charts, smaller intervals of 1, 2, or 4 microseconds may be employed. On smaller scale charts, intervals of 200, 250, or 500 microseconds are necessary to ensure the desired spacing between adjacent LOPs. Normally, the interval will be constant for a rate throughout the chart, but in some cases it is necessary to vary the spacing for the same rate in different areas of the chart.2 In this event, the larger interval is selected as an integer multiple of the smaller. For example, if the TDs spaced at a 10 microsecond interval begin to
spread such that the spacing is not within tolerances, a 5 microsecond interval would be used for a portion of the chart to maintain the desired

spacing of LOPs. The microsecond interval between adjacent TDs may differ among the rates shown on the chart.

These conventions on line spacing are quite reasonable, and undoubtedly result in a chart of greater utility. However, users should note carefully the interval between adjacent TDs when plotting a position and not make the assumption that the interval is constant throughout the chart for a given rate, or the same for all rates shown on the chart.

Users should note carefully the interval between adjacent TDs when plotting a position and not make the assumption that the interval is constant throughout the chart for a given rate, or the same for all rates shown on the chart.

Rate Designators on NOS Charts

Rate designators are the coded sequence of numbers or index that identify a rate. Thus, for example, the rate designator for a loran TD printed with the index

9960

W

14500 would be

9960

W. These rate designators are shown every fifth TD on Loran-C overprinted charts produced by NOS unless the microsecond interval is 25, 50, or 250 microseconds. In this latter event, rate designators can be shown on every fourth line, such that the indexed lines will be at 100, 200, or 1,000 microsecond intervals.

ASF Compensation on NOS Loran-C Charts

As noted in Chapter II, the location of the Loran-C LOP on a chart depends upon the speed of propagation of the loran radio waves from the transmitter(s) to the users position. In particular, it is often necessary to include an allowance for landpath delays in computing the location of a Loran-C LOP on the nautical chart. These delays, termed ASFs, can be computed from theoretical propagation models (see Appendix F) or a combination of theoretical models and actual survey data. (Where actual survey data of acceptable quality are available, ASFs are calculated by statistical procedures that force fit the TD lattice so as to reflect the theoretical estimates and provide good fits to the survey data as well.) The surveys are conducted by various agencies of the U.S. Government and provided to DMAHTC for ASF calculation.3 In turn, DMAHTC provides computer tapes containing the ASF corrections to NOS for use in chart compilation. The format and fineness of the ASF grid varies from chart to chart. For example, for charts with a scale smaller than 1:875,000, ASF corrections are probably unnecessary. (This is because the differences between corrected and uncorrected LOPs would appear very small when plotted on such a small-scale chart. Recall from Chapter II that ASF corrections are generally within +/- 4 usec.) For charts with a scale between 1:250,000 and 1:875,000, DMAHTC may provide a single ASF lattice shift (in microseconds) for each rate to be charted. This shift represents an average correction for overland signal delay and is constant over the entire area of chart coverage. Alternatively, for coastal charts with a scale larger than 1:250,000, DMAHTC furnishes NOS with a data tape containing ASF corrected Loran-C coordinate values for each rate at every 5 minutes of latitude and longitude in the area of chart coverage. On these charts, if the hyperbolic curvature of the TDs is clearly noticeable (e.g., in areas near baseline extensions) a finer grid (e.g., at 1 minute intervals) is provided.

The available survey data varies by area, and is dscribed on each chart with a specific chart note found as part of the Title Block or in the Supplemental Notes where the other general loran information is presented. Table VI 2 provides the text of the three standard chart notes now being printed on NOS Loran-C overprinted charts. Older charts may contain different text, depending upon how the chart was compiled.4 Users should read this note carefully to

determine whether or not it is appropriate to use the DMA ASF tables to adjust the printed TDs on a chart, or whether these corrections have already been incorporated into the chart.

Provided the users Loran-C receiver is programmed to include ASFs, the latitude and longitude read from the receiver should be nearly the same as that determined from the TDs when these are plotted directly on nautical charts corrected for ASF. Some differences may result, however, because the ASFs incorporated into the receiver may differ from those provided by DMAHTC to NOS. Additionally these tables can be used by users to correct TDs prior to automatic conversion on receivers not programmed to include ASFs.

Standard Color Coding for Loran-C TDs
Loran-C rates plotted on NOS (and DMA) charts employ a standard color coding, noted in earlier chapters and in the Glossary. As of this writing, no color code has yet been assigned to the Victor secondary, although gold or brown are options under consideration.

The standard color coding for loran TDs serves as an additional check to ensure that the correct line is used to plot a position. Normally, this is not an issue, because the CDs are selected to ensure that there is a wide variation in the numerical values of the various TDs throughout a region. Additionally, the rate designators (noted above) are shown on selected (every fourth or fifth) TDs. Finally, the color coding serves as yet another check.

Users should pay special attention to identifying the correct family of loran LOPs if these are plotted for two GRIs on the same chart, otherwise substantial position errors could result.

Plotting and Interpolation
As noted, only selected TDs are overprinted on the charts, so it is generally necessary to interpolate between printed TDs to plot an exact position. For example, suppose the vessel were cruising in the northern areas of Rhode Island Sound. In this location the TDs for best accuracy (refer to coverage diagrams) would be the Xray and Yankee secondaries of the 9960 NEUS chain. Suppose the TD readings on the receiver were 25,744 and 43,952 microseconds. (Normally, a receiver would display these numbers with one or two figures to the right of the decimal point for the Xray and Yankee secondaries respectively, but these are omitted here for simplicity.) Reference to the appropriate chart indicates that the TDs for the Xray secondary are spaced 10 microseconds apart, so that 25,744 would be located between the 25,740 and 25,750 TDs. On this same chart, the interval between adjacent TDs on the Yankee secondary is 5 microseconds, so the 43,952 TD line would be located between the 43,950 and 43,955 overprinted TDs.

As shown in Figure VI
1, without interpolation all that can be said is that the users position is in the shaded polygon bounded by the overprinted TDs. For many purposes, this approximate position would be entirely satisfactory, but for more accurate navigation it would be necessary to determine exactly where the vessel is located within this polygon.

Although loran LOPs are really hyperbolas, it is convenient to treat these as parallel straight lines within a small area and to use linear interpolation. Thus, the 25,744 TD would be parallel to and approximately 4/10ths of the distance between the 25,740 and 25,750 lines. There are several techniques for locating this 25,744 TD. Perhaps the simplest is to use one of the many loran linear interpolators on the market, or those provided by NOS or the U.S.Coast Guard. These interpolators are made of plastic or stiff cardboard and have several uniform scales with either 5 or 10 equally spaced divisions. All that is necessary is to fix one of the scales with ne end at the lower TD, and the other end at the upper TD, much as is shown in Figure VI
2. The desired TD for the Xray TD is located 4 units along the 10 unit scale of the interpolator. Using a pencil, simply make a mark next to the 4th mark out

of ten and draw in a 24,744 TD parallel to the adjacent TDs printed on the chart. A similar procedure would be followed for the other TD and the vessels location fixed at the intersection of the dotted TDs. In the case of the Yankee secondary, adjacent overprinted TDs are only 5 units apart, so either a 5 unit scale must be used or the difference must be prorated on a 10 unit scale of the plotter.

Depending upon the plotting convention used, the mariner would normally plot the resulting fix as a dot within a circle or dot within a triangle (to denote an electronic fix) and write
LORAN next to the symbol. The fix time (four-digit 24-hour time) is recorded and written next to the fix symbol and parallel to one of the chart axes.

Each Loran-C overprinted chart contains an interpolator printed on the chart, as shown in Figure VI
2. All that is required to use this interpolator is a set of dividers. The procedure is quite simple. First, the dividers are placed on the chart in the vessels approximate position and set to the spacing between adjacent overprinted TDs. Next, one end of the dividers is placed on the bottom of the chart interpolatorwhile holding the dividers perpendicular to the bottomand the dividers moved along the bottom axis until the other end of the dividers intersects the line for the appropriate spacing, e.g., 10 microseconds. The user simply puts a faint pencil mark at the bottom axis at this point. Next, the spacing of the dividers is reduced, while holding one end on the bottom axis, until the other end intersects the desired spacing. This length is then transferred to the chart. In practice, this procedure is easier to do than to describe, and works quite well. Whether to use a separate interpolator or that provided on the chart is a matter of personal preference. Moreover, as noted, it may not be necessary to interpolate at all if the area of the shaded polygon illustrated in Figure VI
1 is sufficiently small for the navigators purpose.

Finally, the user may elect to use the automatic coordinate converter in the loran receiver (if so equipped) and simply plot latitude and longitude directly. Recall, however, that the receivers ASF corrections are not subject to any industry standard, and may not ensure that the system accuracy limits are satisfied.

Use of Loran-C Without Loran-C Overprinted Charts
As noted above, USCG, NOS, and DMAHTC have developed a clear policy about which rates to show on a loran overprinted chart, which charts to overprint, and which areas of the charts to overprint with LOPs. Omission of loran overprinting generally means that the absolute accuracy standards of the Loran-C system cannot be guaranteed in the area covered by the chart.

Loran-C can, however, be used in areas where overprinted charts are not available. If the user has previously transited the area and entered waypoints in the receiver memory (or noted these in hard copy form), the user can generally exploit the receivers high repeatable accuracy for navigation. Even if previously recorded TDs are not available, the mariner can still use the coordinate conversion capability of the receiver (if so equipped) to determine an approximate position. However, the accuracy of this approximate position cannot be guaranteed, and loran should only be used to provide a general indication of position. Most mariners will encounter this situation (within the CCZ) only in harbors and harbor entrances where other aids to navigation are abundant, and should serve as the primary method for navigation.

Although loran can sometimes be used to great advantage in areas where charts do not provide TDs, the omission of overprinted LOPs generally means that system absolute accuracy specifications cannot be guaranteed in these locations.

Local Notice to Mariners
Another important ource of Loran-C information relevant to coastal waters available from the U.S. Government is the Local Notice to Mariners, published by the U.S. Coast Guard, and available from each District office of the U.S. Coast Guard. Experienced mariners rely on the information contained in this publication for chart corrections and other information. It is mentioned here to indicate that loran related information is also presented in this publication.

Table VI
3 provides a sample of such information pertinent to loran extracted from the Local Notice to Mariners for the Fifth Coast Guard District. In general, this publication is used to disseminate information on such topics as the availability of new chains, additional secondaries, scheduled maintenance downtime, reported interference, test efforts, and a host of other time-critical information. The illustrations furnished in Table VI