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PREDICTED LORAN-C GROUNDWAVE COVERAGE

1. INTRODUCTION.

The attached diagrams show the predicted Loran-C groundwave coverage for each chain. A brief discussion of how the coverage diagrams are generated follows:

A. Geometric-fix-accuracy limits.

Each of two LOP's in each Loran-C chain is assigned a TD standard deviation of 0.1 microseconds. The geometric-fix-accuracy is assigned a value of 1500 feet, 2dRMS. Using the two constraints above a contour is generated within the area of the Loran-C chain. This contour represents the geometric-fix-accuracy limits.

B. Range limits.

- (1) Predicted atmospheric noise field strength is calculated for a judiciously selected point in the middle of the service area for each chain. The predicted noise is the average of noise levels calculated to be exceeded only 5% of the time over each 4-hour period of a day for each season of the year.
- (2) Cross-rate Loran-C signals act as interference and can limit reception in some areas. Where signals from adjacent Loran-C chains are relatively strong, values for noise are generally increased to compensate for the additional interference.
- (3) Predicted atmospheric noise for each Loran-C chain is combined with estimated Loran-C signal strength for each Loran-C transmitting station to obtain expected 1:3 SNR range limits for each transmitted signal.
- (4) Where valid measurements of signal strength have been made in a Loran-C service area, these have been incorporated into the coverage diagrams in the form of revised limits.

C. To generate the predicted Loran-C coverage diagrams, the geometric-fix-accuracy limits and predicted SNR range limits are combined on a geographic plot for each Loran-C chain. The area within both the geometric and range limits is the coverage area shown.

2. SAMPLE NOISE CALCULATION.

The predicted noise is determined from data contained in CCIR Report 322-3, Characteristics and Applications of

Atmospheric Radio Noise, Geneva 1988. A sample noise calculation follows:

A. Definition of terms:

**Fa** = Effective antenna noise factor which results from the external noise power available from a loss free antenna.

**Fam** = Median of the hourly values of Fa within a four-hour time block.

**Du** = Value of the average noise power exceeded for 10% of the hours within a four-hour time block (dB above the time block median).

**En** = root-mean-square (RMS) noise field strength for a 1kHz bandwidth (dB/1uV/m).

**D** = RMS noise value added to the time block median to change the percentage of time exceeded from 50% to the desired value; desired value is 5% for the calculations below.

**CF** = correction factor used to permit calculation for any given bandwidth.  $CF = (10 \log_{10} BW) - 30$  in units of dB above 1uV/m.

- B. For the purpose of this sample noise calculation, assume position with latitude 40°N and longitude 135°W.
- C. Determine Fam (1Hz) from Figures 2A-25A (CCIR 322). For this example Fam (1 MHz) is tabulated in Table 1. The first data sample for winter, 0000 - 0400, Figure 2A (CCIR 322), will be used to illustrate how the other rows of Table 1 are calculated.

$$Fam (1MHz) = 60.0$$

- D. Determine Fam for 100 kHz from Figure 2B (CCIR 322) which uses frequency and curves parametric in Fam (1 MHz) as the entering arguments.

$$Fam (100 kHz) = 108.0$$

- E. Determine Du for 100 kHz from Figure 2C (CCIR 322).

$$Du (100 kHz) = 9.0$$

- F. Calculate En using Equation (2), p. 6, CCIR 322.

$$En = Fam (100kHz) - 65.5 + 20 \log_{10} f(MHz)$$

$$\text{For } Fam (100 kHz) = 108.0 \text{ and } f = 100 \text{ kHz,}$$

$$E_n = 108.0 - 65.5 + 20 \log_{10}(0.1)$$

$$E_n = 22.5$$

- G. D, the incremental noise value, is calculated from Du as follows:

$$D = 1.3 (D_u) = 1.3 (9.0) = 11.7$$

The constant factor, 1.3, has been determined by graphical construction using the technique described on p. 10, CCIR 322.

- H. CF is calculated to correct the noise level to the desired noise bandwidth, i.e., 30 kHz:

$$CF = 10 \log_{10} BW - 30 = 14.77$$

- I. The noise level which will not be exceeded more than 5% of the time for a four-hour time block is:

$$N = E_n + D + CF$$

$$N = 22.5 + 11.7 + 14.77$$

$$N = 48.97 \text{ dB above } 1 \text{ uV/m}$$

- J. Steps (b) thru (i) above are repeated for each four-hour time block given in CCIR 322. These calculations are tabulated in Table 1 below.
- K. The average value of the noise levels calculated for each time block (right-most column, Table 1) becomes the noise level which is used in combination with the Loran-C signal strengths to estimate range limits throughout the Loran-C service area.

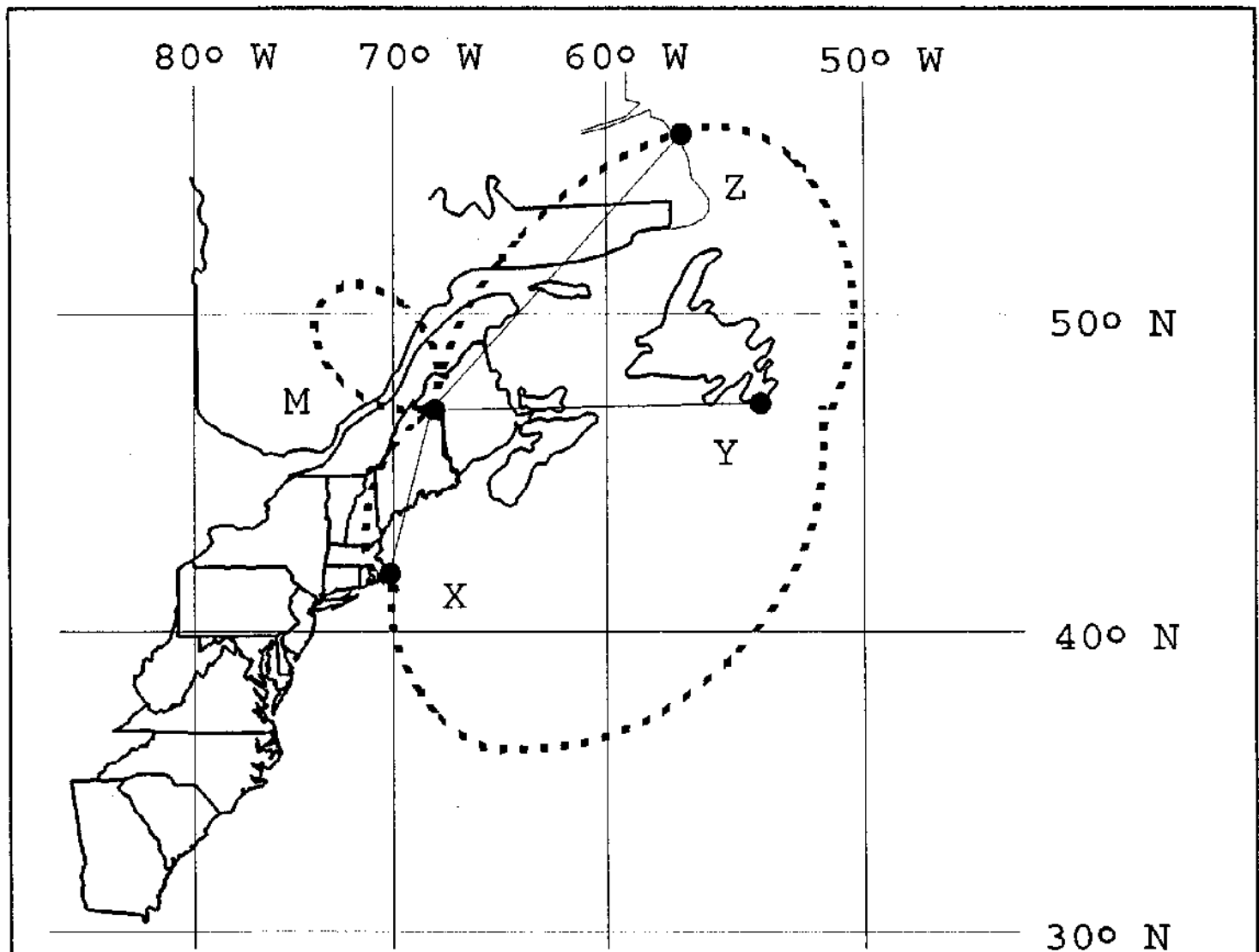
| <u>Time<br/>Block</u> | <u>Fam<br/>(1 MHz)</u> | <u>Fam<br/>(100 kHz)</u> | <u>Du<br/>(100 kHz)</u> | <u>En</u> | <u>D(5%)</u> | <u>CF</u> | <u>N</u> |
|-----------------------|------------------------|--------------------------|-------------------------|-----------|--------------|-----------|----------|
| 00-04/WI              | 60                     | 108                      | 9.0                     | 22.5      | 11.7         | 14.77     | 48.97    |
| 04-08/WI              | 56                     | 104                      | 13.0                    | 18.5      | 16.9         | 14.77     | 50.17    |
| 08-12/WI              | 25                     | 85                       | 13.8                    | -0.5      | 17.9         | 14.77     | 32.21    |
| 12-16/WI              | 27                     | 83                       | 13.8                    | -2.5      | 17.9         | 14.77     | 30.21    |
| 16-20/WI              | 41                     | 95                       | 13.8                    | 9.5       | 17.9         | 14.77     | 42.21    |
| 20-24/WI              | 59                     | 106                      | 9.8                     | 20.5      | 12.7         | 14.77     | 48.01    |
| 00-04/SP              | 65                     | 112                      | 9.0                     | 26.5      | 11.7         | 14.77     | 52.97    |
| 04-08/SP              | 45                     | 99                       | 13.5                    | 13.5      | 17.6         | 14.77     | 45.82    |
| 08-12/SP              | 25                     | 89                       | 15.5                    | 3.5       | 20.2         | 14.77     | 38.42    |
| 12-16/SP              | 32                     | 93                       | 17.0                    | 7.5       | 22.1         | 14.77     | 44.37    |
| 16-20/SP              | 46                     | 97                       | 16.0                    | 11.5      | 20.8         | 14.77     | 47.07    |
| 20-24/SP              | 66                     | 112                      | 10.0                    | 26.5      | 13.0         | 14.77     | 54.27    |
| 00-04/SU              | 58                     | 110                      | 8.0                     | 24.5      | 10.4         | 14.77     | 49.67    |
| 04-08/SU              | 45                     | 103                      | 12.5                    | 17.5      | 16.3         | 14.77     | 48.52    |
| 08-12/SU              | 19                     | 88                       | 13.2                    | 2.5       | 17.2         | 14.77     | 34.43    |
| 12-16/SU              | 36                     | 93                       | 12.5                    | 7.5       | 16.3         | 14.77     | 38.52    |
| 16-20/SU              | 54                     | 106                      | 11.3                    | 20.5      | 14.7         | 14.77     | 49.96    |
| 20-24/SU              | 66                     | 114                      | 7.9                     | 28.5      | 10.3         | 14.77     | 53.54    |
| 00-04/AU              | 70                     | 113                      | 9.0                     | 26.5      | 11.7         | 14.77     | 52.97    |
| 04-08/AU              | 52                     | 105                      | 13.9                    | 19.5      | 18.7         | 14.77     | 52.34    |
| 08-12/AU              | 27                     | 94                       | 16.7                    | 8.5       | 21.7         | 14.77     | 44.98    |
| 12-16/AU              | 30                     | 93                       | 16.5                    | 7.5       | 21.5         | 14.77     | 43.77    |
| 16-20/AU              | 57                     | 106                      | 14.5                    | 20.5      | 18.9         | 14.77     | 54.12    |
| 20-24/AU              | 68                     | 114                      | 9.8                     | 28.5      | 12.7         | 14.77     | 56.01    |

TOTAL = 1113.50

AVG = 46.4 dB above 1uV/m

TABLE 1 - SAMPLE NOISE CALCULATION FOR  
LATITUDE 40° N, LONGITUDE 135° W.

# Canadian East Coast Loran-C Chain GRI 5930



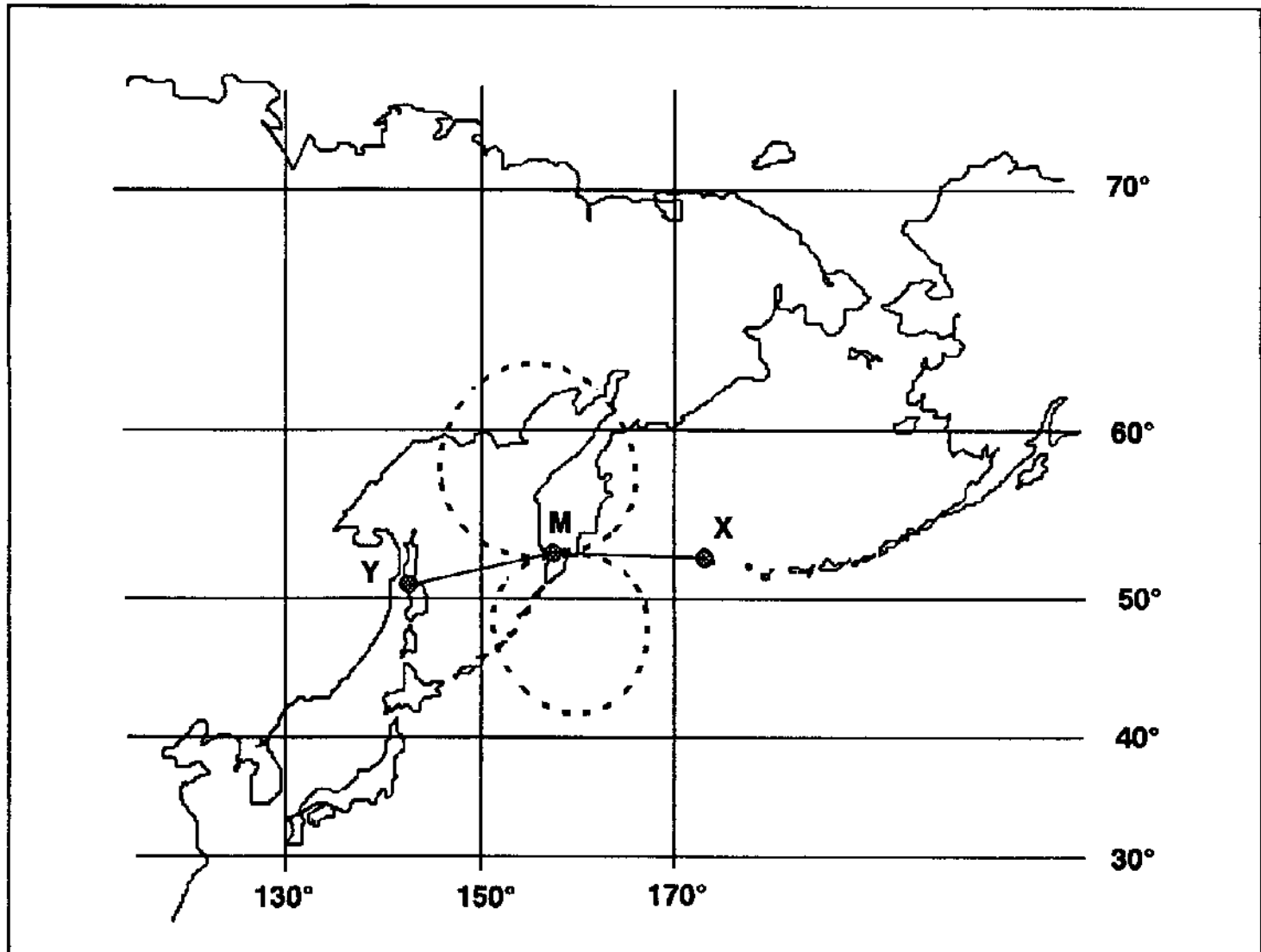
|                   |                           |
|-------------------|---------------------------|
| SNR               | 1:3                       |
| Fix Accuracy      | 1/4 NM (95% 2 dRMS)       |
| Atmospheric Noise | 47.6 dB above 1 $\mu$ V/m |

| Transmitter       | Coordinates    |                | CD<br>( $\mu$ S) | Power<br>(kW) |
|-------------------|----------------|----------------|------------------|---------------|
| M Caribou, ME     | 46°48'27.305"N | 67°55'37.159"W |                  | 800           |
| X Nantucket, MA   | 41°15'12.046"N | 69°58'38.536"W | 11000            | 400           |
| Y Cape Race, CAN  | 46°46'32.286"N | 53°10'27.606"W | 25000            | 500           |
| Z Fox Harbor, CAN | 52°22'35.252"N | 55°42'27.862"W | 38000            | 900           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# Russian American Loran-C Chain

## GR1 5980



SNR

1:3

Fix Accuracy

1/4 NM (95% 2 dRMS)

Atmospheric Noise

44.4 dB above 1 $\mu$ V/m

Transmitter

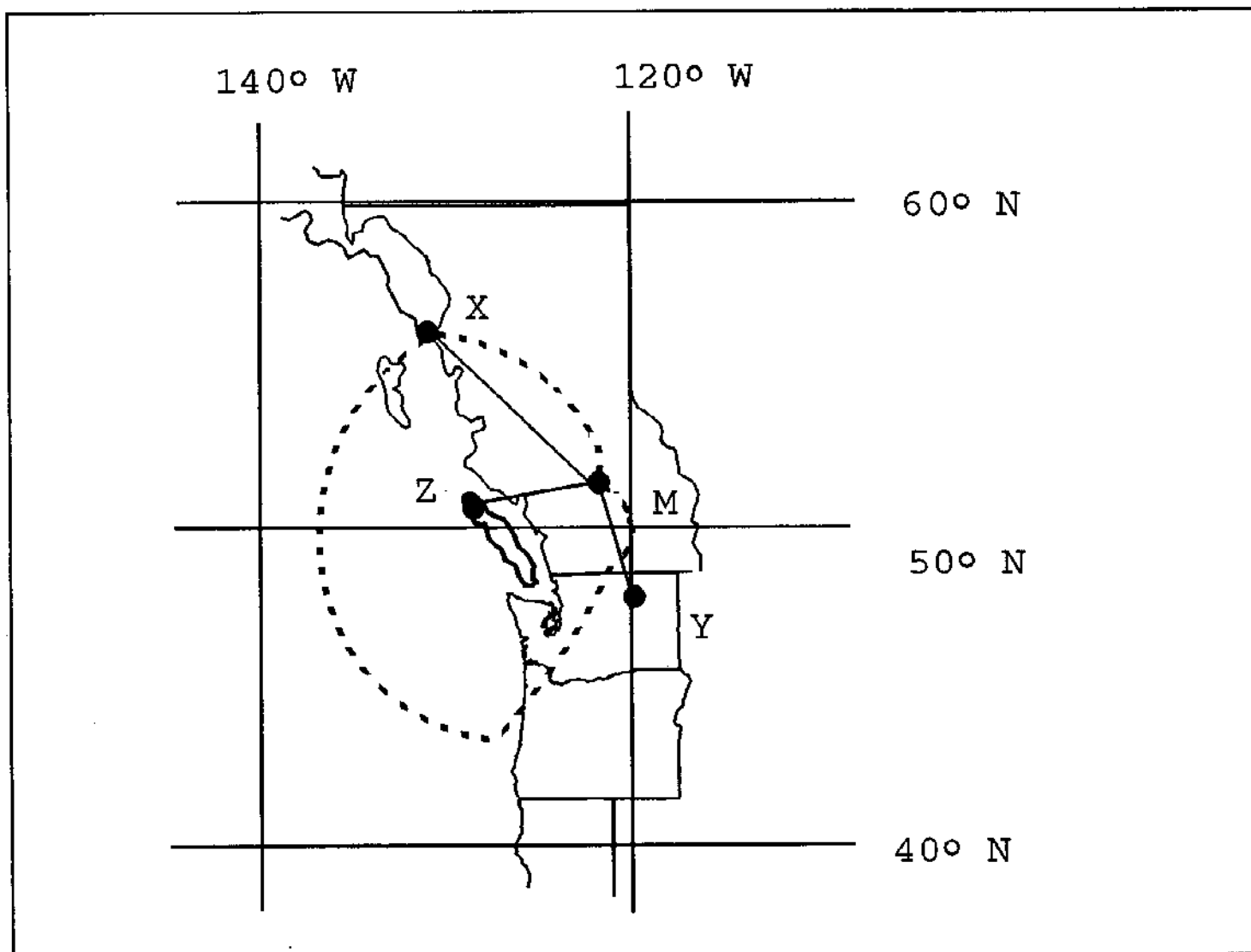
Coordinates

CD Power  
( $\mu$ S) (kW)

|                      |                |                 |       |     |
|----------------------|----------------|-----------------|-------|-----|
| M Petropavlovsk, CIS | 53°07'47.584"N | 157°41'42.900"E |       | 700 |
| X Attu, AK, USA      | 52°49'44.134"N | 173°10'49.528 E | 11000 | 400 |
| Y Alexandrovsk, CIS  | 51°04'42.80" N | 142°42'04.95" E | 28000 | 700 |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# Canadian West Coast Loran-C Chain GR1 5990



SNR  
Fix Accuracy  
Atmospheric Noise

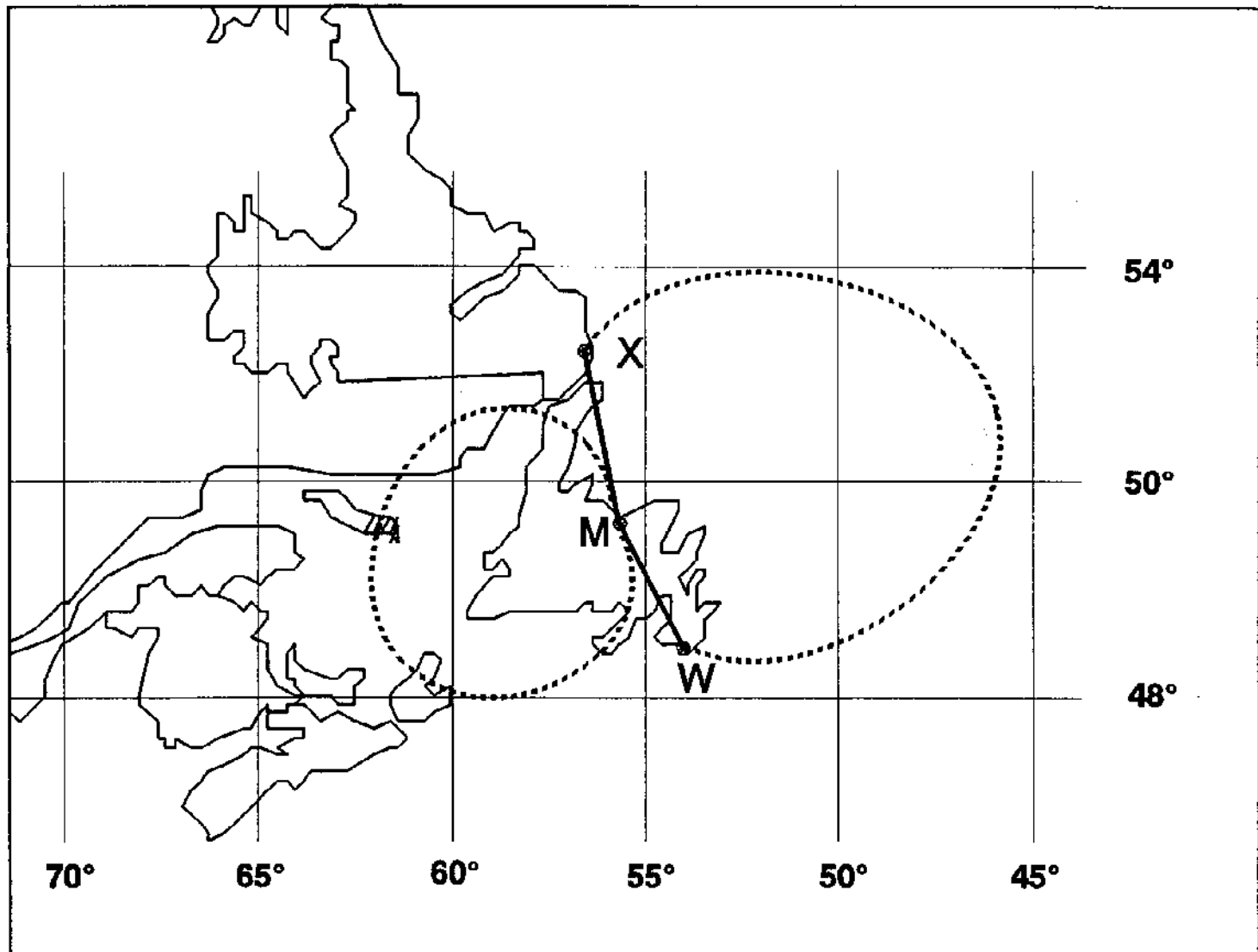
1:3  
1/4 NM (95% 2 dRMS)  
46.4 dB above 1 $\mu$ V/m

| Transmitter           | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|-----------------------|----------------|-----------------|------------------|---------------|
| M Williams Lake, CAN  | 51°57'58.876"N | 122°22'01.686"W |                  | 400           |
| X Shoal Cove, AK, USA | 55°26'20.940"N | 131°15'19.094"W | 11000            | 560           |
| Y George, WA, USA     | 47°03'48.096"N | 119°44'38.976"W | 27000            | 1400          |
| Z Port Hardy, CAN     | 50°36'29.830"N | 127°21'28.489"W | 41000            | 350           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.



# Newfoundland East Coast Loran-C Chain GR1 7270



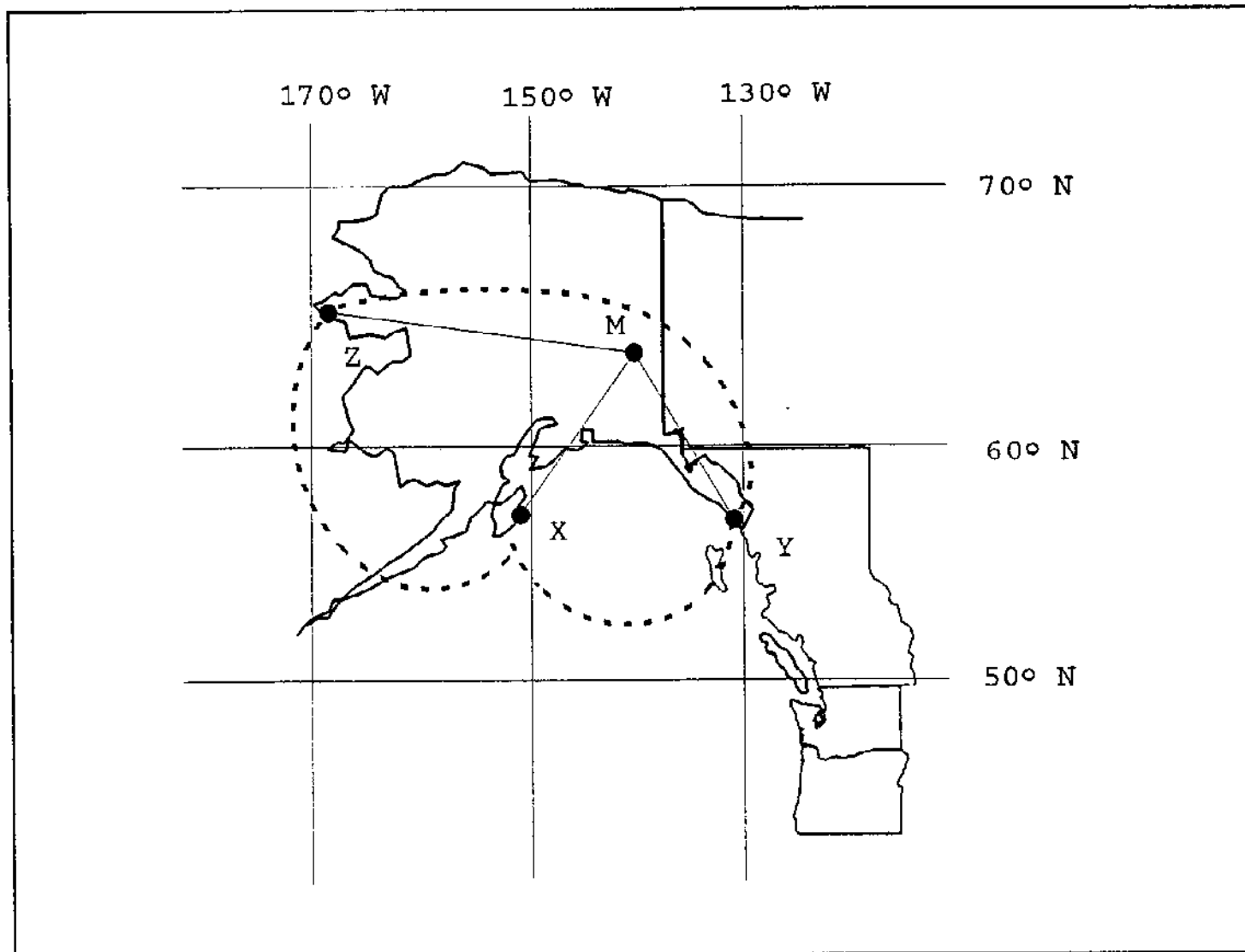
|                   |                           |
|-------------------|---------------------------|
| SNR               | 1:3                       |
| Fix Accuracy      | 1/4 NM (95% 2 dRMS)       |
| Atmospheric Noise | 44.4 dB above 1 $\mu$ V/m |

| Transmitter         | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|---------------------|----------------|-----------------|------------------|---------------|
| M Comfort Cove, CAN | 49°19'53.57" N | 054°51'42.57" W |                  | 250           |
| W Cape Race, CAN    | 46°46'32.286"N | 053°10'27.606"W | 11000            | 500           |
| X Fox Harbor, CAN   | 52°22'35.252"N | 055°42'27.862"W | 25000            | 900           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# Gulf of Alaska Loran-C Chain

## GR1 7960



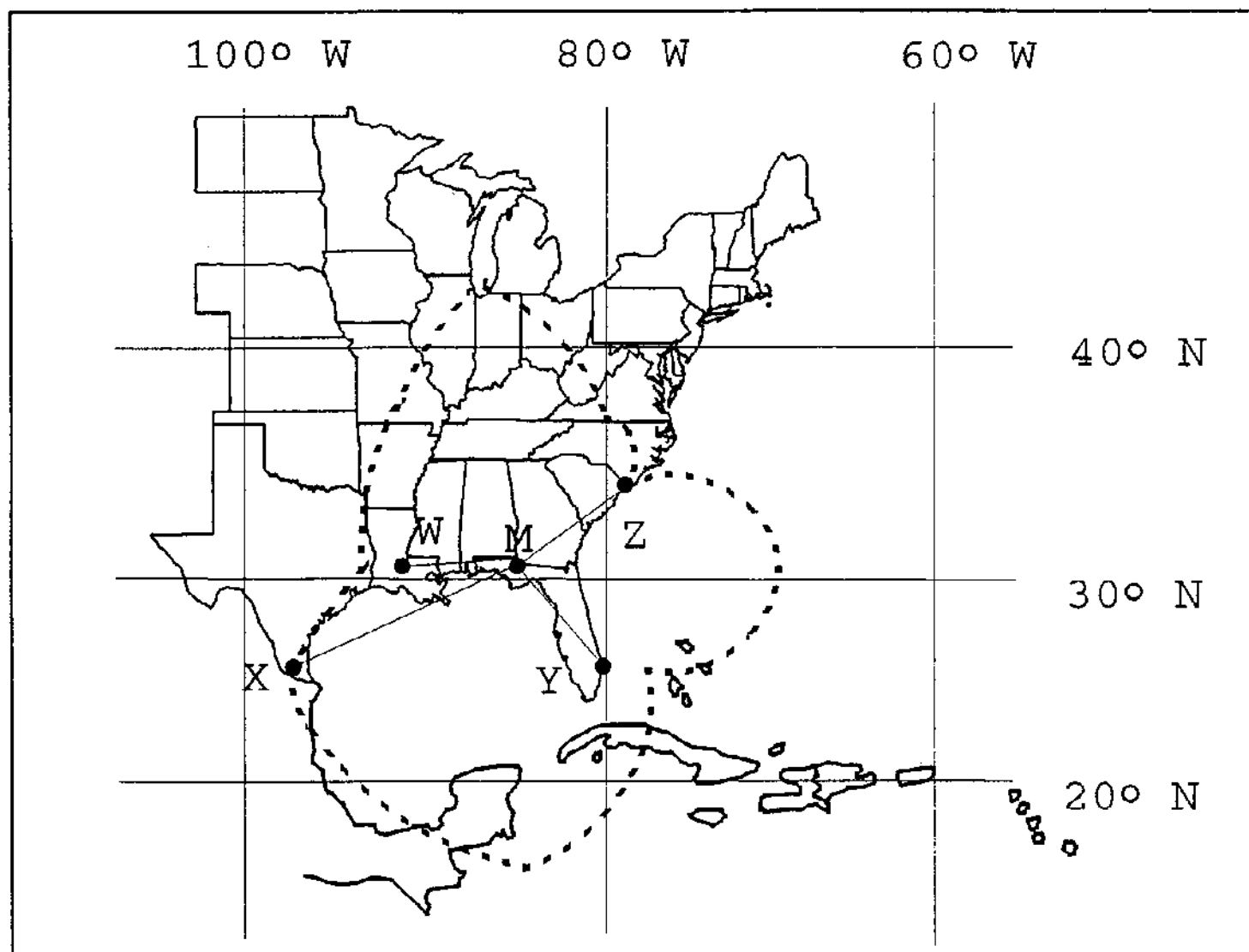
SNR  
Fix Accuracy  
Atmospheric Noise

1:3  
1/4 NM (95% 2 dRMS)  
49.0 dB above  $1\mu\text{V/m}$

| Transmitter         | Coordinates    |                 | CD<br>( $\mu\text{S}$ ) | Power<br>(kW) |
|---------------------|----------------|-----------------|-------------------------|---------------|
| M Tok, AK           | 63°19'42.884"N | 142°48'31.346"W |                         | 560           |
| X Kodiak, AK        | 57°26'20.30"N  | 152°22'10.65"W  | 11000                   | 400           |
| Y Shoal Cove, AK    | 55°26'20.940"N | 131°15'19.094"W | 26000                   | 560           |
| Z Port Clarence, AK | 65°14'40.372"N | 166°53'11.996"W | 45000                   | 1000          |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# Southeast U.S. Loran-C Chain GR1 7980



SNR  
Fix Accuracy  
Atmospheric Noise

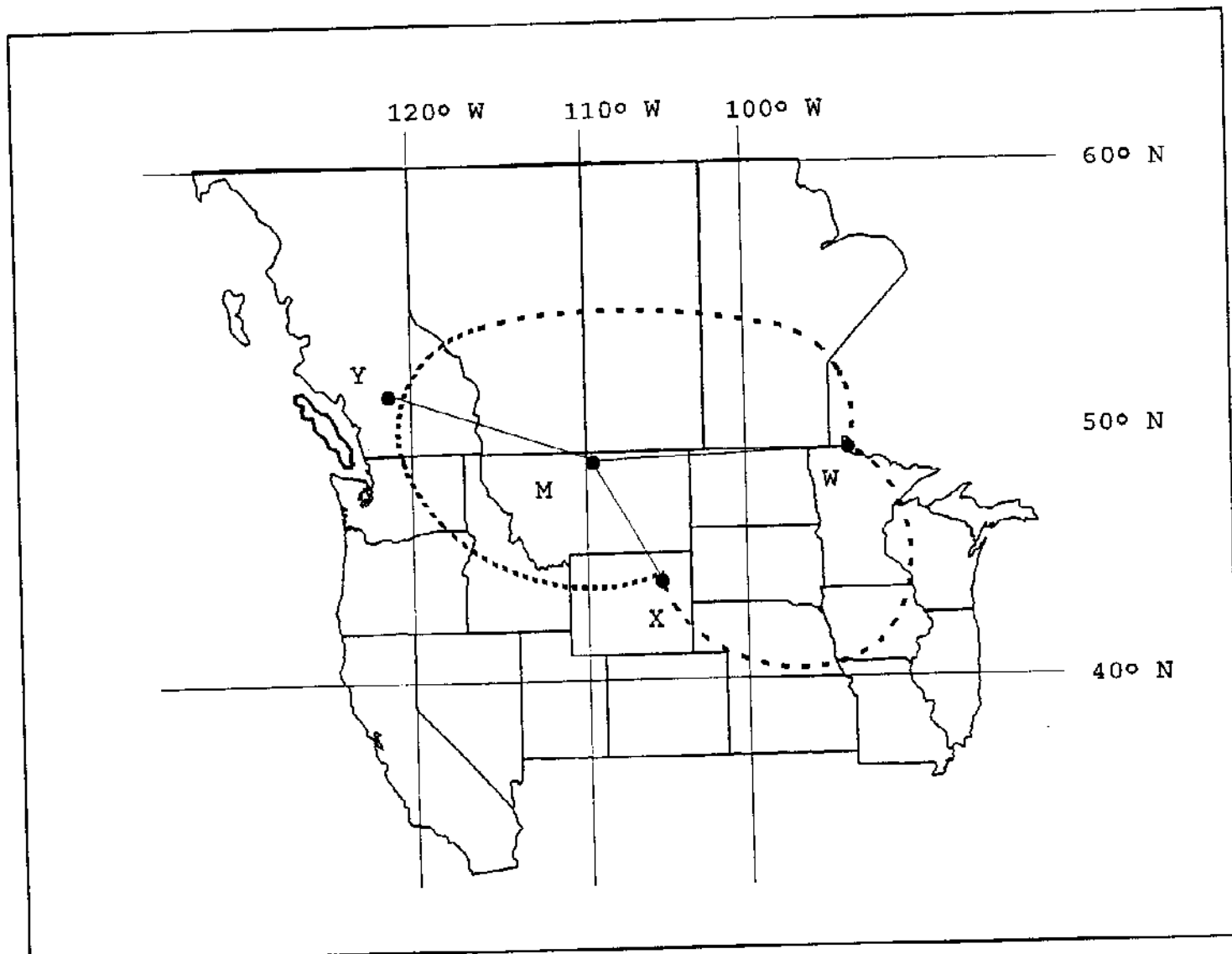
1:3  
1/4 NM (95% 2 dRMS)  
60.5 dB above 1 $\mu$ V/m

| Transmitter          | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|----------------------|----------------|-----------------|------------------|---------------|
| M Malone, FL         | 30°59'38.870"N | 085°10'08.751"W |                  | 800           |
| W Grangeville, LA    | 30°43'33.149"N | 090°49'43.046"W | 11000            | 800           |
| X Raymondville, TX   | 26°31'55.141"N | 097°49'59.539"W | 23000            | 540           |
| Y Jupiter, FL        | 27°01'58.63"N  | 080°06'52.97"W  | 43000            | 350           |
| Z Carolina Beach, FL | 34°03'46.17"N  | 077°54'46.21"W  | 59000            | 600           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# North Central U.S. Loran-C Chain

## GR1 8290



SNR  
Fix Accuracy  
Atmospheric Noise

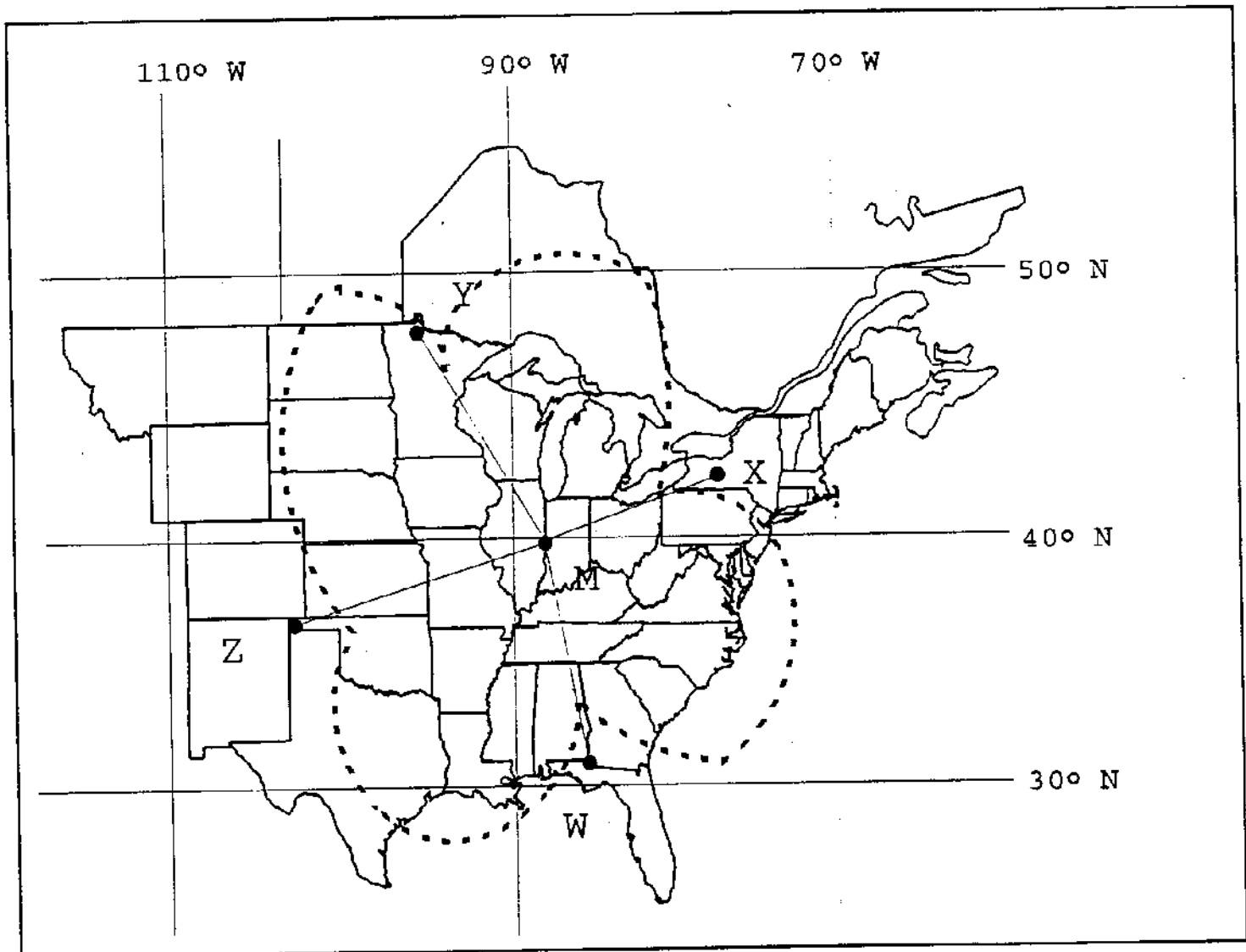
1:3  
1/4 NM (95% 2 dRMS)  
57.8 dB above 1 $\mu$ V/m

| Transmitter          | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|----------------------|----------------|-----------------|------------------|---------------|
| M Havre, MT          | 48°44'38.589"N | 109°58'53.613"W |                  | 400           |
| X Baudette, MN       | 48°36'49.947"N | 094°33'17.915"W | 11000            | 800           |
| Y Gillette, WY       | 44°00'11.305"N | 105°37'23.895"W | 27000            | 540           |
| Z Williams Lake, CAN | 51°57'58.876"N | 122°22'01.686"W | 42000            | 400           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# Great Lakes Loran-C Chain

## GR1 8970



SNR  
Fix Accuracy  
Atmospheric Noise

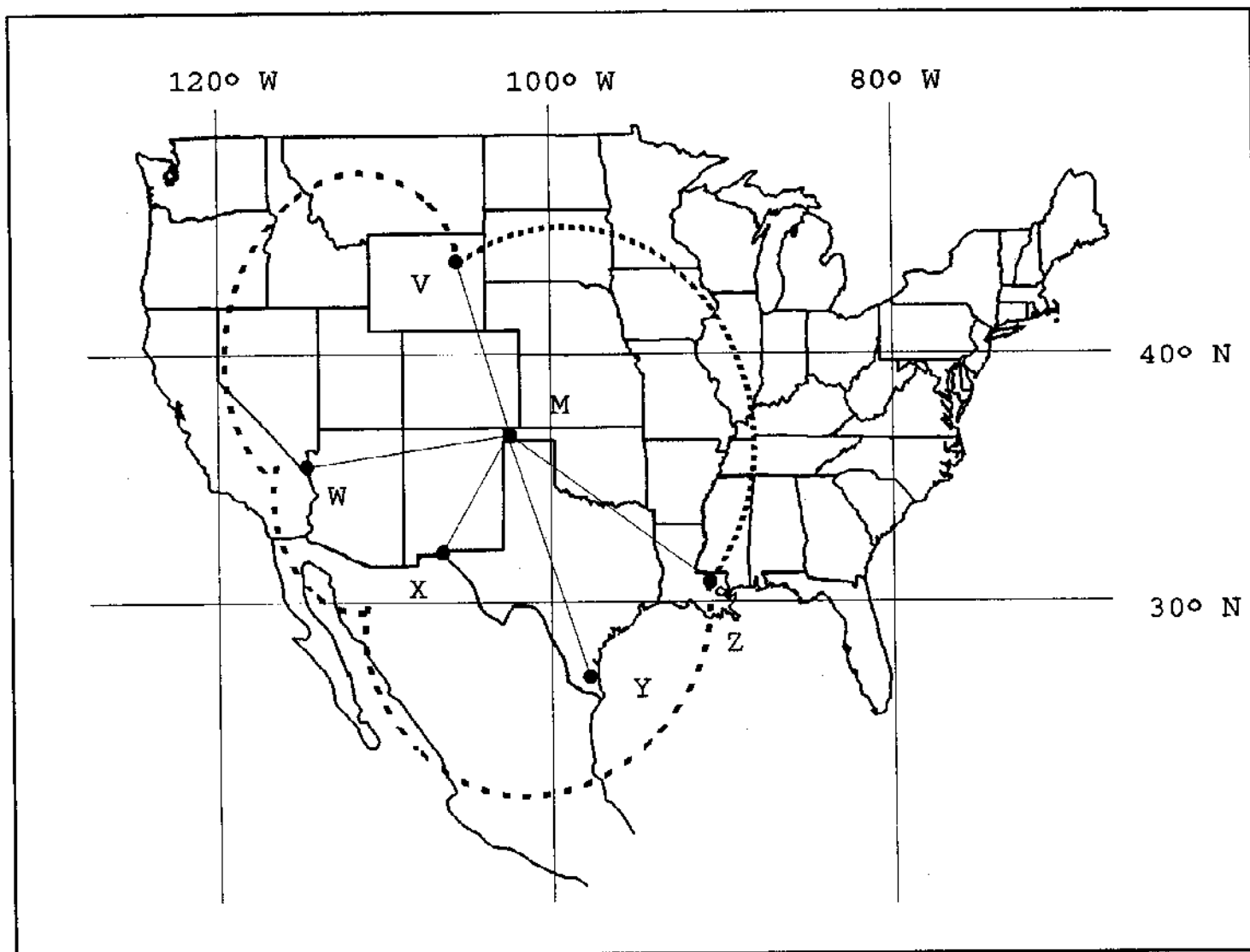
1:3  
1/4 NM (95% 2 dRMS)  
58.1 dB above 1 $\mu$ V/m

| Transmitter      | Coordinates    |                 | CD         | Power |
|------------------|----------------|-----------------|------------|-------|
|                  |                |                 | ( $\mu$ S) | (kW)  |
| M Dana, IN       | 39°51'07.658"N | 087°29'11.586"W |            | 400   |
| W Malone, FL     | 30°59'38.870"N | 085°10'08.751"W | 11000      | 800   |
| X Seneca, NY     | 42°42'50.716"N | 076°49'33.308"W | 28000      | 800   |
| Y Baudette, MN   | 48°36'49.947"N | 094°33'17.915"W | 44000      | 800   |
| Z Boise City, OK | 36°30'20.783"N | 102°53'59.487"W | 59000      | 900   |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# South Central U.S. Loran-C Chain

## GR1 9610



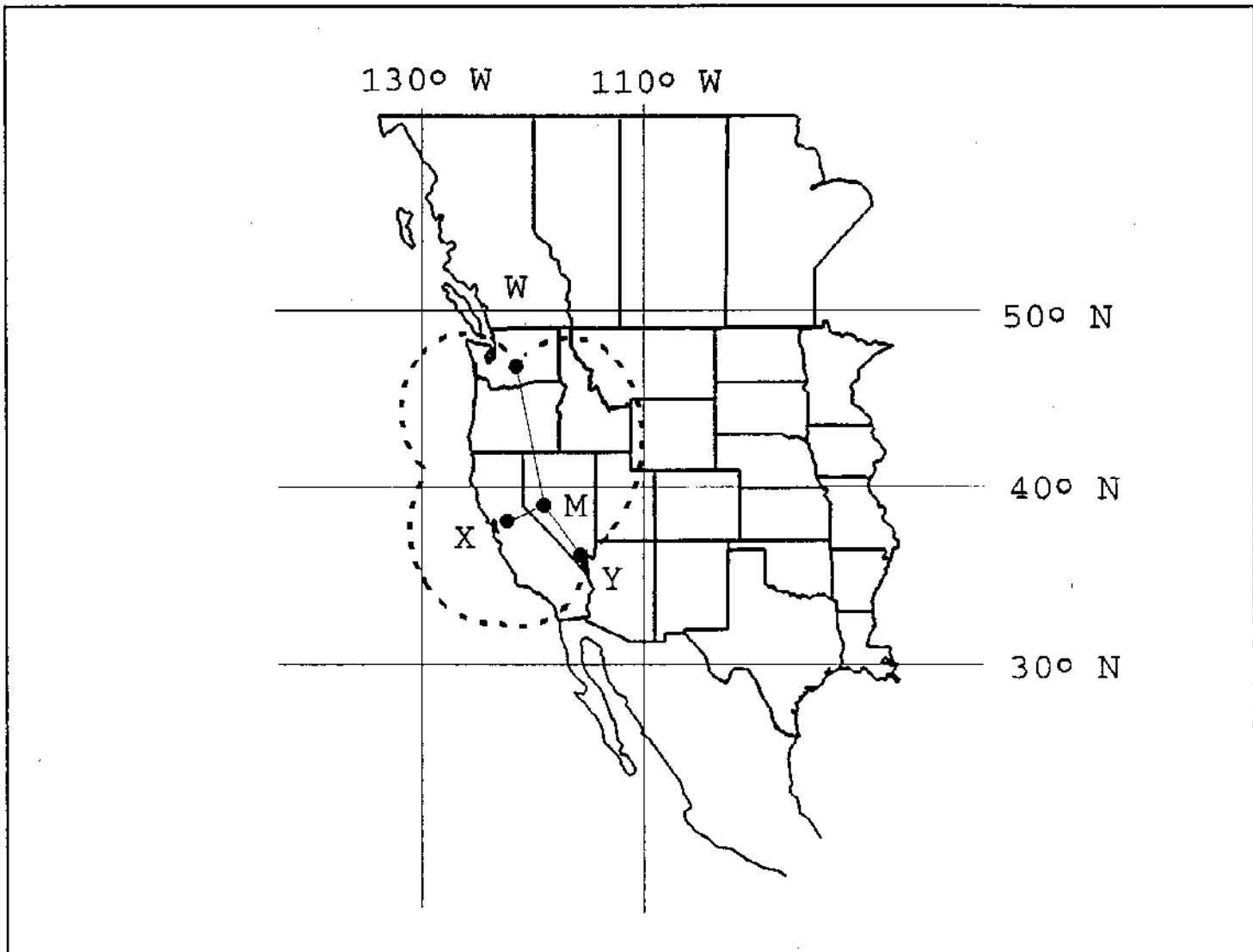
SNR  
Fix Accuracy  
Atmospheric Noise

1:3  
1/4 NM (95% 2 dRMS)  
57.8 dB above  $1\mu\text{V/m}$

| Transmitter        | Coordinates    |                 | CD<br>( $\mu\text{S}$ ) | Power<br>(kW) |
|--------------------|----------------|-----------------|-------------------------|---------------|
| M Boise City, OK   | 36°30'20.783"N | 102°53'59.487"W |                         | 900           |
| V Gillette, WY     | 44°00'11.305"N | 105°37'23.895"W | 11000                   | 540           |
| W Searchlight, NV  | 35°19'18.305"N | 114°48'16.881"W | 25000                   | 540           |
| X Las Cruces, NM   | 32°04'18.130"N | 106°52'04.388"W | 40000                   | 540           |
| Y Raymondville, TX | 26°31'55.141"N | 097°49'59.539"W | 52000                   | 540           |
| Z Grangeville, LA  | 30°43'33.149"N | 090°49'43.046"W | 65000                   | 800           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# U.S. West Coast Loran-C Chain GR1 9940

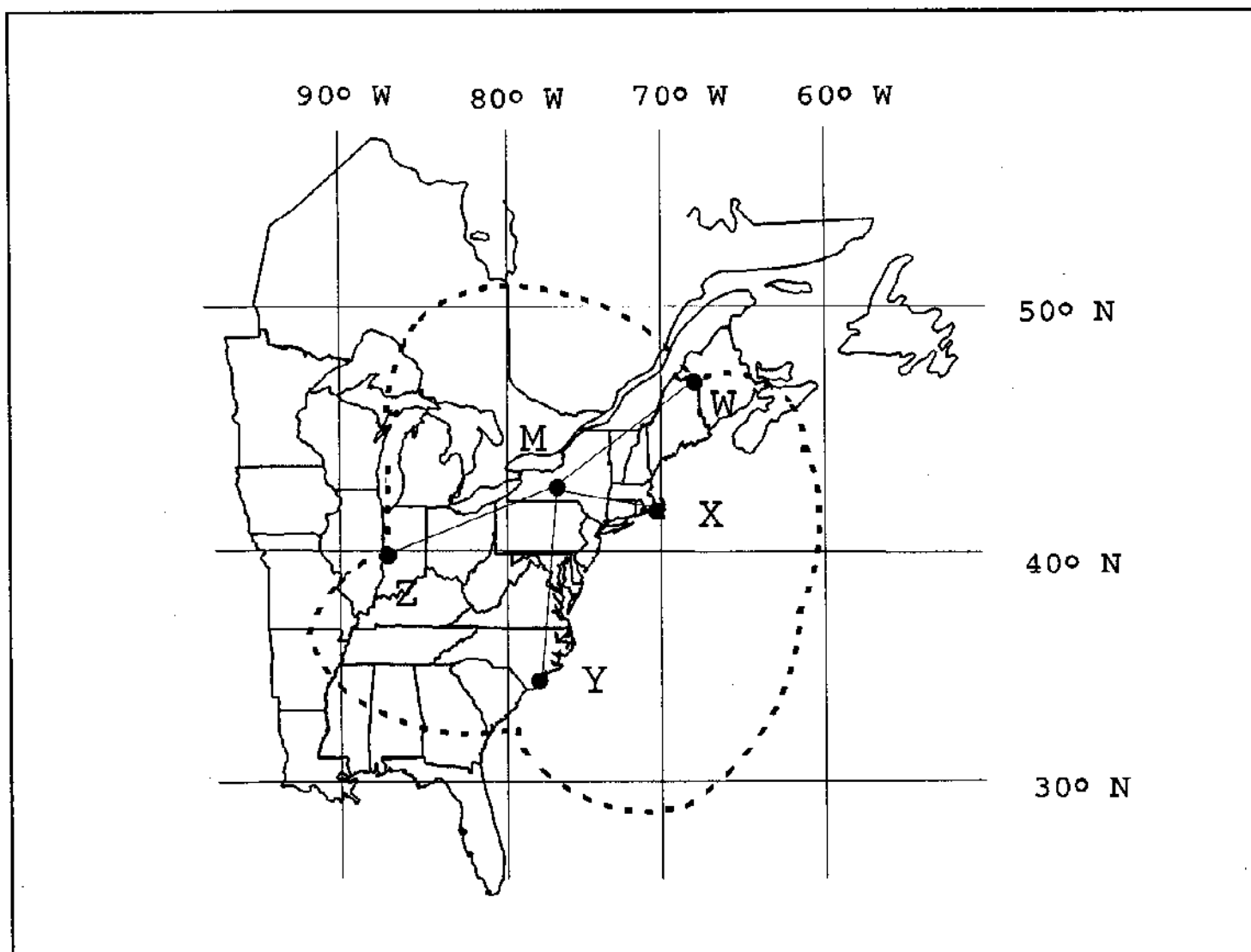


|                   |                           |
|-------------------|---------------------------|
| SNR               | 1:3                       |
| Fix Accuracy      | 1/4 NM (95% 2 dRMS)       |
| Atmospheric Noise | 52.4 dB above 1 $\mu$ V/m |

| Transmitter       | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|-------------------|----------------|-----------------|------------------|---------------|
| M Fallon, NV      | 39°33'06.740"N | 118°49'55.816"W |                  | 400           |
| W George, WA      | 47°03'48.096"N | 119°44'38.976"W | 11000            | 1400          |
| X Middletown, CA  | 38°46'57.110"N | 122°29'43.975"W | 27000            | 400           |
| Y Searchlight, NV | 35°19'18.305"N | 114°48'16.881"W | 40000            | 560           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.

# Northeast U.S Loran-C Chain GR1 9960



SNR  
Fix Accuracy  
Atmospheric Noise

1:3  
1/4 NM (95% 2 dRMS)  
55.1 dB above 1 $\mu$ V/m

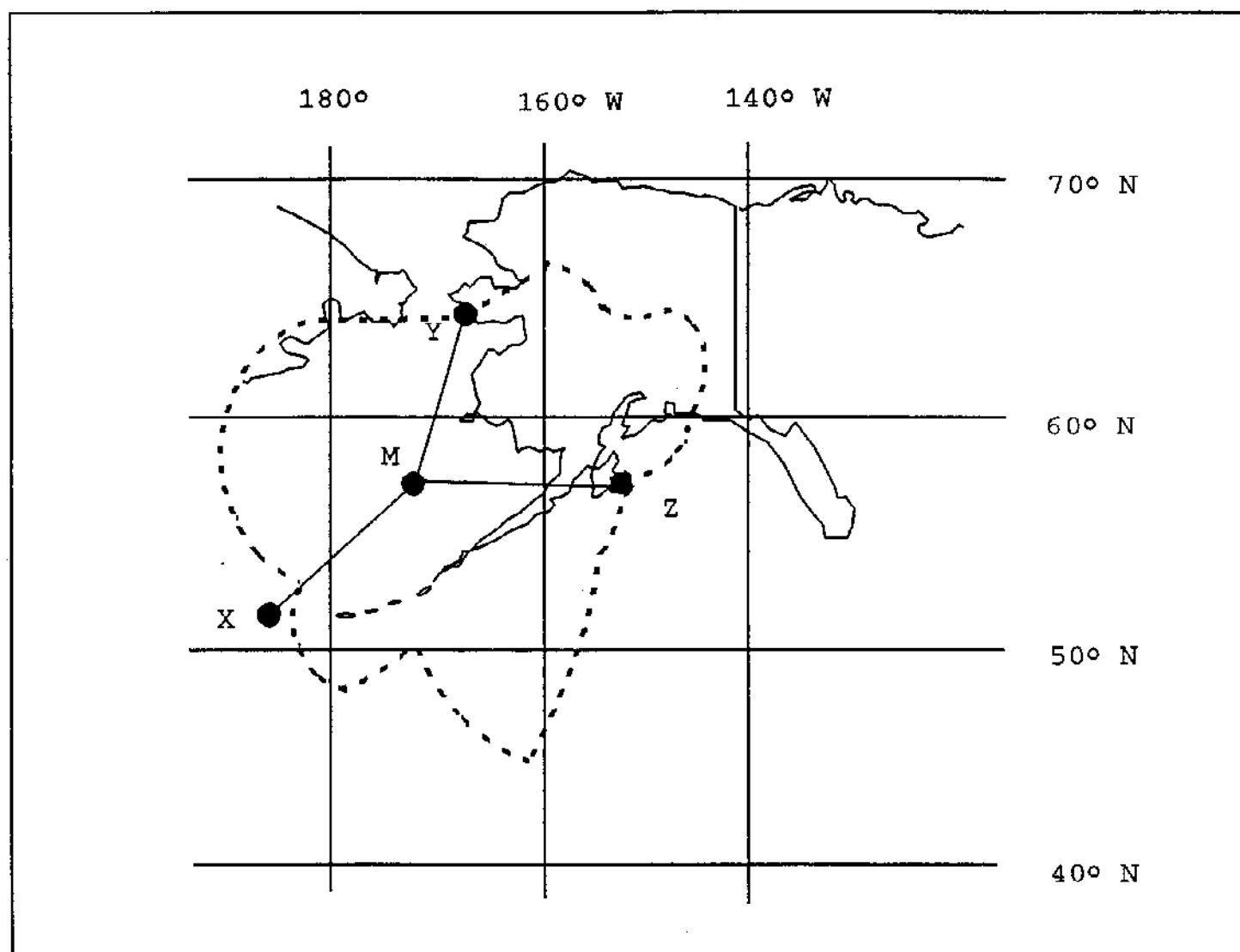
| Transmitter          | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|----------------------|----------------|-----------------|------------------|---------------|
| M Seneca, NY         | 42°42'50.716"N | 076°49'33.308"W |                  | 800           |
| W Caribou, ME        | 46°48'27.305"N | 067°55'37.159"W | 11000            | 800           |
| X Nantucket, MA      | 41°15'12.046"N | 069°58'38.536"W | 25000            | 400           |
| Y Carolina Beach, NC | 34°03'46.17"N  | 077°54'46.21"W  | 39000            | 600           |
| Z Dana, IN           | 39°51'07.658"N | 087°29'11.586"W | 54000            | 400           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.



# North Pacific Loran-C Chain

## GR1 9990



SNR  
Fix Accuracy  
Atmospheric Noise

1:3  
1/4 NM (95% 2 dRMS)  
48.2 dB above 1 $\mu$ V/m

| Transmitter         | Coordinates    |                 | CD<br>( $\mu$ S) | Power<br>(kW) |
|---------------------|----------------|-----------------|------------------|---------------|
| M St. Paul, AK      | 57°09'12.350"N | 170°15'06.245"W |                  | 400           |
| X Attu, AK          | 52°49'44.134"N | 173°10'49.528"E | 11000            | 400           |
| Y Port Clarence, AK | 65°14'40.372"N | 166°53'11.996"W | 29000            | 1000          |
| Z Kodiak, AK        | 57°26'20.30"N  | 152°22'10.65"W  | 43000            | 400           |

NOTE: Estimated Groundwave Coverage, actual coverage will vary.