SYE 3803
Fundamentals of Avionics
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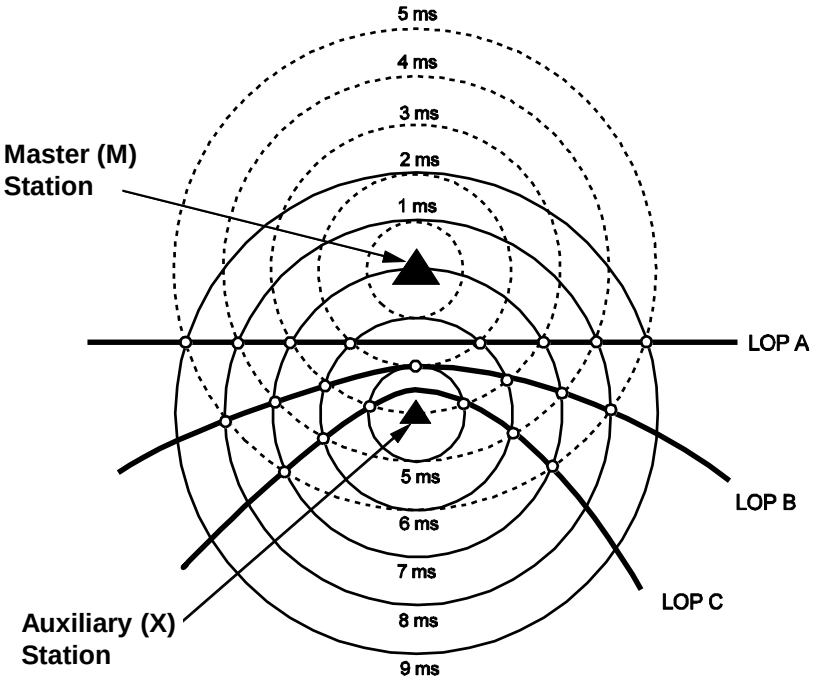
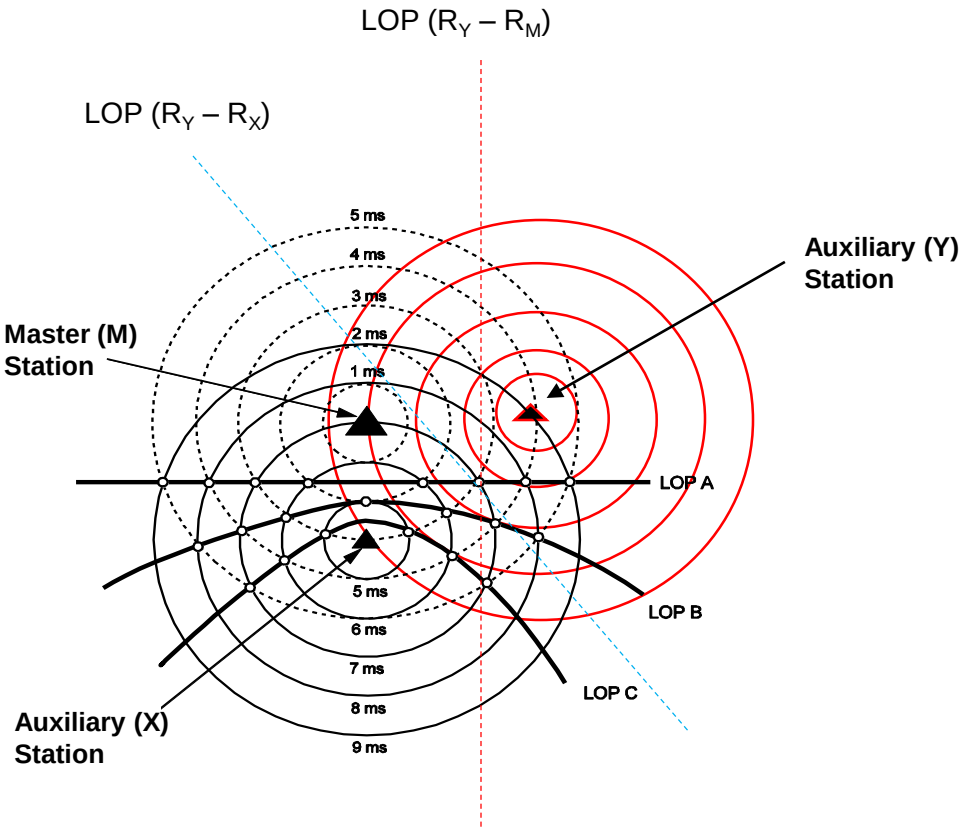
Long Range Navigation (LORAN)

- LORAN was originally designed for ship use during WWII
- Based on hyperbolic navigation
- LORAN stations are only still operational in Europe and Asia
- VORTACs are usually accessible within about 100 NM and NDBs between 10 and 50 NM
- RNAV (area navigation) is used to compute off-airway routes, thus allowing for More flexibility that purely VORTAC or NDB-based stations
- LORAN-A (original), LORAN-B (modification of original), and LORAN-C (established in 1958 for coverage of the east coast of the US)
- LORAN-C uses a series of synchronized transmitters

- Time M transmits $t_{Mxmit} = 0$
- Time X transmits $t_{Xxmit} = \Delta_C(M,X)$
- Time M is received $t_{Mrcv} = R_M/V$
- Time X is received $t_{Xrvc} = R_X/V + \Delta_C(M,X)$
- Δ_C = Coding Delay
- Observe that M is always received before X
- Calculate $\Delta\tau(X,M) = t_{Xrvc} - t_{Mrcv} = R_X/V + \Delta_C(M,X) - R_M/V$
- Solve for $R_X - R_M = (\Delta\tau(M,X) - \Delta_C(M,X))V$
- Note: $\Delta_C(M,X)$ and V are constants, and $\Delta\tau(M,X)$ is constant "if" the receiver is stationary
- Note 2: Hyperbola: In this figure the lower focus is Auxiliary Station (X) and equal values of $R_X - R_M$ are equidistant from the focus
- Note 3: The "Line of Position" describe the hyperbola
- Note 4: Knowing one's position to a LOP leaves ambiguity



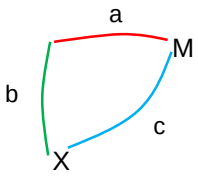
- Add a new synchronized transmitter, Y
- Define new LOPs for $(R_Y - R_M)$ and $(R_Y - R_X)$
- Compute $R_Y - R_M = (\Delta\tau(M,Y) - \Delta_C(M,Y))V$
- $R_Y - R_X = (\Delta\tau(X,Y) - \Delta_C(M,Y) + \Delta_C(M,X))V$
- This is referred to as rho-rho navigation

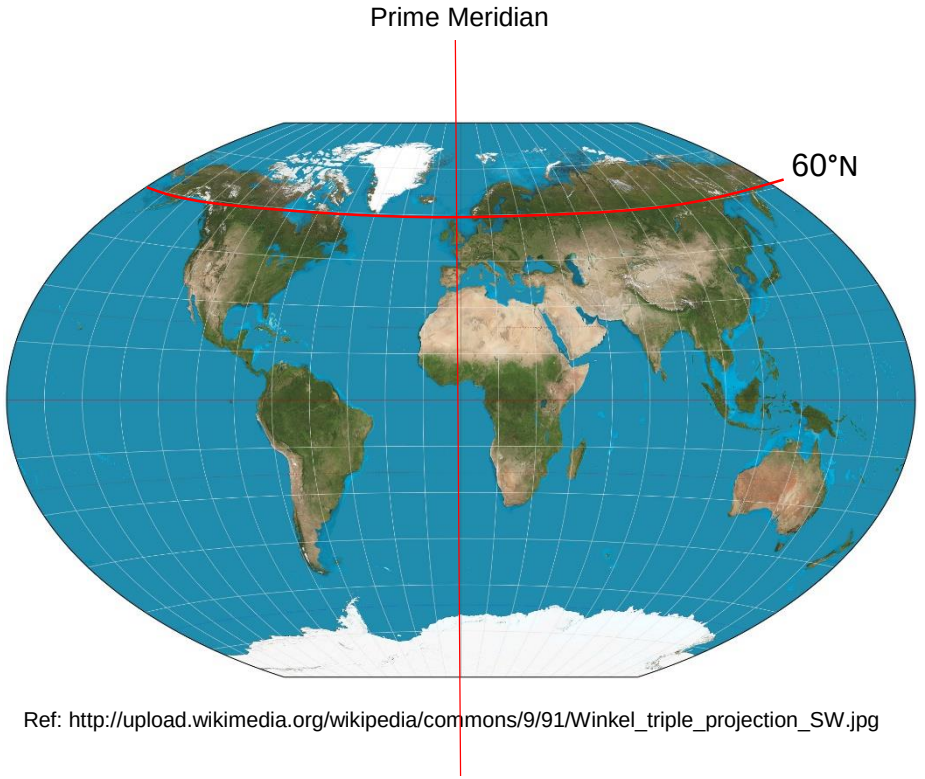


• Example: Determine the distance between the master and X auxiliary station in a LORAN-C chain, where the master (M) is located at 54°59′N; 08°32′ E and X is located at 52°42′ N; 06°22′ E

Solution: The difference in longitude is 2°10′ 0r 2.167°. The difference in latitude is 2°17′ or 2.283°. By using The law of cosines in spherical geometry we calculate:

cos(c) = cos(a) * cos(b) = 0.9985





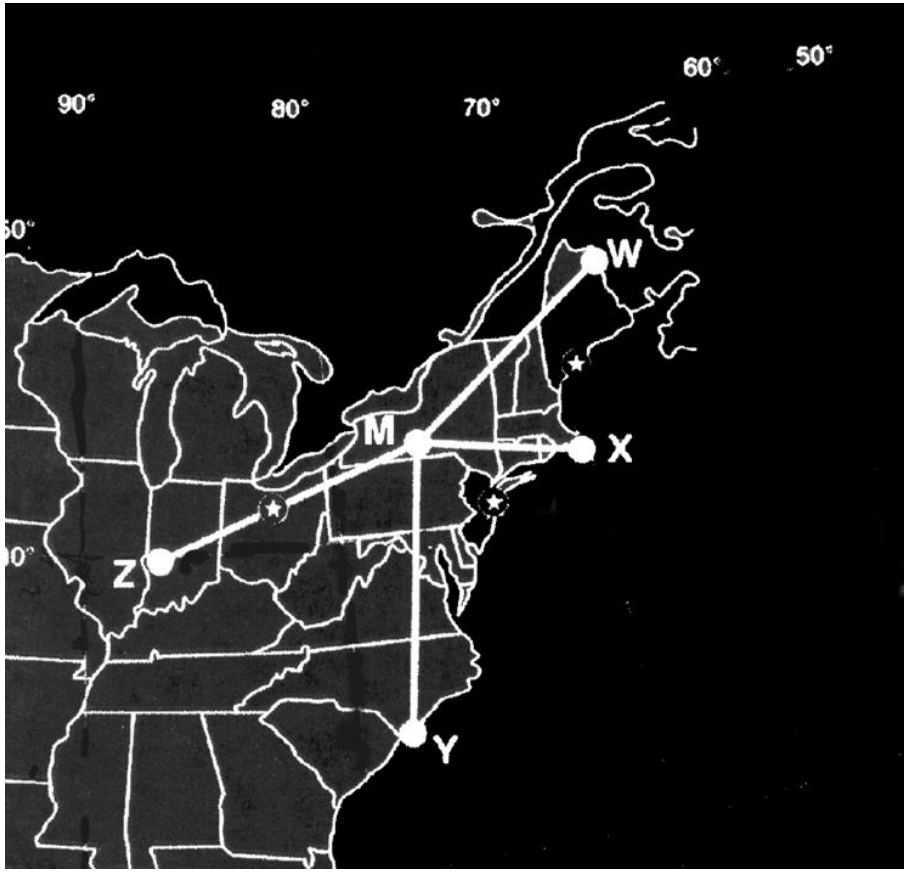
Ref: http://upload.wikimedia.org/wikipedia/commons/9/91/Winkel_triple_projection_SW.jpg

Recall: arc = rΘ
Therefore, separation between M and X equals:
Radius of Earth * spherical ∟(X and M) = 3444 NM * arcos(0.9985) = 189 NM

- LORAN-C transmitters related to a common master station are referred to as a chain
- In a chain the master transmits first followed in succession by increasing letter designated stations; e.g. W, X, Y, and Z
- The carrier frequency in LORAN systems is 100 kHz
- The synchronization rate for a group of transmitters in a chain is referred to as the GRI
- No two LORAN chains use the same GRI
- Typical station separations are between 150 and 250NM yielding a chain size greater than 1000 NM
- Chains are identified by their GRIs: For example: East Asia 9930 represents the East Asia chain, which possesses a group repetition rate of 9930 carrier cycles per every group transmit sequence 1/100,000 s * 9930 = 99,300 μs (GRI)

URL: https://www.youtube.com/watch?v=PDtHulWGMGg

URL: http://www.navcen.uscg.gov/?pageName=loranMain



- LORAN-C antenna with “capacitive hat,” which improves the transmit efficiency and reduces Transmit power requirements