WILD GOOSE ASSOCIATION

RADIONAVIGATION JOURNAL
1975

— FILE COPY —

EDITORIAL

There is probably no adversity so tough to handle as the lack of information - there is just no place to start. Except for those few closely involved in government and industry, the Loran-C system was for many years an unknown system, with its own special language and no references except individual interpretations. The Coast Guard's decision to implement the system brought to light the need to quickly disseminate and formalize this system information. The Loran-C Workshop, held in June of 1974 and sponsored by the Coast Guard with WGA cooperation, was the first step. The Loran-C Users Handbook, published by the Coast Guard briefly summarizes the system status as of August 1974. We have attempted to bring together in this, the first edition of the Radionavigation Journal, a compendium of Loran-C data for both engineers and users.

The most significant is the proposed Loran-C System Specification. It is the first step in our cooperative effort with the Coast Guard, to precisely describe the system. It will help to put us all on a common ground of understanding the vocabulary of the system - and provide the basis of an accepted standard for specifying the system and its performance. We hope you will find it enlightening and at the same time stimulating to your thoughts and opinions.

Many Loran-C system users and potential users have questioned where to obtain basic information: 'where can I buy equipment?'; 'where is the service available?'; 'how can I get charts?'. We have attempted to provide all this information in articles on these subjects. If you have ideas on other needed information, or on more useful forms of the information, please let us know.

Just as surely as we are human, we have not provided all the information each of you needs, and further, a year from now there will be new information. We have already begun planning the 1976 edition of the Radionavigation Journal, with more on Loran-A, C, and D. What's more, if the efforts of our members interested in broadening the WGA's base succeed, on other radionavigation systems as well.

Special credit and thanks go to Bahar Uttam for his many hours as assistant editor and advertising manager, to Gil Nelson of Simrad Inc. for researching all the charting information, and to John Beukers and his committee for the Loran-C Specification. Without their untiring efforts and patience, we could not have gathered, organized, and edited the information presented here.

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December 20, 1974

FOREWORD

In the past few years great strides have been made toward the establishment of effective policies concerning radio-navigation interests in the United States. I have been proud to be associated with and to have had the assistance of the Loran community through the Wild Goose organization during this time.

This publication which is intended to draw together current information regarding Loran activities and systems is another significant effort on the part of the Wild Goose people toward successful implementation of the policies which we have mutually worked so hard to establish. I am, therefore, pleased to have this opportunity to publicly thank the Association for its participation in the efforts of the Congress, and especially the Coast Guard Subcommittee of the U.S. House of Representatives, over the past few years and to extend my very best wishes for continued success.

Sincerely,

John M Murphy

JOHN M. MURPHY
Chairman
Subcommittee on Coast
Guard and Navigation

JMM:p

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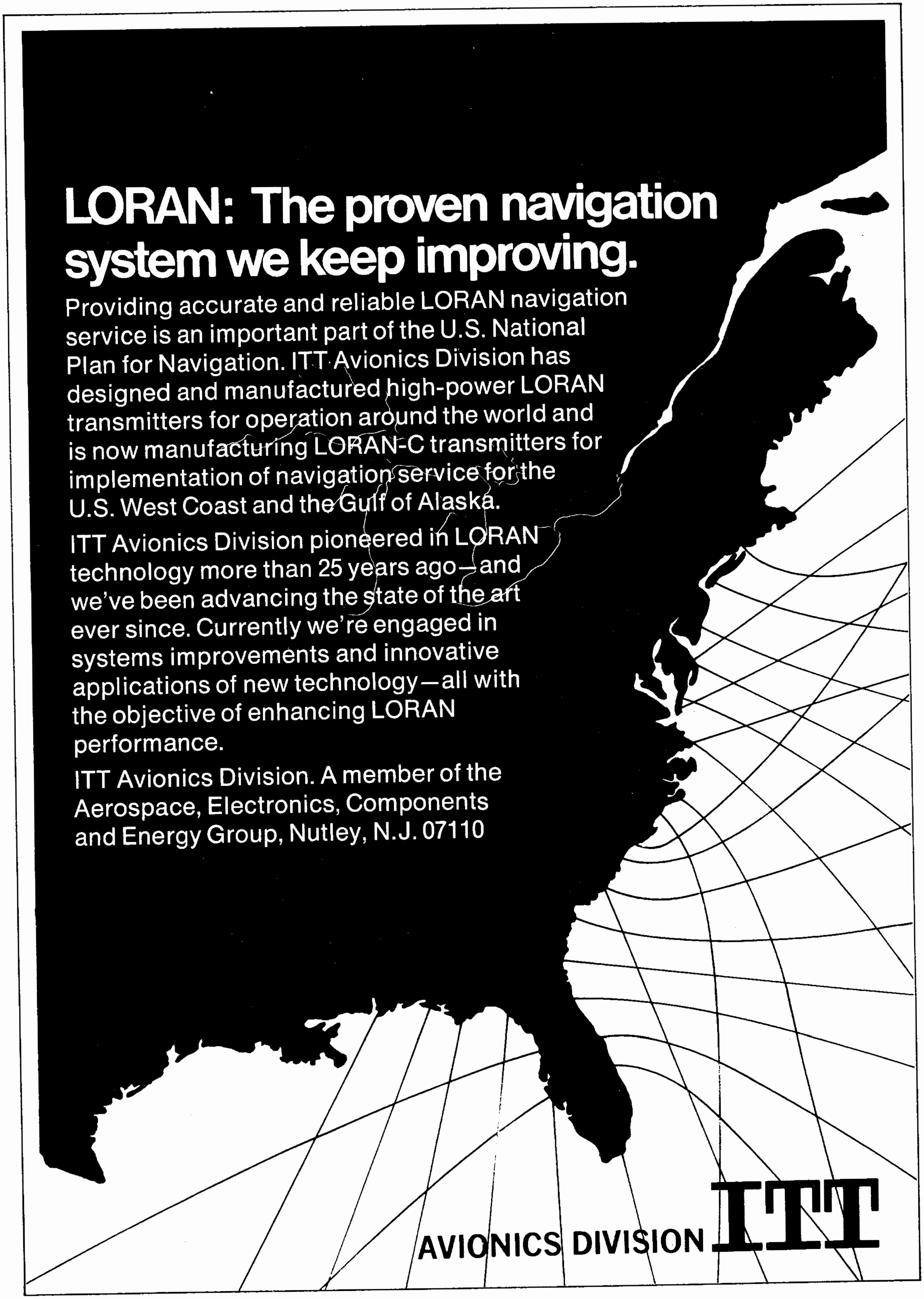
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PRESIDENT'S PAGE

In the brief three year period since the formation of the Wild Goose Association, we have been rather effective as a group in objective and constructive dialog, actions and initiatives.

1974 was a milestone year for the WGA because it was the year in which Loran-C was selected as the national navigation system for the Coastal Confluence Zone. The WGA, under the leadership of our first president, Lloyd Higginbotham, contributed to that decision in 1974 by official testimony before the Subcommittee on Coast Guard and Navigation of the House Committee on Merchant Marine and Fisheries.

The WGA has continued to contribute to this important national effort in 1975. Some of the important initiatives which have been undertaken this year are:

--Correspondence with the Secretary of Transportation urging codification and publication of a Loran-C System Specification.
--WGA Committee action to draft a Loran-C System Specification. The excellent first draft, although incomplete, is included in this Journal; publication of the complete specification is planned for next year.
--Correspondence with the Commandant of the Coast Guard to recommend initiatives in preparation for the 1979 General World Administrative Radio Conference with the goal to eliminate interference between Loran-C and other authorized services in the 90 to 110 kHz band.
--Correspondence with appropriate congressional committee leaders to urge timely continued support of the announced program to expand and modernize the Loran-C System.
--Publication of this Radionavigation Journal. Planned to be published annually, the Journal will provide an annual report of significant activities, accomplishments and objectives of the WGA, and additionally will provide a compendium of loran information and related topics.

Our next important happening in 1975 will be our Fourth Annual National Convention to be held at the Hunt Valley Inn. The technical sessions are being cooperatively planned with the Institute of Navigation's National Marine Meeting.

Our continued progress and success in 1975 is certainly due to the contributions, enthusiasm and dedication of many members and directors. Thank you!

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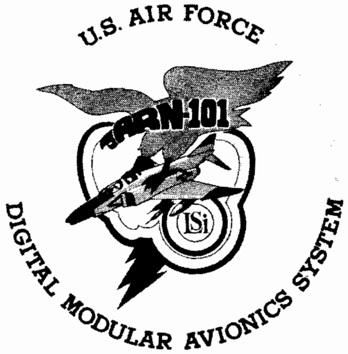

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LORAN — C SYSTEM DESCRIPTION

PREFACE

The Loran-C system as we know it today has existed for almost twenty years. Developed by the U. S. Department of Defense and operated by the U.S. Coast Guard the system has provided precision navigation transmissions for over a decade. During this period of time the main user, the U.S. Department of Defense, and those responsible for signal transmissions worked hand in glove to create and maintain compatibility between transmitted signal format and receiver specifications to ensure a total system performance. The transmitting and receiving functions being under one authority enabled changes to receivers and transmitted signal, to accommodate system improvements, to be made with a minimum of administrative procedure.

On May 16, 1974 the Department of Transportation of the U.S. Government made a significant announcement to the effect that the Loran-C system of navigation would be adopted for precision navigation in the U.S. Coastal Confluence Zone to be used by any interested party, domestic, foreign, government, commercial or public. This announcement was followed by an amendment to the U.S. National Plan for Navigation and publication of the announcement in the U.S. Federal Register. To cement this decision in the eyes of the public the US Coast Guard established a Loran-C public awareness program which consisted of demonstration and lectures throughout the coastal regions of the country.

Perhaps the most significant aspect of the announcement is that the U.S. Government while maintaining responsibility for signal transmission has relinquished control and responsibility for the receiving function. Designers of receiving and processing equipment and manufacturers are at liberty to design and sell Loran-C equipment throughout the world to operate with Loran-C transmissions. But what is a Loran-C transmission? As of now there is no published Loran-C specification to which designers, manufacturers or users can refer.

The WGA membership recognized this fact and at their 1974 Annual Convention recommended that a committee be set up with the charter of assisting in the preparation of a Loran-C specification to be published by the U.S. Government at the earliest date possible. This committee, consisting of a group of individuals experienced in the various aspects of the Loran-C system, was set up and has been active during the year in pressing its goal, namely: (a) to develop a Loran-C specification and definition of terms (b) to coordinate this document with the system's operational authority, the Department of Transportation and (c) to encourage official publication of the document by the U.S. Government in the Federal Register or similarly recognized reference media. Several official communications have taken place between the WGA and the Department of Transportation (DOT) which have established the recognition by the DOT of the need for a specification and a willingness to work with the WGA to achieve this end.

Coordination of all the efforts of the WGA with the DOT is not yet complete; therefore the description which follows should be considered a Loran-C description and definition of terms and not a system specification. The system specification will be made available as soon as it is complete.

Committee Chairman - John M. Beukers

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CHAPTER 1
Introduction

1.1 Purpose

To provide a reference document of the Loran-C system consisting of definitions, specifications and explanations for general distribution to users, manufacturers and designers with the objective of being the material upon which an official US publication of the System can be based. The goal being that with official publication of the specification, the Loran-C system design will be frozen and therefore will not be changed unless by established regulatory procedures thus giving a measure of protection to both user and manufacturer against obsolescence.

1.2 Scope

To cover specifications for the overall Loran-C system, the signal format employed and the transmitted pulse. To define terms generally employed in describing the Loran-C system and its component parts. To explain the meaning and relevance of terms employed and to highlight characteristics of the received signal which affect system accuracy and usage.

CHAPTER 2

The Loran-C System

2.1 Loran-C is a low frequency radionavigation aid operating in the radio spectrum of 90 to 110 kHz. Although primarily employed for navigation, transmissions are used for time dissemination, frequency reference, and communications. The Loran-C system consists of transmitting stations in groups forming chains – a coverage area specific to each chain, receiving equipment, a propagation medium between transmitters and receivers and methods of application. At least three transmitter stations make up a chain. One station is designated master while others are called secondaries. * Chain coverage area is determined by the transmitted power from each station, the geometry of the stations, including the distance between them and their orientation. Within the coverage area propagation of the Loran-C signal is affected by physical conditions of the earth's surface and atmosphere which must be considered when using the system. Natural and man-made noise is added to the signal and must be taken into account. Receivers determine the applied coverage area by their signal processing techniques and can derive position, velocity and time information from the transmission. Methods of application provide for conversion of basic signal time of arrival to geographic coordinates, bearing and distance, along track distance and cross error, velocity vectors, and time and frequency reference.

2.2 Loran-C Chain

All transmitters in the Loran-C system share the same radio frequency spectrum by sending out a burst of short pulses and then remaining silent for a predetermined period. Each chain within the system has a characteristic repetition interval between the pulse bursts which enables receiving equipment to be uniquely synchronized thereby identifying the chain and stations within the chain being employed.

2.2.1 The Pulse

Each of the stations in all Loran-C, tactical loran (formerly Loran-D) and privately owned chains transmit pulses that have standard characteristics. The pulses consist of a 100 kHz carrier that rapidly increases in amplitude in a carefully controlled manner and then decays at a specified rate forming an envelope of the signal. Standard characteristics for the envelope shape and carrier phase in relationship to the envelope carrier polarity (phase coding) and other parameters are covered in detail in this specification.

2.2.2 Signal Format

Each station in a chain repetitively transmits a series of closely spaced pulses called a pulse group at the group repetition interval of the chain. When the chain is synchronized to Universal Time (UT) the master station also sets the time reference for the chain. Other stations of the chain are secondaries and transmit in turn after the master. Each secondary is delayed in time so that nowhere in the coverage area will signals from one

*The term "slave" for stations other than master is no longer used.

station overlap another. The number of pulses in a group, pulse spacing in a group, carrier phase code of each pulse, time of transmission, the time between repetition of pulse groups from a station, and the delay of secondary station pulse groups with respect to the master signals constitute the signal format. Each station in a chain is assigned a signal format based on its function. The signal format is modified by "blinking" certain pulses to notify the user of faulty signal transmission. The signal format is also modified to accommodate a signal transmitter station into two chains. This is accomplished by permitting transmission for one of the chains to take precedence over the other when the signal format calls for simultaneous transmissions in both chains. This function is called blanking. Signal format parameters, values and tolerances form part of this specification.

2.2.3 Communications

In addition to providing a navigation service, the Loran-C transmissions can be used for the purpose of communications. For example, messages for system control may be sent from station to station within a chain by varying certain signal format parameters of the pulse. This can be accomplished without significant adverse effect on the processing of the navigation signals in receiving equipment. The specification describes current and proposed communication methods and specifies the parameters of signal format which have been established and are in current use.

2.3 Received Signal Characteristics

While the transmitted signal can be uniquely expressed, and transmitting equipment built and adjusted to meet the specified criteria, the received pulse cannot enjoy this rigorous treatment. Vagaries in the earth's surface, atmosphere and ionosphere together with man-made radio noise and structures created by man, modify the transmitted pulses and add noise into the spectrum of frequencies to be received. These factors have to be considered when defining the area of coverage and the receiver design.

2.3.1 Coverage Area

The coverage area of a chain is usually defined in terms of signal strength and geometry of the transmitting stations with respect to each other, as they will support a specified position accuracy from a Loran-C receiver having certain minimum performance characteristics. This specification defines coverage area as the term is applied on charts prepared by the US National Ocean Survey and the U.S. Defense Mapping Agency and in the Loran-C implementation plan by the Coast Guard. Included in the specification is a brief discussion of application coverage areas which may differ significantly from those published by virtue of the methods of signal utilization and processing of information derived from the Loran-C system.

2.3.2 Propagation and Interference

The effects of the earth's shape, conductivity and permitivity, the atmosphere, the ionosphere, and natural and man-made noise, modifies the Loran-C pulse and alters components of the frequency spectrum that must be addressed in the receiver. The specification describes the known effects, their magnitude and impact on receiver design.

2.4 Receiving Equipment and System Usage

The material for the generation of receiving equipment specifications and system application is in preparation and will be published in next year's edition of the Radionavigation Journal..

CHAPTER 3

The Loran-C Chain

A Loran-C chain is a group of Loran-C transmitting stations having a common timing reference and located in the same general geographic area.

3.1 Chain Geometry

The relative location of stations in a typical chain is shown in Figure 3.1. A central station provides the chain timing reference and is called the "master" station. Other stations, called secondaries are identified by alphabetics.

The minimum number of secondary stations is two, and although there is no defined maximum number of stations, six is the most that can reasonably be expected.

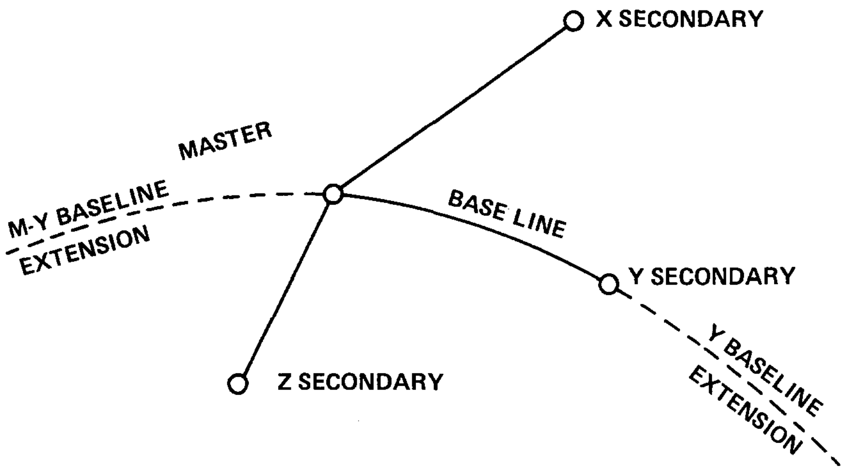


Figure 3.1 Chain Geometry

3.1.1 Station Location

The location of a station is defined by the latitude and longitude of the phase center of the transmitting antenna. Latitude and longitude are referenced to the Mercury Datum (1960) on the Fischer Spheroid (1960).

3.1.2 Base Line

A Base Line (BL) is the geodesic between any two stations. It's length is expressed in nautical miles, kilometers, or the time of travel in microseconds of a 100 kHz-radio wave. The Base Line is approximately equivalent to the great circle between the two stations. A Base Line is identified by the alphabetic designators of the stations it connects.

3.1.3 Base Line Extension

The Base Line Extension (BLE) is the extension of the geodesic beyond the stations. The master BLE extends beyond the master station and the secondary BLE beyond that station.

3.1.4 Time Difference

Time difference (TD) is the time of arrival of the radio wave from a secondary minus the time of arrival of the radio wave from the master station. The measurement process is defined later.

3.1.5 Hyperbolic Line-of-Position

A hyperbolic line-of-position (LOP) is a line on the earth's surface having constant difference of geodesic distance from two transmitting stations and represents the difference in propagation time from the two stations. These LOP's may be overprinted on charts for use in position fixing. On larger scale charts (1:100,000 or less) computed or observed time difference data may be used to correct LOP's for propagation velocity variations, in which case the LOP's will be called time difference lines-of-position (TDLOP's).

LOP's on charts are labeled with the chain identification, the secondary station, and the time difference in microseconds associated with the LOP. For example 9930-Y-49720, is the LOP in rate 9930 associated with a Y secondary time difference of 49720 microseconds. When it is clear which chain and secondary station are being used, time difference only may be shown so as to avoid cluttering charts. Not all LOP's are plotted on charts. Usually LOP's separated by multiples of 10 microseconds are shown so that the chart has lines spaced every one to three centimeters. For LOP's associated with time differences not shown, the navigator must interpolate between lines.

3.1.6 Gradient

Gradient is the vector rate of change of time difference with distance, in microseconds per kilometer, at a point on the surface of the earth. The vector direction is perpendicular to the LOP at that point, in the direction of increasing time difference. The maximum magnitude of gradient is approximately 7.68 µsec/km, which occurs on the base line. The gradient decreases off the base line to zero on the base line extension. Gradient is proportional to the sine of one half the angle subtended by the geodesics from the two transmitting stations at the point in question.

3.1.7 Fix

A fix is a statement of position, expressed in any useful coordinate system, such as, time difference coordinates, range and bearing coordinates or in degrees of latitude and longitude. A fix is determined by the intersection of two or more LOP's.

3.1.8 Geometric Dilution of Precision

Geometric dilution of precision (GDOP) is a measure of the sensitivity of fix accuracy to errors in time difference measurement, expressed in meters per microsecond. As GDOP increases in a given area, the impact of atmospheric noise, interference, and propagation vagaries increases. Figure 3.1.8 shows curves of constant GDOP in the coverage area of a typical three station chain. GDOP is a function of the gradient of each LOP, and the angle at which the LOP's cross. As crossing angles and/or gradient decreases, the GDOP increases. Lines of constant GDOP are lines on which accuracy of fix are expected to be equal.

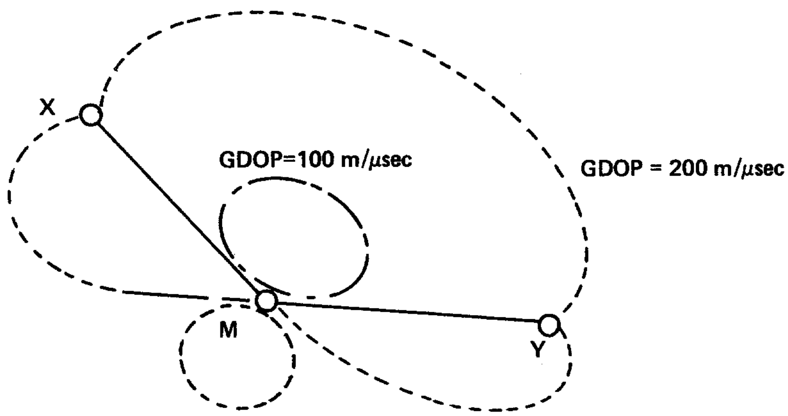


Figure 3.1.8 Curves of constant GDOP

3.1.9 Chain Coverage Area

A chain's coverage is defined as the region where the GDOP, transmitted power, estimated propagation unknowns, and predicted atmospheric noise will provide the indicated accuracy with the groundwave signal-to-noise ratio above a specified minimum 95% of the time over a period of a year. For example: The advertised coverage of Loran-C in the U.S. Coastal Confluence Zone is the region where the accuracy is one quarter of a nautical mile and where the signal to noise ratio is above - 3db. This region is plotted on a chart as the Loran-C Coverage Area.

Coverage areas for particular signal processing techniques, or "application coverage areas" may be different than the chain coverage areas. For example, a receiver which processes skywave signals would operate over a much greater area than is indicated by the chain coverage area. System users operating on other than time differences would have an application coverage area extending beyond that shown on published charts. Operating in a range-range mode, using stations from different chains or using secondaries without a master are examples of methods which alter the chain coverage area by virtue of application methods.

3.2 Transmitted Pulse

3.2.1 Pulse Shape and Tolerances 0-60μsec with no Communications

3.2.1.1 Generated pulse is defined as the pulsed antenna base current into the transmitting antenna. Loran-C pulse characteristics are defined in terms of this pulsed antenna base current. The antenna base current, i (t), is defined by the following expression:

$$i(t) = 0 \ , t < \tau$$

$$i(t) = A \left[\frac{t-\tau}{\Delta t_p} \exp\left(1 - \frac{t-\tau}{\Delta t_p}\right) \right]^2 (\sin \omega_o t + \phi); \ \tau \leq t \leq t_p \qquad (3.2.1.1)$$

For $t > t_p$, i(t) is controlled to satisfy the radiated spectrum requirements (satisfaction of equation (3.2.1.1) beyond the pulse peak would insure spectrum compliance.). Precise control of the pulse shape over the rise of the pulse permits users to extract required navigational information.

where:

A is a constant related to peak current (in amperes)

t is time (in usec);

τ is the time origin for the envelope; also called ECD (in μsec)

t_p is the pulse envelope peak = $(65 + \tau)$

Δt_p is rise time of pulse envelope = $(t_p - \tau) = 65$ μsec

w_o is angular carrier frequency = $0.2\,\pi$ rad/μsec

ϕ is the phase code = O or π radians

Residual Energy from Previous Pulse

To prevent contamination of the rising edge of a Loran-C pulse by the tail of the previous pulse, ideally, the amplitude of tail should be well attenuated before the next pulse starts. If skywave of the tail of the pulse is considered, then a Loran-C pulse should be attenuated as fast as possible after attaining its peak amplitude. Unfortunately, a serious constraint in the form of the frequency spectrum bound must be considered. A compromise between these two requirements is to allow a pulse length of 500 microseconds. By requiring the amplitude of the pulse at 500 microseconds to be .001A (-60 dB) where A is the peak amplitude of the pulse, the spectrum specification can be met and the pulse tail/skywave contamination problem can, in most cases, be avoided.

3.2.1.2 Amplitude and Phase Values with Time, Tolerances, and Stability

Figure 3.2.1.2 shows a Loran-C pulse (for 0 radian phase code and ECD=0) and identifies the particular half cycle peaks and zero crossings in reference to Tables 3.2.1.2(a) and 3.2.1.2(b). Table 3.2.1.2(a) specifies zero crossing tolerances and stability for each zero crossing in the region of interest on the loran pulse. Similarly, Table 3.2.1.2(b) specifies the half cycle amplitude tolerances and stability.

Explanation: Zero crossing stability is important because it affects the system phase accuracy. In addition, it affects the apparent signal-to-noise ratio as seen by the receiver and therefore, the available receiver accuracy with a given averaging time.

Amplitude stability is important because it affects the envelope-to-cycle difference (ECD) of a transmitted Loran-C pulse and thereby affects the ability of a receiver to lock on and track the correct cycle.

Definitions:

Pulse time reference (PTR) is the positive-going zero crossing nearest to the 30 microsecond point on the pulse for 0 radian phase-coded pulses (negative-going zero crossing for π radians phase-coded pulses).

Reference delay (D_R) is the fixed delay from the timing circuits (transmitter trigger generator) to the pulse time reference.

Pulse start is defined as the time 30 microseconds minus the algebraic value of the ECD earlier than the pulse time reference.

Time-to-pulse peak (Δt_p) is the time interval from pulse start to the peak value of the envelope of the pulse. Time-to-pulse peak is 65 microseconds.

Pulse tail is that portion of the loran pulse after the peak has occurred.

Zero crossing is the instant at which the direct coupled voltage (or current) reaches its dc level. (For a sinusoidal waveform, the "zero" level is midway between maximum positive peak and maximum negative peak.)

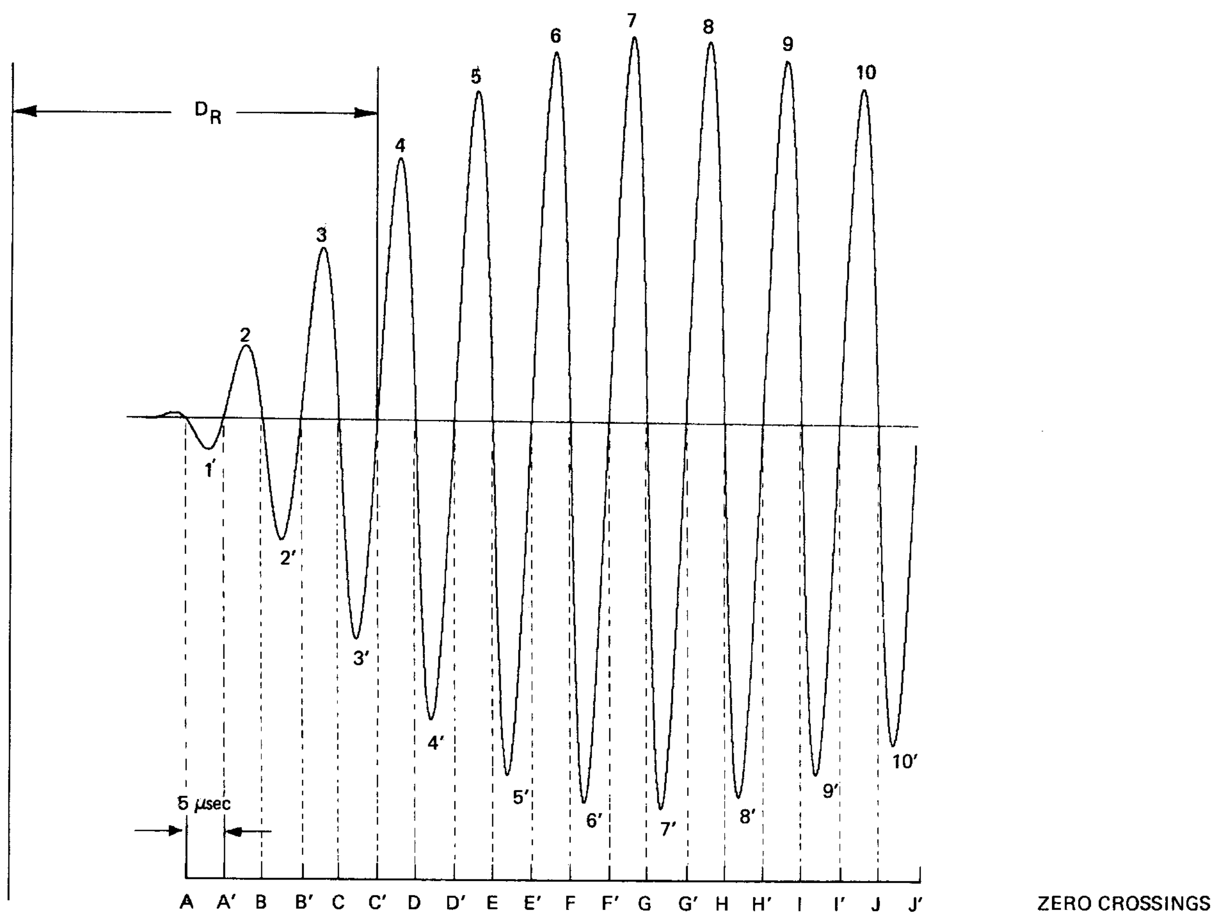


Figure 3.2.1.2

ZERO CROSSING TIMES

Zero Crossing (Reference Figure 3.2.1.2	Nominal Time (relative to pulse time reference) (microseconds)	Deviation of Mean Maximum Allowable (nanoseconds)	Jitter Maximum Allowable Peak-to-Peak (nanoseconds)
A	-30	–	–
A1	-25	± 500	1000
B	-20	± 150	500
B1	-15	± 100	500
C	-10	± 100	250
C1	- 5	± 100	100
D	0	0	100
D1	5	± 100	100
E	10	± 100	100
E1	15	± 100	100
F	20	± 100	100
F1	25	± 100	100
G	30	± 100	100

Table 3.2.1.2(a)

CYCLE AMPLITUDE STABILITY

Cycle Peak (Reference Figure 3.2.1.2)	Nominal Time (ECD = 0)	Absolute Error (Deviation of mean from computed value) Maximum Allowable (percent- See Note 1)	Cycle Amplitude Jitter Peak (See Note 2) (percent - See Note 1)
1	2.5	5*	20
11	7.5	5*	20
2	12.5	5*	10
21	17.5	5*	5
3	22.5	5*	5
31	27.5	5*	5
4	32.5	5*	5
41	37.5	5*	5
5	42.5	5*	5
51	47.5	5*	5
6	52.5	5*	5
61	57.5	5*	5

* or 1% of the peak amplitude whichever is larger

NOTE 1 - Percentage of the value for the specified half cycle time computed using the equation in paragraph 3.2.1.1

NOTE 2 - Amplitude jitter is measured over a 10 second interval and shall be symmetrical about the mean amplitude.

Table 3.2.1.2(b)

3.2.1.3 Radiated Far Field

Definitions:

Primary Travel Time (t_p) is the computed travel time of the Loran-C pulse over a distance equal to the length of a geodesic, accounting only for the velocity of light and the index of refraction of the atmosphere in the computation.

Secondary Phase Factor (t_c) is a correction to primary travel time which accounts for propagation over the earth's surface on the presumption the path is entirely seawater.

Additional Secondary Factor (asf) is a correction to secondary phase factor which accounts for an inhomogenous surface. That is, it corrects for variations in surface conductivity and permittivity as might be caused by overland propogation.

Altitude effect, Δt_c, is that part of secondary phase factor, t_c, which varies with altitude. Secondary phase factor can be represented as the sum of two terms and expressed as a function of altitude:

$$t_c\,(h) = t_c\,(h = 0) + \Delta t_c\,(h) \qquad (3.2.1.3\text{-}1)$$

where t_c (0) is the secondary phase factor at the earth's surface and Δt_c is that portion of the secondary phase factor due to a receiver being located at an altitude h above the earth's surface.

Far field — When distance from transmitting antenna exceeds 5 wavelengths (λ), the radial electric field becomes negligible with respect to the tangential field. This region is called the far field. The phase of the far field Loran-C signal transmitted from a monopole can be recovered very accurately with an electric dipole at distances in excess of 5λ, and with a magnetic dipole at distances no closer than 1λ.

Envelope-to-cycle difference (ECD, τ) is the time relationship between the phase of the RF carrier and the time origin of the envelope waveform. An ECD = 0 is mathematically defined as the signal condition occurring when the 30 microsecond point of the Loran-C pulse envelope is in time coincidence with the third positive-going zero crossing (reference zero crossing) of the 100 kHz RF carrier for a zero radian phase-coded signal (The reference zero crossing is the third negative-going zero crossing for a π radian phase-coded signal.) ECD is positive when the 30 microsecond point of the Loran-C pulse envelope lags the reference zero crossing, and ECD is negative when the 30 microsecond point of the Loran-C pulse envelope leads the reference zero crossing. The ECD magnitude is the amount of lag or lead.

Specification

To a first order, the far field pulse envelope is proportional to the envelope of the transmitting antenna current and delayed from it by the primary field propagation delay. (Primary field delay is a function of distance and atmospheric refractivity only.)

Although the far field envelope is proportional to the envelope of the transmitting antenna current and delayed from it by the propagation delay, there is a phase lag of $\pi/2$ between the far field carrier phase and the antenna current carrier phase in addition to the propagation delay. Stated another way, if the transmitting antenna current pulse has an ECD = 0, the far field pulse will have an ECD off -2.5 microseconds.

There are, additionally, second order effects which are not insignificant. These include secondary phase factor and altitude effect (height-gain function) and the pulse distortion (with respect to reference antenna current) caused by the fact that the antenna is not a point source and by the fact that the antenna radiation resistance and the propagation media have frequency dependent characteristics.

Open circuit voltage of a small electric dipole or the short circuit current of a small magnetic dipole properly situated in the far field will be proportional to the far field.

3.2.2 Radiated Power

Definitions:

Peak Radiated Power, P_R, of a Loran-C transmitted signal is defined as the power equivalent to that of a cw carrier having the same zero-to-peak amplitude as the maximum RF half cycle of the signal.

Antenna Radiation Resistance, R_{RAD}, is defined by the following equation:

$$R_{RAD} = \frac{2 P_R}{i_p^2} \qquad (3.2.2\text{-}1)$$

where P_R = peak radiated power

i_p = zero-peak value of the maximum RF cycle in the loran antenna base current

Specification

The specification of peak radiated power for Loran-C transmitted signals varies depending on the application. However, those stations presently operated by the U.S. Coast Guard have radiated power specifications of from 250 kW to 3000 kW.

The power radiated by a Loran-C station directly determines the coverage area within which the transmission will provide a desired level of navigation accuracy. The power density (W/m^2) of a groundwave propagating over a perfectly conducting surface is inversely proportional to the square of the distance to the source. Because the ground conductivity over any real propagation path is not perfect, the power density is further attenuated. Other factors which affect system navigation accuracy are the baseline geometry, the receiver system characteristics, and the ambient noise conditions. If all these factors are known, then minimum radiated powers may be specified which will insure that system navigation accuracy requirements will be met.

3.2.2.1 Measurement of Radiated Power

Measurement of the total power radiated by a Loran-C station is most conveniently done by measuring field strength with a calibrated antenna and receiver at a known distance from the antenna and then using the relation

$$E = \frac{9.5}{d} \sqrt{P_r} \qquad (3.2.2\text{-}2)$$

where E = is the rms field strength of a cw carrier having the same zero-to-peak value as the maximum RF 1/2 cycle of the loran field (volts/meter)

P_r = total radiated power (watts)

d = distance from transmitting to receiving antenna (meters)

This relation is valid for distances, d, in the range $2\lambda \leq d \leq 3\lambda$ where λ is the wavelength of the Loran-C signal or 3 km. For distance less than 2λ, the electrostatic and induction components of the field are significant. For ranges greater than 3λ, attenuation effects due to finite ground conductivity may be significant. While the above relation is derived using the radiation pattern for a vertical monopole antenna, it holds with good accuracy for most Loran-C antennas.

Calibrated loop receiving antennas can also be employed for making LF field strength measurements (See Watt AD, "VLF Radio Engineering")

After the radiated power has been determined by field strength measurements and the antenna base current, i_p, corresponding to that radiated power has been measured, then the antenna radiation resistance R_{RAD} can be calculated. All subsequent determinations of radiated power, P_R, for that antenna configuration can then be determined simply by application of Equation 3.2.2.1, transposed:

$$P_R = \frac{i_p^2 R_{RAD}}{2} \qquad (3.2.2\text{-}1)$$

3.2.2.2 Field Strength vs. Distance

As discussed above, the groundwave field strength of Loran-C signals decreases with distance from the station. The propagation path ground conductivity affects signal attenuation with distance. This effect becomes more pronounced with increasing distance and with decreasing conductivity. Field strength as a function of distance with conductivity as a parameter and for 300 kW radiated power is shown in Figure 3.2.2.2, which is derived from "Decca Loran-C Compatibility Study" Jansky and Bailey Systems

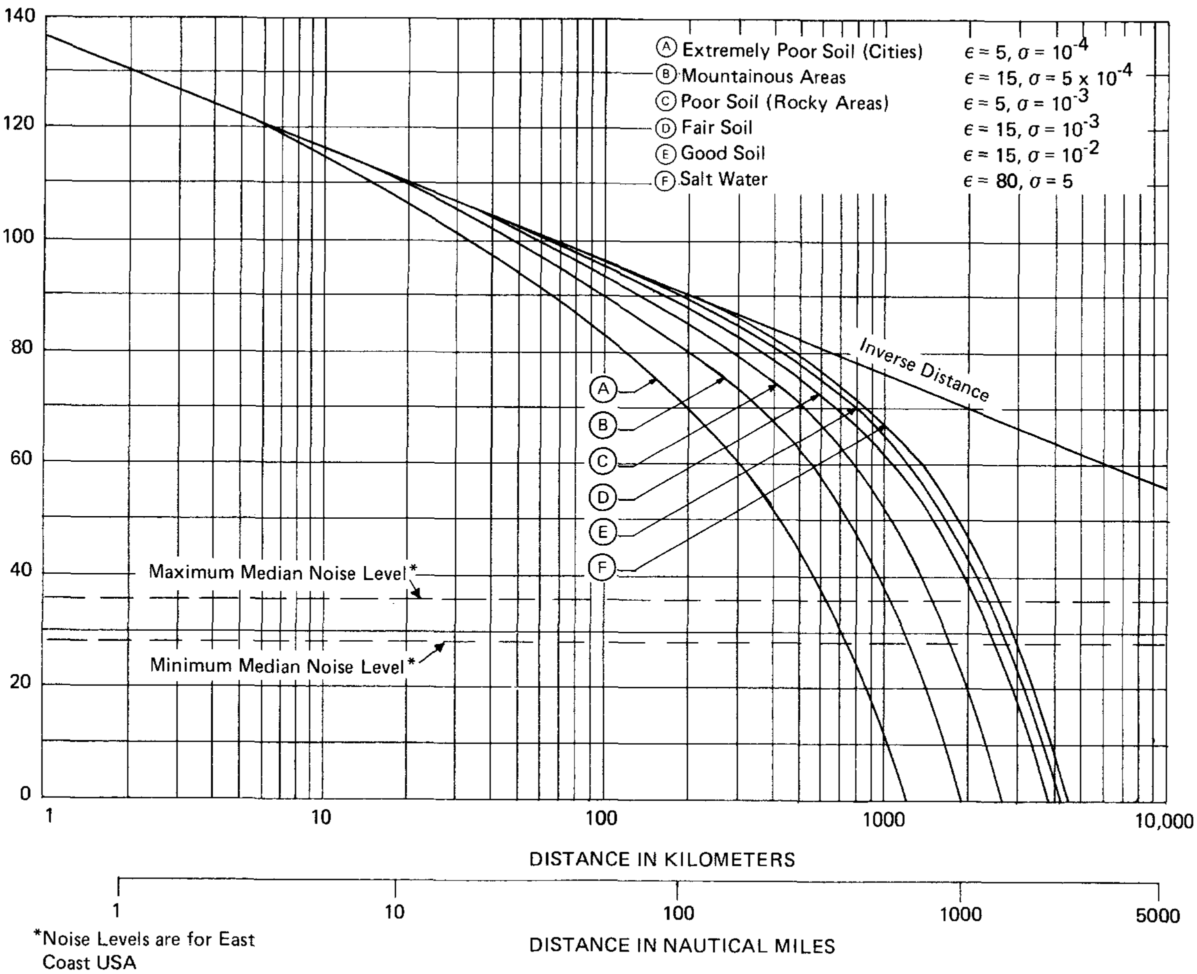


Figure 3.2.2.2 Ground Wave Field Intensity 90-110 KHz 400kw Radiated Power

3.2.3 Transmitted Spectrum

Definition:

If the radiated Loran-C field intensity as a function of time is given by f(t), then the transmitted spectrum is defined to be the spectral density function of the time function f(t). This spectral density function is given by

$$S(\omega) = \left[\frac{|F(\omega)|}{|F(\omega)|_{max.}} \right]^2 \qquad (3.2.3\text{-}1)$$

where

$$F(\omega) = \int_{-\infty}^{\infty} f(t) \; \epsilon^{-j\omega t} \, dt \qquad (3.2.3\text{-}2)$$

and

ω = angular frequency (rad/sec).

3.2.3.1 Energy Distribution

The total energy outside the 90-110 kHz band shall be less than 1% of the total radiated energy. The energy below 90 kHz shall be no greater than 0.5% and the energy above 110 kHz shall be no greater than 0.5% of the total radiated energy. As a practical matter for Loran-C type signals, this will be achieved if the spectral density of the radiated signal at 90 kHz and 110 kHz is down at least 20 db relative to its value at 100 kHz.

3.2.3.2 Measurement of Spectrum

Spectral Density, $S(\omega)$ is measured as follows:

1. Using a spectrum analyzer with a resolution bandwidth which is much narrower than the repetition rate of the loran pulses, measure and record the received voltage level of all the spectral lines in the received loran signal, down to a level which is 30 db below the peak spectral line.

2. Locate the peak spectral line level and divide all the measured values by this peak value. Record these normalized values.

3. Square the above normalized values and record the squared values.

4. The resulting table is the spectral density function of the received time function.

Integration of $S(\omega)$ over the entire frequency range in which $S(\omega)$ is greater than -30 db (where 0 db represents the level of the peak spectral line) provides a practical measurement of the total spectral energy. This integration is generally done by Simpson's rule. Similarly, integration of $S(\omega)$ below 90 kHz and above 110 kHz provides the total spectral energy content below and above the 90-110 kHz band. Each of these values must be less than 0.5% of the total spectral energy.

3.2.3.3 Harmonics

The spectral level of any harmonic relative to the value at 100 kHz shall not exceed the following bounds:

Harmonic	Upper Bound
2nd	-70 db
3rd	-80 db
4th	-85 db
5th (or greater)	-90 db

Explanation:

The intent of the above specification is to assure that Loran-C transmissions do not interfere with other services in adjacent parts of the radio spectrum. These specifications can be met by standard Loran-C transmissions without any communication modulation.

3.3 Pulse Group

A pulse group is a series of pulses from a single transmitting station. The number of pulses in a group is 8 for the Loran-C signal and 16 for the tactical loran signal.

3.3.1 Pulse Spacing

Pulse spacing is the time between adjacent pulses. The pulse spacing is 1000 microseconds between all pulses of a Loran-C pulse group. The tactical loran pulse spacing is 500 microseconds. In Loran-C there is a ninth pulse in the master station signal, spaced 2000 microseconds after the eighth. This pulse is intended for visual identification of the master signal, using an oscilloscope, and not intended for navigation.

3.3.2 Pulse Group Time Reference

The pulse group time reference (PGTR) is the pulse time reference of the first pulse in the group.

3.3.2.1 Group Repetition Interval (GRI)

The time interval between successive PGTR's from any one station is the Group Repetition Interval of the signal from that station. All stations in a chain have the same GRI, and the GRI expressed in tens of microseconds is the identifier for that chain and is called the chain "rate". GRI's may range from 40,000 microseconds to 99,990 microseconds, in increments of 10 microseconds.

3.3.2.2 Double Rated Station

A double rated station is a Loran-C transmitting station which transmits signals for each of two chains using one transmitter. Each chain has its own identifying group repetition interval (rate), hence the name.

3.3.2.3 Transmitter Blanking

At a double rated station, when the signals for both rates might overlap in time, the lower priority signal is blanked or suppressed. Priority is first given to a master signal if the station is a master on one of the rates, and second to the rate with the larger GRI.

3.3.3 Pulse-to-Pulse Differences

Zero crossing and amplitude stability within any particular pulse of the group is specified in Para 3.2.1.2. Pulse-to-pulse zero crossing and amplitude stability are defined in the following paragraphs. These specifications apply to both single and double rated configurations.

3.3.3.1 Intra-group Droop is the amplitude change from pulse-to-pulse within the group of pulses. Historically, droop has resulted from power supply sag caused by the bunched power demand during the pulse group.

3.3.3.2 Inter-group Droop refers to group-to-group variations. This type of droop is more likely to occur in a double rated station.

3.3.3.3 Amplitude Stability

Pulse-to-pulse amplitude stability of a Loran-C pulse may be considered in two parts:

a. The peak-to-peak amplitude jitter of any RF (100kHz) half cycle of the pulses in the group.

b. The peak-to-peak variation of the mean amplitude of any RF half cycle of a given pulse within a group as compared with the mean amplitude of the corresponding RF half cycle of any other given pulse.

The peak-to-peak amplitude jitter of any RF half cycle shall be less than 0.02A for 1000 samples. 'A' is a multiplier, depending on the units and parameter measured, designating the desired peak amplitude of all pulses in a group.) The mean amplitude of an RF half cycle of a given pulse within a group shall be equal to the mean amplitude of the corresponding half cycles of any other given in the group to within ± 10 nsec.

3.3.3.4 Zero Crossing Accuracy

The mean zero crossing time of the pulse time reference of a given pulse shall not differ from the mean zero crossing time of the pulse time reference of any other pulse in the group by more than the closest integer multiple of 1000 microseconds ± 10 nsec.

3.4 Phase Code

Phase code is the pattern of 0 and π radian states of the RF carrier phase in the pulses of each group. That is, each pulse may have a carrier phase of 0 or π radians, and the statement of the sequence of carrier phase of each pulse in a group is the phase code.

3.4.1 Phase Code Notation

To provide a compact notation for phase code, a "+" sign describes a pulse with 0 radian phase and a "–" sign describes a pulse with π radian phase. A group of eight Loran-C pulses might be described thus:

+––+++++

3.4.2 Phase Code Interval (PCI)

Successive pulse groups from a station do not have the same phase code, however only a limited number of phase codes are used by any one station. Phase code interval is the sum of the GRI's over which the phase code is cyclic. Loran-C phase codes are cyclic over two GRI. Tactical loran phase codes are cyclic over four GRI.

3.4.2.1 Loran-C Phase Codes

Group repetition intervals are designated A and B in the phase code interval. The phase code in the A and B intervals, and from the master and secondary stations differ. The following table describes the phase codes for Loran-C:

Station		
GRI	Master	Secondary
A	+ + – – + – + – +	+ + + + + – – + –
B	+ – – + + + + + –	+ – + – + + – –

Table 3.1 Loran-C Phase Codes

3.4.2.2 Tactical Loran (Loran-D) Phase Codes

STATION			
GRI	Master	X & Z Secondary	Y Secondary
A	+ + + + – + – – + + – + + – – +	+ + + – + + + + + – – + – + + +	+ + + – + + + + + + – – – – + –
B	+ + – + – + + – + – + – + + + –	+ – – + + – – – + – + + – + – +	+ + – – + + – + + – + + – + – +
C	+ – + – – – – + + – – – + + – –	+ – + + + – + – + + – – + – + –	+ – + + + – + – + – – + – + + +
D	+ – – – – – + + + + + + + – + +	+ + – – + + – + + + + – – – – –	+ – – + + – – – + + + – – – – –

Table 3.2 Tactical Loran Phase Codes

3.5 Timing Relationships and Control

Time in a Loran-C chain is measured modulo PCI. That is, the time of occurence of an event is cyclic in one phase code interval. The time reference for the chain is the time of transmission of the PGTR of a "A" group of the master station signal (PGTRA).

3.5.1 Time of Transmission (TOT)

The time of transmission of a pulse group of a station's signal is the time of occurence of the PGTR of the "A" interval group of the antenna current waveform.

3.5.2 Time of Arrival (TOA)

Time of arrival of a pulse group of a station's signal is the time of occurence of the PGTR of the electromagnetic field at the receiving antenna. Note that because signal processing circuits cause delays, there is an offset associated with the observed TOA of a signal. Also, because of processing associated with most receivers, the observed TOA is the average of the PTR's (modulo pulse spacing) of the pulses in a group and the average of PGTR over a number of groups.

3.5.3 Time Difference (TD)

Time difference is the time of arrival of the secondary signal minus the time of arrival of the master signal, as observed on a single receiver.

3.5.3.1 Time Difference Notation

A time difference is identified with the geographic location of a receiver and the secondary station observed, as shown:

"RTDY" represents the time difference of the Y secondary as observed at point R. The first character represents the geographic location and the last represents the secondary station.

3.5.4 Coding Delay (CD)

Coding delay is the TD, observed at a secondary station, of its own signal. Note that CDX = coding delay for the X secondary = XTDX. Coding delay is approximately equal to the TD which would be observed on the secondary BLE.

3.5.4.1 Coding Delay Measurement

Coding delay measurement may be made using an antenna and time difference receiver at the secondary station, or by measuring the TOT of the secondary signal minus the TOA of the master signal. This latter technique is that most commonly used. Actual coding delay is not significant to control, however changes of TOT-TOA are observed and corrected, maintaining CD constant.

3.5.4.2 Coding Delay Adjustment (CDA)

Coding delay adjustment is a change of coding delay by change of the TOT of the secondary signal. Its purpose is to correct for propagation velocity changes or equipment caused TOT changes which cause the TD's observed in the coverage area to change.

3.5.5 Encelope-to-Cycle Difference (ECD)

Envelope-to-cycle difference is defined in paragraph 3.2.1.3.

3.5.5.1 Envelope Timing Adjustment (ETA)

Envelope timing adjustment is a change of ECD by adjustment of the driving waveform for the transmitter. Its purpose is to compensate for variations of the ECD which may be caused by aging components in the transmitter or by changed propagation conditions.

3.5.6 Master Station Timing

The master station carrier frequency, pulse spacing, and GRI are based on timing derived from an ultra-stable frequency standard. Generally, cesium beam oscillators are used.

3.5.6.1 Chain Reference Time

A chain is timed to Universal Coordinated Time (UTC-USNO) when the phase and frequency of the master station frequency standard are controlled, so that the PGTRA of the master station is in coincidence with the particular second tick of the US Naval Observatory (USNO) master clock at each time of coincidence (TOC).

3.5.6.2 Time of Coincidence (TOC)

The TOC's are computed and published by the USNO for all timed chains. Tables are available on request from: Superintendant, US Naval Observatory, Attn: Time Service Division, Washington, D.C. 20390. TOC reference presumes that all chains, if they had existed, would have had a TOC at 00:00:00, 1 January 1958.

3.5.6.3 Chain Timing Tolerance

Chain timing tolerances are with respect to the USNO master clock. Tolerances will be decreased to those in parenthesis when the measurement techniques are improved by a new equipment program, now underway.

a. Frequency is within 1 part in $5x10^{12}$ (1 : $1x10^{12}$)

b. Time of PGTR is within 25 μsec of TOC (5 μsec)

3.5.7 Secondary Station Timing

The secondary station carrier frequency, pulse spacing, and GRI are based on timing derived from an ultra-stable frequency standard. Generally, cesium beam standards are used. The master station signal is used as the basis for setting the frequency standards at secondary stations.

3.5.7.1 Secondary Timing Tolerance

Frequency tolerance is with respect to the master station frequency. Timing tolerance is with respect to the commanded value, which is set by the Control Station as described in the following paragraphs.

a. Frequency is within 1 part in 1×10^{12}

b. Coding delay is within 100 nanoseconds of the commanded value

c. ECD is within 0.25 microseconds of the commanded value

3.5.8 Chain Control

Chain control is the process of measurement of time differences and ECD's, comparison with standards, determination of CDA's and ETA's required, and the making of the changes.

3.5.8.1 Control Station

The control station is the station assigned the task of evaluating time difference measurements from various sources, making comparisons and ordering CDA's and ETA's as necessary to maintain the timing tolerances of the chain or pairs of stations over which control is exercised.

3.5.8.2 System Area Monitor (SAM)

The system area monitor is a station designated as the point of observation of TD's and ECD's for a chain or station pairs for control.

3.5.8.3 Controlling Standard Time Difference (CSTD)

The controlling standard time difference is the reference standard against which the control station compares the observations of the SAM.

3.5.8.4 Correlated Time Difference

A correlated time difference is a TD which is observed at an alternate system area monitor, when the observed TD equals the CSTD at the SAM. The purpose of correlated time differences is to permit alternate control should the SAM be unable to perform due to equipment failures or loss of communications.

3.5.8.5 Control Tolerance

Control tolerance is the limit of deviation from the commanded value of TD or ECD before a CDA or ETA will be commanded. Typically control tolerances are one half of the alarm tolerance, which is the limit of deviation beyond which blink is initiated.

	Control Tolerance	Alarm Tolerance
TD	±50 nsec	± 100 nsec
ECD	±500 nsec	± 1000 nsec

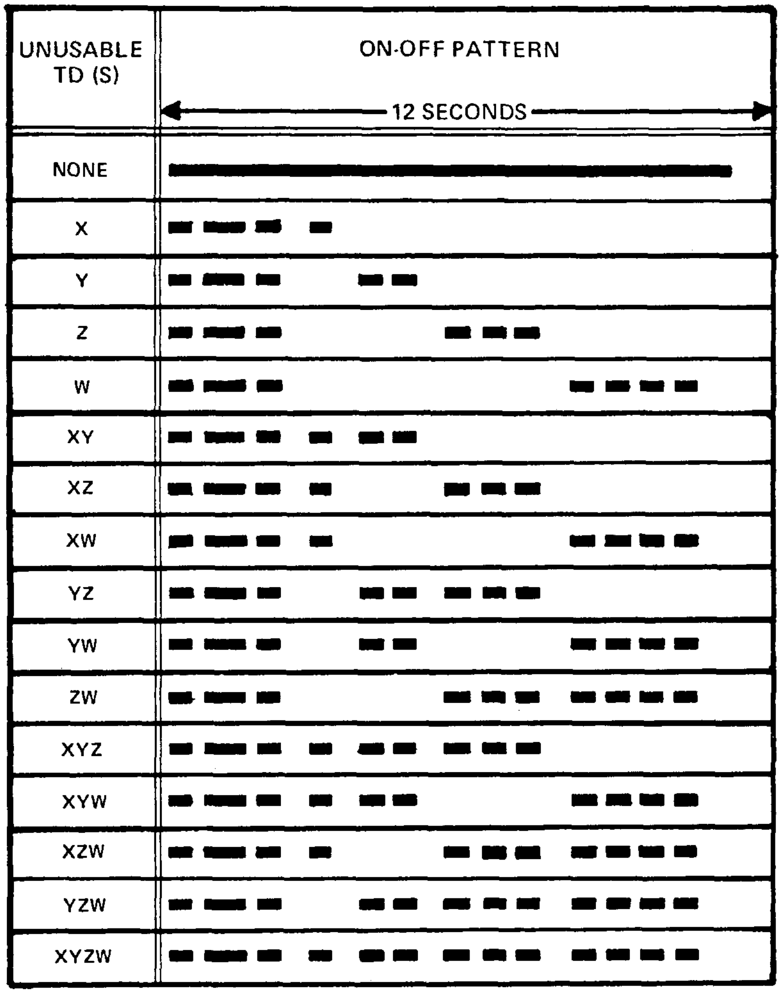
3.5.9 Blink Alarm

Blink is a repetitive off-on pattern of individual pulses in a group. Blink is used to indicate unusable conditions of the signals and that they should not be relied upon until blink is stopped.

3.5.9.1 Master Blink Pattern - Ninth Pulse Only

▬ = approximately 0.25 seconds on
▬▬ = approximately 0.75 seconds on

LORAN-C BLINK CODE



3.5.9.2 Secondary Blink Pattern - First and second pulses only. At the effected secondary only, the first and second pulses of each group are on for approximately 0.25 seconds out of every 4 seconds. All secondaries use the same code.

3.6 Communications

Although designed specifically for navigation purposes the Loran-C system transmissions have been found to be an effective method by which to conduct long distance communications. For navigation it is required that the pulse rise in a controlled manner to a maximum signal amplitude in 65 microseconds from start and then to be quenched as quickly as possible commensurate with regulation spectrum assignments within the 90 to 110 KHz band. Further requirements are that signals from one station should not overlap those of another. Within the definition of these parameters, time and frequency spectrum are available for communication providing that the modulation techniques utilized do not interfere with or degrade the system's navigation performance standards. Several methods of communications are in operation and others are experimental or in the proposal stage. The methods fall into three general categories.

a. Pulse position modulation of navigation pulses (PPM)

b. Polyphase modulation using the pulse tail

c. Modulation of additional pulses.

3.6.1 Clarinet Pilgrim (PPM)

3.6.1.1. Modulation Method

Loran-C pulses are modulated with binary information by shifting the pulse position, advancing or retarding them in accordance with the transmitted message.

3.6.1.2 Pulses Modulated

Pulses number 1 and 2 are not modulated with Clarinet Pilgrim data. As many of the remaining pulses are modulated as required to handle the data rate. If less than six are required, the last pulse(s) in the group are not modulated, except for the "sync" words.

3.6.1.3 Modulation Characteristics

The single-channel system operational in the Northwest Pacific chain shifts the pulses advanced or retarded one microsecond (36^{o}) in accordance with the "one" or "zero" bits in the transmitted message, each bit assigned to one pulse. In order to maintain a zero-mean balance of the phase shifts, a "bit flip" code is added to the data, modulo 2, as follows:

Pulse No.	3	4	5	6	7	8
GRI A	0	1	0	1	1	0
B	1	0	1	0	0	1

Since the pulse rate is necessarily higher than the data bit rate, some pulses cannot carry data. To fill these gaps, special 6-bit "sync" words are sent as required. These are recognized and removed by the receiver. The same message is transmitted from each station in a chain with some delay between data from different stations. Receivers receiving three stations correlate data and majority vote data to improve the error rate.

3.6.1.4 Transmitted Spectrum

The pulse-position modulation causes an increase in the number of discrete sidebands, since the GRI is being jittered by ± 1 microsecond, bu there is no change in the total sideband energy or in the "envelope" of the spectrum.

3.6.1.5 Pulse Specifications

This modulation offsets only the timing of the transmitted pulses and does not affect the transmitted or received pulse shape.

3.6.2 Teletype II (PPM)

Interstation teletype communications

3.6.2.1 Modulation Method

Loran-C pulses are modulated by shifting the pulse position, advancing or retarding them in accordance with the transmitted message.

3.6.2.2 Pulses Modulated

Pulses number 1 and 2 only are modulated, using Clarinet Pilgrim modulators. Presently used only on the Northwest Pacific chain.

3.6.2.3 Modulation Characteristics

Six bits (start plus 5 data) for each teletype character are transmitted in three repetition periods. The pulses are advanced or retarded one microsecond (36^{o}) for mark or space. In the Northwest Pacific chain (9970) each character takes 0.3 seconds to transmit, giving a maximum data rate of 200 characters or 33-1/3 words per minute.

For communication under adverse conditions, a "repeat mode" is available, in which each character is repeated three times and a majority vote used to improve the error rate at the expense of the data rate.

When no message is being sent, the pulses are unmodulated. At the start of each transmission, a "start code" is automatically sent before the first character to allow the receiver to synchronize.

A special interlock with the blink control at secondary stations allows a sharing of the blink interval if communication is required.

3.6.2.4 Transmitted Spectrum

The pulse-position modulation causes an increase in the number of discrete sidebands, since the GRI is being jittered by ± 1 microsecond, but there is no change in the total sideband energy or in the "envelope" of the spectrum.

3.6.2.5 Pulse Specifications

This modulation offsets only the timing of the transmitted pulses and does not affect the transmitted or received pulse shape.

3.6.3 USCG High Speed Communication (PPM)

Interstation teletype communications

3.6.3.1 Modulation Method

Loran-C pulses are modulated with binary teletype information by shifting the pulse position, advancing or retarding them in accordance with the transmitted message.

3.6.3.2 Pulses Modulated

All pulses in a group are modulated in accordance with the transmitted data.

3.6.3.3 Modulation Characteristics

The system previously installed in Southeast Asia, is being installed in the Central Pacific. Each pulse is modulated $\pm 27^{o}$ in accordance with a teletype message.

The modulation format consists of five teletype data bits, plus one parity bit, repeated four times over 3 GRI. When no data is being transmitted, a "blank" of all zeros is transmitted, with a balancing code as follows:

Pulse #	1	2	3	4	5	6	7	8
GRI 1	–	+	+	–	–	+	+	–
2	–	+	+	–	+	–	–	+
3	–	+	–	+	+	–	+	–

This also serves to synchronize the receivers so they can identify the start of each character.

The linear receiver sums the four repetitions of each bit, and if parity does not check, reverses the weakest approving bit. Blinking pulses 1 and 2 will simply remove one of the four repeated characters, so it will degrade signal-to-noise performance but not introduce errors.

3.6.3.4 Transmitted Spectrum

The pulse-position modulation causes an increase in the number of discrete sidebands, since the PRI is being jittered by 0.75 microsecond, but there is no change in the total sideband energy or in the "envelope" of the spectrum.

3.6.3.5 Pulse Specifications

This modulation offsets only the timing of the transmitted pulses and does not affect the transmitted or received pulse shape.

3.6.4 CALOC (Calculator Assisted Loran-C) (PPM)

Interstation communication of control information

3.6.4.1 Modulation Method

Loran-C pulses are modulated by shifting the pulse position, advancing or retarding them in accordance with the transmitted data.

3.6.4.2 Pulses Modulated

On chains where no other PPM system is in operation, specifically the U.S. East Coast, 9930, pulses number 7 and 8 are modulated. If installed where Clarinet Pilgrim is in operation, as in the Western Pacific rate 9970, pulses 1 and 2 will be modulated.

3.6.4.3 Modulation Characteristics

Digital data is transmitted using four pulses on two GRI to designate 0 or 1 as follows:

MASTER:	GRI 1	GRI 2
Pulse No.	7 8	7 8
0	– +	+ –
1	+ –	– +

SECONDARY:	GRI 1	GRI 2
Pulse No.	7 8	7 8
0	+ –	– +
1	– +	+ –

Modulation index is $\pm 36^{\circ}$ ($\pm 1\ \mu$sec)

Periodically, a sync bit is transmitted, as follows

GRI 1	GRI 2
7 8	7 8
+ +	– –

Modulation index is $\pm 72^{o}$ ($\pm 2\ \mu$sec)

3.6.4.4 Transmitted Spectrum

The pulse-position modulation causes an increase in the number of discrete sidebands, since the GRI is being jittered by ± 1 microsecond, but there is no change in the total sideband energy or in the "envelope" of the spectrum.

3.6.4.5 Pulse Specifications

This modulation offsets only the timing of the transmitted pulses and does not affect the transmitted or received pulse shape.

3.6.5 Polyphase Modulation of Pulse Tail

Currently (1975) being evaluated is a system of modulation which uses a time interval following the 0-60 microsecond portion of the pulse and for navigation. Since the system is experimental no firm specifications for the pulse nor the added requirements (if any) on the navigation receivers can be specified at this time.

3.6.6 Supernumerary Pulse Modulation

A method of communication that adds additional pulses to these required for navigation is being proposed. The additional pulses will be interleaved with the navigation pulses and will be either pulse position modulated or polyphase modulated. No specifications for the system are available nor is the effect (if any) on navigation receivers known at this time.

3.6.7 Effect of Modulation on Navigation receivers.

Since navigation performance is the prime concern of Loran-C receiver designers they should be aware of the various communication methods in operation or proposed and evaluate where possible the impact of these modified signals on receivers and processing design and performance. This paragraph (3.6) of the specification will be updated as further information becomes available.

LORAN AND OMEGA CHART AVAILABILITIES

We have all been frustrated, at one time or another, by the dearth of Loran-C charts. Generally, it has been difficult to determine which charts are available with lines-of-position for each of the various radionavigation systems. That situation is rapidly changing, so, on the following pages we have attempted to present data on available charts, including areas covered and sources of information. We strongly suggest that if you have a continuing need for charts that you obtain the indicated chart catalogs for the areas of interest.

The chart data is presented in tabular form. Table #1 is a list of nautical charts of U.S. waters printed by the National Ocean Survey. Table #2 is a list of charts known to be published by other nations. Table #3 is a list of world-wide charts printed by the U.S. Defense Mapping Agency Hydrographic Center (DMAHC). Table #4 lists world-wide aviation charts prepared by the U.S. Defense Mapping Agency, Aerospace Center (DMAAC). Table #5 is a list of loran and Omega tables which are prepared by the DMAHC.

ORDERING INFORMATION:

NATIONAL OCEAN SURVEY:

National Ocean Survey and Defense Mapping Agency Aerospace Center charts may be ordered from the nearest N.O.S. sales agent or from:

DISTRIBUTION DIVISION (C-44)
NATIONAL OCEAN SURVEY
RIVERDALE, MD. 20840

Nautical Chart Catalogs are available from the same source, at no charge:

CHART NO.	CATALOG TITLE
1.	Atlantic and Gulf Coasts, including Puerto Rico and the Virgin Islands
2.	Pacific Coast, including Hawaii, Guam, and the Samoa Islands
3.	Alaska
4.	Great Lakes and Adjacent Waterways

Also, a quarterly subscription to 'Dates of Latest Editions, Nautical Charts' is available. This list indicates the lines-of-position available on each chart edition.

DEFENSE MAPPING AGENCY HYDROGRAPHIC CENTER:

Requests for DMAHC charts should be directed to either of the DMAHC Depots:

DEFENSE MAPPING AGENCY
HYDROGRAPHIC CENTER DEPOT
CLEARFIELD, UTAH 84016
TEL: 801-773-3254

DEFENSE MAPPING AGENCY
HYDROGRAPHIC CENTER DEPOT
5801 TABOR AVENUE
PHILADELPHIA, PA. 19120
TEL: 215-697-4262

A Catalog of Nautical Charts is available at no charge (Publication No. 1-N-A). This catalog lists regional catalogs available at nominal charge, and lists DMAHC and British Admiralty Charts sales agents.

CANADIAN HYDROGRAPHIC SERVICE:

HYDROGRAPHIC CHART DISTRIBUTION OFFICE
MARINE SCIENCES DIRECTORATE
DEPARTMENT OF THE ENVIRONMENT
OTTAWA, ONTARIO, CANADA K1A OE6

ICELANDIC HYDROGRAPHIC SERVICE:

SJÓMAELINGAR ISLANDS
PÓSTHÓLF 7094
SELJAVEGI 32
REYKJAVIK, ICELAND

NORWEGIAN HYDROGRAPHIC OFFICE:

NORGES SJØKARTVERK
KLUBBT 1, P.O. BOX 60,
4001 STAVANGER, NORWAY

GERMAN HYDROGRAPHIC INSTITUTE:

DEUTSCHES HYDROGRAPHISHES INSTITUTE (D.I.H.)
BERNHARD - NOCHT STR. 78
2000 HAMBURG 4,
GERMANY

Some three dozen charts are reportedly available from D.I.H. for waters between Iceland, Norway, and Great Britain. (Possibly charts for U.S. waters as well). We have not determined the exact areas and availability.

TABLE #1
NATIONAL OCEAN SURVEY CHARTS
WITH LORAN-C OVERLAYS

Old Chart #	New Chart #	Title	Scale	Proposed NOAA(NOS) Issue Date
70	13006	West Quoddy Head to N.Y.	1:675,000	9/75
71	13009	Gulf of Maine & Georges Bank	1:500,000	Avail.
77	12260	Chesapeake Bay-Northern Part	1:197,250	Avail.
78	12220	Chesapeake Bay-Southern Part	1:200,000	Avail.
612	13204	Georges Bank	1:220,000	9/75
1000	13003	Cape Sable to Cape Hatteras	1:1,200,000	11/75
1001	11009	Cape Hatteras to Straits of Florida	1:1,200,000	11/75
1002	11013	Straits of Florida and approaches	1:1,200,000	9/75
1003	11006	Gulf Coast-Key West to Mississippi River	1:875,000	2/76
1007	411	Gulf of Mexico	1:2,160,000	1/76
1050	11352	New Orleans to Calcasieu River, East Section	1:175,000	9/75
1051	11345	New Orleans to Calcasieu River, West Section	1:175,000	4/76
1106	13260	Bay of Fundy to Cape Cod	1:378,838	11/75
1107	13200	Georges Bank-Nantucket Shoals	1:400,000	2/76
1108	12300	Approaches to N.Y., Nantucket Shoals to 5 Fath.	1:400,000	Avail.
1109	12200	Cape May to Cape Hatteras	1:416,944	Avail.
1110	11520	Cape Hatteras to Charleston	1:432,720	Avail.
1111	11480	Charleston Lt. to Cape Canaveral	1:449,659	Avail.

Table #1 continued

Old Chart #	New Chart #	Title	Scale	Proposed NOAA(NOS) Issue Date
1112	11460	Cape Canaveral to Key West	1:446,940	Avail.
1114	11400	Tampa Bay to Cape San Blas	1:456,394	11/75
1115	11360	Cape St. George to Mississippi River	1:456,394	6/76
1116	11340	Mississippi River to Galveston	1:458,596	10/75
1117	11300	Galveston to Rio Grande	1:460,732	8/75
1201	13325	Quaddy Narrows to Petit Manon I.	1:80,000	5/76
1204	13288	Monhegan Island to Cape Elizabeth	1:80,000	5/76
1205	13286	Cape Elizabeth to Portsmouth	1:80,000	9/75
1206	13278	Portsmouth to Cape Ann	1:80,000	10/75
1207	13267	Massachusetts Bay	1:80,000	10/75
1208	13246	Cape Cod Bay	1:80,000	1/76
1209	13237	Nantucket South and approaches	1:80,000	1/76
1210	13218	Martha's Vineyard to Block Island	1:80,000	8/75
1211	13205	Block Island Sound and approaches	1:80,000	Avail.
1212	12354	Long Island Sound-Eastern Part	1:80,000	Avail.
1213	12363	Long Island Sound-Western Part	1:80,000	Avail.
1215	12326	Approaches to N.Y.- Fire Isl. Lt. to Sea Girt Lt.	1:80,000	12/75
1216	12323	Sea Girt to Little Egg Inlet	1:80,000	9/75
1217	12318	Little Egg Inlet to Hereford Inlet	1:80,000	12/75
1218	12304	Delaware Bay	1:80,000	1/76
1219	12214	Cape May to Fenwick Isl. Lt.	1:80,000	5/76
1220	12211	Fenwick Isl. Lt. to Chincoteaque Inlet	1:80,000	5/76
1221	12210	Chincoteaque Inlet to Gt. Machipongo Inlet	1:80,000	5/76
1222	12221	Chesapeake Bay Entrance	1:80,000	11/75
1223	12225	Chesapeake Bay-Wolf Trap to Smith Point	1:80,000	12/75
1224	12230	Smith Point to Cove Point	1:80,000	9/75
1225	12263	Cove Point to Sandy Point	1:80,000	10/75
1226	12273	Sandy Point to Head of Bay	1:80,000	10/75
1227	12207	Cape Henry to Currituck Beach Lt.	1:80,000	4/76
1229	12204	Currituck Beach Lt. to Wimble Shoals	1:80,000	5/76
1231	11548	Pamlico Sound-Western Part	1:80,000	2/76
1232	11555	Cape Hatteras-Wimble Shoals to Oracoke Inlet	1:80,000	10/75
1233	11544	Portsmouth Island to Beaufort	1:80,000	5/76
1234	11543	Cape Lookout to New River	1:80,000	4/76
1236	11536	Approaches to Cape Fear River	1:80,000	4/76
1238	11531	Winyah B. Entrance to Isle of Palms	1:80,000	2/76
1239	11521	Charleston Harbor and approaches	1:80,000	8/75
1241	11509	Tybee Island to Doboy Sound	1:80,000	2/76
1242	11502	Doboy Sound to Fernandina	1:80,000	10/75
1245	11484	Ponce de Leon Inlet to Cape Kennedy	1:80,000	8/75
1246	11476	Cape Canaveral to Bethel Shoal	1:80,000	1/76
1247	11474	Bethel Shoal to Jupiter Inlet	1:80,000	9/75
1256	11424	Lemon Bay to Passage Key Inlet	1:80,000	5/76
1257	11412	Tampa Bay & St. Joseph's Sound	1:80,000	3/76
1258	11409	Anclote Keys to Crystal River	1:80,000	5/76
1261	11405	Apalachee Bay	1:80,000	11/75
1262	11401	Apalachicola Bay to Cap San Blas	1:80,000	3/76
1263	11389	St. Joseph & St. Andrew Bay	1:80,000	3/76
1264	11388	Choctawhatchee Bay	1:80,000	11/75
1265	11382	Pensacola Bay and approaches	1:80,000	11/75
1266	11376	Mobile Bay	1:80,000	2/76
1267	11373	Mississippi Sound and approaches	1:80,000	1/76

Table #1 continued

Old Chart #	New Chart #	Title	Scale	Proposed NOAA(NOS) Issue Date
1268	11371	Lake Borgne and approaches	1:80,000	3/76
1269	11369	Lakes Pontchartrain & Maurepas	1:80,000	2/76
1270	11363	Chandeleur & Breton Sounds	1:80,000	12/75
1271	11364	Mississippi River-Venice to New Orleans	1:80,000	5/76
1272	11361	Mississippi River Delta	1:80,000	10/75
1273	11358	Barataria Bay and approaches	1:80,000	10/75
1274	11357	Timbalier & Terrebonne Bays	1:80,000	12/75
1275	11356	Isles Dernieres to Point au Fer	1:80,000	2/76
1276	11351	Point au Fer to Marsh Island	1:80,000	12/75
1278	11344	Rollover Bayou to Calcasieu Pass	1:80,000	11/75
1279	11341	Calcasieu Pass to Sabine Pass	1:80,000	6/76
1282	11323	Approaches to Galveston Bay	1:80,000	5/76
1283	11321	San Luis Pass to E. Matagorda Bay	1:80,000	2/76
1284	11316	Matagorda Bay and approaches	1:80,000	3/76
1288	11301	Southern Part of Laguna Madre	1:80,000	2/76
4000	540	Hawaiian Archipelago	1:3,121,170	4/76
4102	19004	Hawaiian Islands	1:600,000	4/76
4116	19340	Hawaii to Oahu	1:250,000	10/75
4172	19401	French Frigate Shoals	1:80,000	9/75
4174	19441	Maro Reef	1:80,000	4/76
4179	19010	Hawaiian Islands-Southern Part	1:675,000	12/75
4183	19022	Laysan Island to Kure Island	1:642,271	11/75
4185	19480	Midway Islands and approaches	1:180,000	6/76
5002	18020	San Diego to Point St. George	1:1,412,349	6/76
5142	18746	San Pedro Channel	1:80,000	6/76
6300	18400	Strait of Georgia & Strait of Juan de Fuca	1:200,000	6/76
6401	18440	Admiralty Inlet and Puget Sound	1:150,000	6/76
8054	17425	Portland Canal-North of Hattie Island	1:80,000	5/76
8528	16683	Point Elrington to Cape Resurrection	1:81,436	6/76
8703	16549	Cold Bay and approaches, Alaska Pen.	1:80,000	10/75
8802	16011	Alaska Pen. & Aleutian Isl. to Sequan Pass	1:1,023,188	6/76
8833	16363	Port Moller & Herendeen Bay	1:80,000	8/75
8860	16520	Unimak & Akutan Passes and approaches	1:300,000	10/75
8861	16500	Unalaska Island to Amukta Island	1:300,000	12/75
8864	16440	Rat Islands-Semisop. Isl. to Buldir Isl.	1:300,000	8/75
8865	16420	Near Islands-Buldir Isl. to Attu Isl.	1:300,000	5/76
9052	16322	Bristol Bay-Nushagak B. and approaches	1:100,000	6/76
9102	16012	Aleutian Isl.-Amutka Isl. to Attu Isl.	1:1,126,321	Avail.
9198	16421	Near Isl.-Ingenstrem Rocks to Attu Isl.	1:160,000	3/76
9302	16006	Bering Sea-Eastern Part	1:1,534,000	
9380	16200	Norton Sound	1:400,000	5/76
LSO		Great Lakes-General Chart (Polyconic P.)	1:1,500,000	12/75
LS7		Lake Michigan (Polyconic P.)	1:500,000	12/75
LS7M		Lake Michigan (Mercator P.)	1:500,000	12/75

TABLE #2

Chart #	Title	Scale	British Admiralty Issue Date	Canadian Hydro Serv Issue Date	Icelandic Hydro Serv Issue Date	Norwegian Hydro Office Issue Date	Price Code
245	Scotland to Iceland		9/75				
L8005	Georges Bank	1:300,000		Avail.			C$2.00
20C	Iceland-Jan Mayen	1:200,000			Avail.		I.K.475
25C	Iceland-Austurhluti	1:750,000			Avail.		I.K.475
26C	Iceland-Vesturhluti	1:750,000			Avail.		I.K.475
56C	Iceland-Kolbeinsey	1:200,000			Avail.		I.K.475
306	Skagerrak vestre blad	1:350,000				12/75	
307	Utsira to Kinn	1:350,000				12/75	
308	Kinn to Trondheimsleden	1:350,000				12/75	
309	Smøla to Vegg	1:350,000				12/75	
311	Stott to Andenes	1:350,000				12/75	
310	Lekaand Sklima to Vestfjorden	1:350,000				12/75	
321	Andenes to Grøtsund	1:200,000				12/75	
552	Vesteralen-Vest Finnmark-Bjørnøya	1:700,000				Avail.	NKr20.00
554	Bjørnøya-Spitsbergen	1:700,000				12/75	
555	Barentshavet, nordvestlige del	1:700,000				12/75	
557	Haltenbanken-Vesteralen	1:700,000				Avail.	NKr20.00
558	Vikingbanken-Haltenbanken	1:700,000				Avail.	NKr20.00
559	Birdshøen, nordre blad	1:800,000				Avail.	NKr20.00
560	Nordsjøen, søre blad	1:800,000				Avail.	NKr20.00

TABLE #3

CHARTS PUBLISHED BY THE DEFENSE MAPPING AGENCY, HYDROGRAPHIC CENTER

Old Chart #	New Chart #	Title	Scale
	28031	Tampico to Progresso (Mexico-East Coast)	1:23,400
	51014	Cabo De Sao Vicente to Meddouza incl. St. of Gibralter	1:964,525
3915	52000	Gibralter to Cabode San Antonio & Cap Tenes	1:778,800
3916	52010	Cabode Palos & Cap Tenes to Sardinia and Balearic Isl.	1:757,900
3920	52020	Tunis to Surt inc. Sicily and Malta	1:798,700
3917	53000	Barcelona to Roma incl. Isle of Corse	1:713,400
3918	53020	Tyrrhenian Sea incl. Sardinia & Sicily	1:754,330
3919	54000	Adriatic Sea	1:918,470
3921	54010	Malta to Crete incl. the Ionian Sea	1:768,450
	54020	Agean Sea	?
3924	54030	Antalyn Korfezi to Alexandria incl. Cypress	1:812,390
3925	56000	Tobruch to Alexandria incl. Crete & Dodecanese	1:817,635
3926	56020	Ras al Barq to Tobruq, Libya	1:817,635
	71028	Pulau Bintan to Mui Bai Bung (Malaysia)	1:613,850
73XX	(Series)	Loran Position Plotting Charts (Loran-A)	1:2,188,800
74XX	(Series)	Loran Position Plotting Charts (Loran-C)	1:2,188,800
75XX	(Series)	Omega Position Plotting Charts	1:2,188,800

See Figs. 1 and 2 for areas covered by these chart series.

Code N.O. 7300/7400

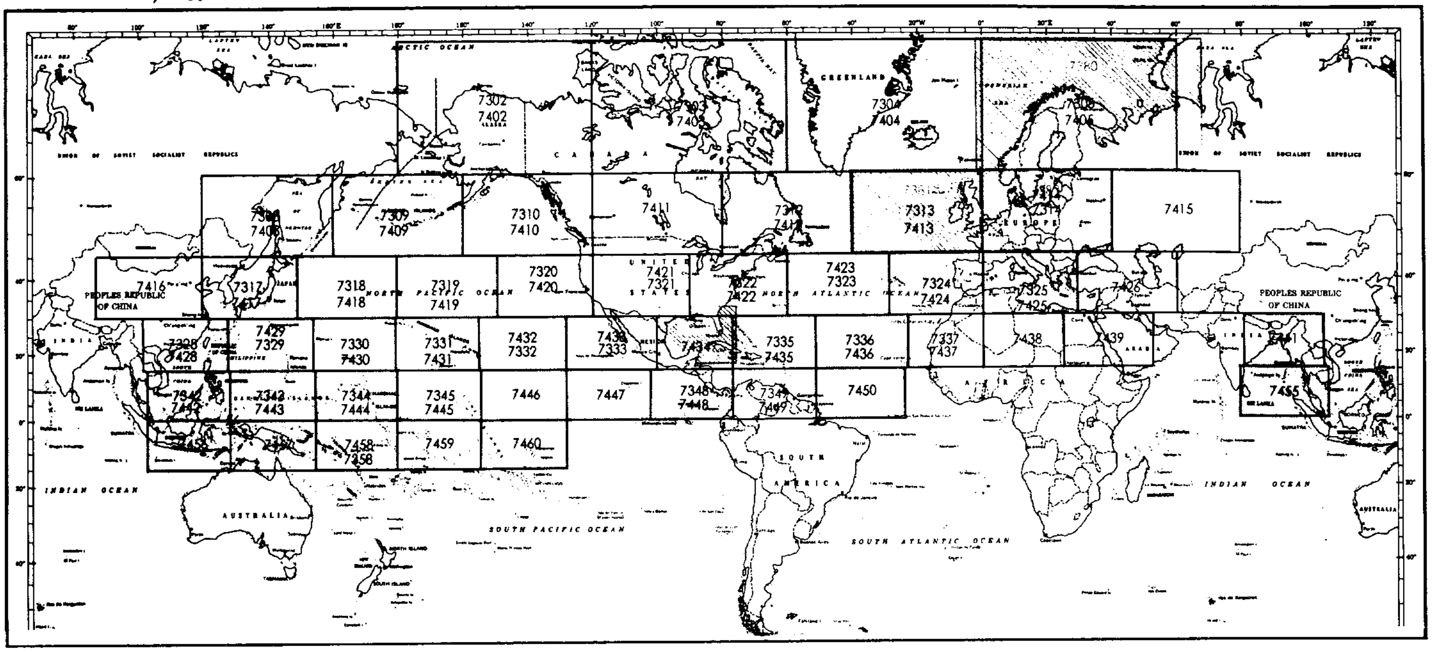


FIGURE 1 - LORAN POSITION PLOTTING CHARTS

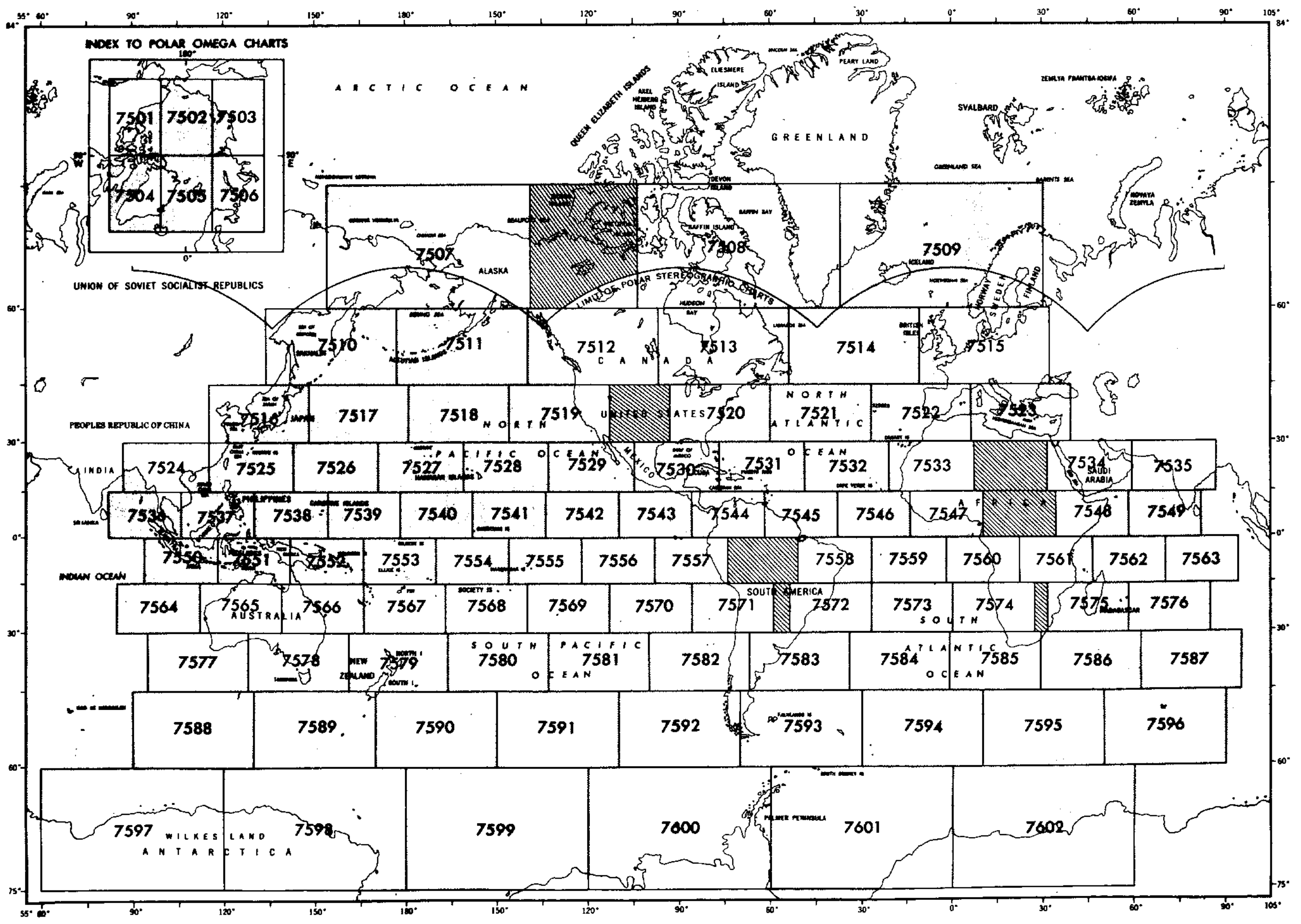


FIGURE 2 - OMEGA POSITION PLOTTING CHARTS

DEFENSE MAPPING AGENCY HYDROGRAPHIC CENTER

CURRENT AS OF 1 MARCH 1974

TABLE #4

Charts published by the Defense Mapping Agency, Aerospace Center. The area coverage charts are used with the permission of DMAAC.

Chart #	Title	Scale
	GLOBAL LORAN CHARTS	1:5,000,000
GLC-1,3,6,7,8,9,10 Loran-A		
GLC-C-1,3,4,6,7,8,9,10,11,13 Loran-C		
	See Figure 3 for areas covered	
	USAF LORAN-C NAVIGATION CHARTS	1:3,000,000
LCC-1A,2A,3A,4A	North Polar Region	
	See Figure 4 for areas covered	
	USAF LORAN NAVIGATION CHARTS	1:2,000,000
LJC-6,7,15,16	Loran-A North Polar Region, Alaska, and Bering Sea	
	USAF CONSOL-LORAN NAVIGATION CHART	1:2,000,000
CJC-9	Consol & Loran-A, North Sea Area	

TABLE #5

Loran-A and Loran-C Rate Tables and Omega Lattice and Propagation Correction Tables published by Defense Mapping Agency, Hydrographic Center.

LORAN RATE TABLES

Pub. No.	Title	Pub. No.	Title
INDIVIDUAL LORAN-A TABLES ($.70)		221 (116)	Bay Biscay (Rate 1S4) (Intermittent use only)
221 (101)	Baffin Bay Area (Rate 2S6)	221 (117)	North Atlantic (Rate 1H2)
221 (102)	Baffin Bay Area (Rate 2S7)	221 (118)	North Atlantic (Rate 1H3)
221 (103)	North Atlantic (Rate 1L6)	221 (119)	North Atlantic (Rate 3H5)
221 (104)	North Atlantic (Rate 1L7)	221 (120)	North Atlantic (Rate 3H4)
221 (105)	North Atlantic (Rate 1L2)	221 (121)	North Atlantic (Rate 3H6)
221 (106)	North Atlantic (Rate 1L3)	221 (122)	North Sea (Rate 1S1) (Intermittent use only)
221 (107)	North Atlantic (Rate 1H1)		
221 (108)	West Indies (Rate 3L2)	221 (123)	North Sea (Rate 1S2) (Intermittent use only)
221 (109)	West Indies (Rate 3L3)		
221 (110)	North Atlantic (Rate 1L0)	221 (124)	West Portugal (Rate 1S5)
221 (111)	North Atlantic (Rate 1L1)	221 (125)	Azores (Rate 1S6)
221 (112)	Denmark Strait (Rate 1L5)	221 (126)	Azores (Rate 1S7)
221 (113)	Denmark Strait (Rate 1L4)	221 (127)	Gulf of Mexico (Rate 3H0)
221 (114)	East Coast U.S. (Rate 3H7) Changed to 3L1 June 1973)	221 (128)	Gulf of Mexico (Rate 3H1)
		221 (129)	Gulf of Mexico (Rate 3H2)
221 (115)	English Channel (Rate 1S3) (Intermittent use only)	221 (130)	Gulf of Mexico (Rate 3H3)

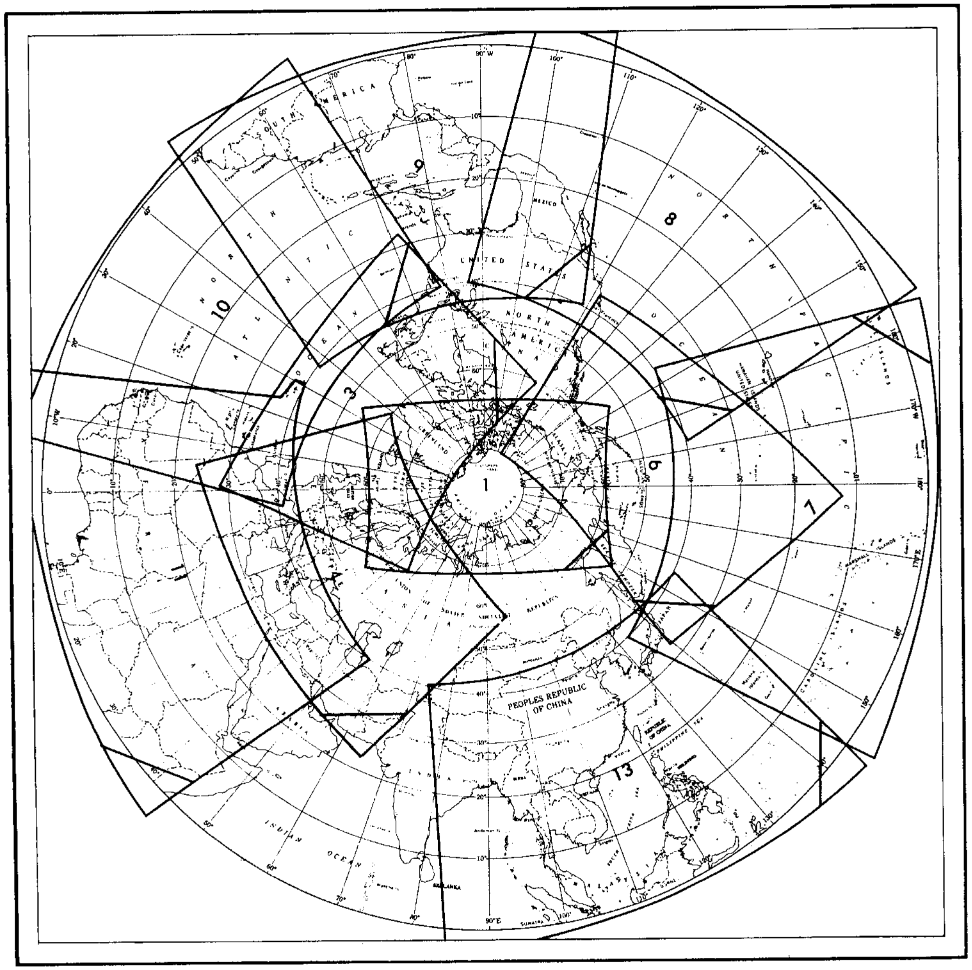


FIGURE 3 - GLOBAL LORAN NAVIGATION CHARTS

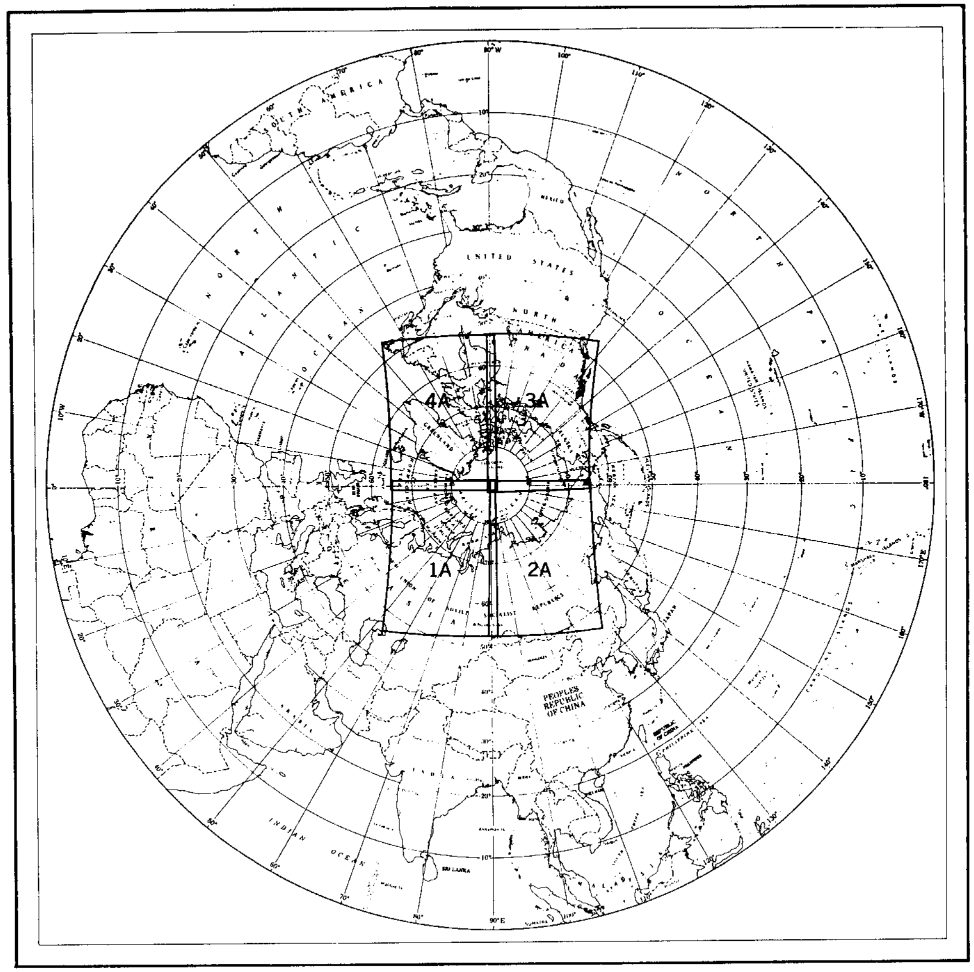


FIGURE 4 - USAF LORAN C NAVIGATION CHARTS

Table #5 continued

Pub. No.	Title
221 (131)	Southeast U.S.A. (Rate 3L5)
221 (132)	Gulf of Maine (Rate 1H7)
221 (201)	South Japan (Rate 2S7)
221 (202)	South Japan (Rate 2H6)
221 (203)	South Japan (Rate 2H7)
221 (204)	Central Pacific (Rate 2L7)
221 (205)	Asiatic Area (Rate 2H4)
221 (206)	Asiatic Area (Rate 2H3)
221 (207)	Asiatic Area (Rate 1L6)
221 (208)	Asiatic Area (Rate 1L7)
221 (209)	Central Pacific (Rate 2L6)
221 (210)	Central Pacific (Rate 1H2)
221 (211)	Central Pacific (Rate 1H1)
221 (213)	Central Pacific (Rate 2L5)
221 (214)	West Coast U.S. (Rate 1H5)
221 (215)	West Coast U.S. (Rate 1H6)
221 (216)	West Coast U.S. (Rate 2H4) (Changed to 1L0 May 1971)
221 (217)	West Coast U.S. (Rate 1L1)
221 (218)	Japanese Area (Rate 2S3)
221 (219)	Japanese Area (Rate 2S4)
221 (220)	West Japan (Rate 2S5)
221 (221)	West Japan (Rate 2S6)
221 (222)	South Pacific (Rate 2L1)
221 (223)	South Pacific (Rate 2L2)
221 (224)	South Pacific (Rate 2L3)
221 (225)	East Japan (Rate 2S1)
221 (226)	East Japan (Rate 2S2)
221 (227)	North Pacific (Rate 1L2)
221 (228)	North Pacific (Rate 1L3)
221 (229)	North Pacific (Rate 1L7)
221 (230)	North Pacific (Rate 1L6)
221 (231)	Philippine Sea (Rate 2H5)
221 (232)	West Coast U.S. (Rate 2H1) (Changed to 1H4 May 1971)
221 (233)	South Japan (Rate 2S0)
221 (234)	West Coast Canada (Rate 1L4)
221 (235)	West Coast Canada (Rate 1L5)

LORAN-C TABLES ($2.25)

Pub. No.	Title
221 (1001)	East Coast U.S.A. (Pair SS7-W)
221 (1002)	East Coast U.S.A. (Pair SS7-Y)
221 (1003)	Mediterranean Sea (Pair SL1-X)
221 (1004)	Mediterranean Sea (Pair SL4-Y redesignated SL1-Y Feb 1967)
221 (1005)	Norwegian Sea (Pair SL3-X)
221 (1006)	Norwegian Sea (Pair SL3-Y)
221 (1008)	Mediterranean Sea (Pair SL1-Z)
221 (1009)	North Sea (Pair SL3-W)
221 (1010)	North Atlantic (Pair SL7-W)
221 (1011)	North Atlantic (Pair SL7-X)
221 (1012)	North Atlantic (Pair SL7-Z)
221 (1013)	East Coast U.S.A. (Pair SS7-X)
221 (1014)	Eastern U.S.A. (Pair SS7-Z)
221 (2001)	North Pacific (Pair SH7-Z)
221 (2002)	North Pacific (Pair SH7-X)
221 (2003)	Central Pacific (Pair S1-X)
221 (2004)	Central Pacific (Pair S1-Y)
221 (2006)	Northwest Pacific (Pair SS3-W)
221 (2007)	Northwest Pacific (Pair SS3-X)
221 (2008)	Northwest Pacific (Pair SS3-Y)
221 (2009)	Northwest Pacific (Pair SS3-Z)
221 (2010)	Southeast Asia (Pair S3-X redesignated SH-3-X Apr 1969)
221 (2011)	Southeast Asia (Pair S3-Y redesignated SH3-Y Apr 1969)
221 (2012)	Southeast Asia (Pair SH3-Z)

AUXILIARY LORAN TABLES AND DIAGRAMS

Chart No.	Title	Rates	Scale
5130	Loran-C Coverage Diagram		1:45,000,000
5131	Loran-A Coverage Diagram		1:45,000,000
5148	Loran Interpolator Diagram		
5179	Omega Linear Interpolator		

LORAN-C RELIABILITY DIAGRAMS ($.50)

5592	Mediterranean Sea	SL1-X,SL1-Y,SL1-Z	1:5,093,677
5593	Norweigian Sea	SL3-W,SL3-X,SL3-Y,SL3-Z	1:5,000,000
5594	East Coast U.S.A.	SS7-W,SS7-X,SS7-Y,SS7-Z	1:5,000,000
5595	North Pacific	SH7-X,SH7-Y,SH7-Z	1:5,000,000
5596	Central Pacific	S1-X,S1-Y	1:5,000,000
5597	Northwest Pacific	SS3-W,SS3-X,SS3-Y,SS3-Z	1:5,000,000
5598	North Atlantic	SL7-W,SL7-X,SL7-Z	1:5,000,000

OMEGA TABLES

LATTICE TABLES

H.O. Pub. No.	Area of Coverage	Area
224 (100) A-D	North Polar	00
*224 (100) A-H	North Polar	00
224 (100) B-C	North Polar	00
*224 (100) B-H	North Polar	00
*224 (100) C-H	North Polar	00
224 (101) A-C	Northern Europe	01
224 (101) A-D	Northern Europe	01
*224 (101) A-H	Northern Europe	01
224 (101) B-D	Northern Europe	01
*224 (101) B-H	Northern Europe	01
224 (101) C-D	Northern Europe	01
224 (102) A-B	Central U.S.S.R.	02
224 (102) A-C	Central U.S.S.R.	02
224 (102) A-D	Central U.S.S.R.	02
224 (102) B-C	Central U.S.S.R.	02
*224 (102) D-H	Central U.S.S.R.	02
224 (103) A-B	Eastern U.S.S.R.	03
224 (103) A-C	Eastern U.S.S.R.	03
224 (103) A-D	Eastern U.S.S.R.	03
224 (103) B-C	Eastern U.S.S.R.	03
224 (103) C-D	Eastern U.S.S.R.	03
*224 (103) C-H	Eastern U.S.S.R.	03
224 (104) A-B	Alaska	04
224 (104) A-C	Alaska	04
224 (104) A-D	Alaska	04
224 (104) B-C	Alaska	04
*224 (104) B-H	Alaska	04
224 (104) C-D	Alaska	04
*224 (104) C-H	Alaska	04
224 (105) A-B	Canada	05
224 (105) A-C	Canada	05
224 (105) A-D	Canada	05
224 (105) B-C	Canada	05
224 (105) B-D	Canada	05
*225 (105) B-H	Canada	05
224 (105) C-D	Canada	05
*224 (105) C-H	Canada	05
*224 (105) D-H	Canada	05
224 (106) A-B	Greenland	06
224 (106) A-C	Greenland	06
224 (106) A-D	Greenland	06
224 (106) B-C	Greenland	06
224 (106) B-D	Greenland	06
*224 (106) B-H	Greenland	06
224 (107) A-B	Mediterranean	07
224 (107) A-D	Mediterranean	07
224 (107) B-C	Mediterranean	07
224 (107) B-D	Mediterranean	07
224 (108) A-C	Asia	08
*224 (108) A-H	Asia	08
224 (109) A-C	Northwest Pacific	09
*224 (109) D-H	Northwest Pacific	09
224 (110) A-B	Central Pacific	10
224 (110) A-C	Central Pacific	10
224 (110) C-D	Central Pacific	10
*224 (110) D-H	Central Pacific	10
224 (111) A-B	North America	11
224 (111) A-C	North America	11
224 (111) B-C	North America	11
224 (111) B-D	North America	11
224 (111) C-D	North America	11
224 (112) A-B	North Atlantic	12
*224 (112) A-C	North Atlantic	12
224 (112) A-D	North Atlantic	12
224 (112) B-C	North Atlantic	12
224 (112) B-D	North Atlantic	12
*224 (115) C-H	Australia	15
224 (116) B-C	South Pacific	16
224 (117) A-B	East Pacific	17
224 (117) B-C	East Pacific	17
224 (117) B-D	East Pacific	17
224 (118) A-B	South Atlantic	18
224 (118) A-C	South Atlantic	18
*224 (121) C-H	Victoria Land	21
224 (122) B-C	Ross Sea	22

PROPAGATION TABLES

H.O. Pub. No.	Area of Coverage	Area
224 (100-C) A	North Polar	00
224 (100-C) B	North Polar	00
224 (100-C) C	North Polar	00
224 (100-C) D	North Polar	00
*224 (100-C) H	North Polar	00
224 (101-C) A	Northern Europe	01
224 (101-C) B	Northern Europe	01
224 (101-C) C	Northern Europe	01
224 (101-C) D	Northern Europe	01
*224 (101-C) H	Northern Europe	01
224 (102-C) A	Central U.S.S.R.	02
224 (102-C) B	Central U.S.S.R.	02
224 (102-C) C	Central U.S.S.R.	02
224 (102-C) D	Central U.S.S.R.	02
*224 (102-C) H	Central U.S.S.R.	02
224 (103-C) A	Eastern U.S.S.R.	03
224 (103-C) B	Eastern U.S.S.R.	03
224 (103-C) C	Eastern U.S.S.R.	03
224 (103-C) D	Eastern U.S.S.R.	03
*224 (103-C) H	Eastern U.S.S.R.	03
224 (104-C) A	Alaska	04
224 (104-C) B	Alaska	04
224 (104-C) C	Alaska	04
224 (104-C) D	Alaska	04
*224 (104-C) H	Alaska	04
224 (105-C) A	Canada	05
224 (105-C) B	Canada	05
224 (105-C) C	Canada	05
224 (105-C) D	Canada	05
*224 (105-C) H	Canada	05
224 (106-C) A	Greenland	06
224 (106-C) B	Greenland	06
224 (106-C) C	Greenland	06
224 (106-C) D	Greenland	06
*224 (106-C) H	Greenland	06
224 (107-C) A	Mediterranean	07
224 (107-C) B	Mediterranean	07
224 (107-C) C	Mediterranean	07
224 (107-C) D	Mediterranean	07
*224 (107-C) H	Mediterranean	07
224 (108-C) A	Asia	08
224 (108-C) C	Asia	08
*224 (108-C) H	Asia	08
224 (109-C) A	Northwest Pacific	09

H.O. Pub. No.	Area of Coverage	Area
224 (109-C) C	Northwest Pacific	09
224 (109-C) D	Northwest Pacific	09
*224 (109-C) H	Northwest Pacific	09
224 (110-C) A	Central Pacific	10
224 (110-C) B	Central Pacific	10
224 (110-C) C	Central Pacific	10
224 (110-C) D	Central Pacific	10
*224 (110-C) H	Central Pacific	10
224 (111-C) A	North America	11
224 (111-C) B	North America	11
224 (111-C) C	North America	11
224 (111-C) D	North America	11
*224 (111-C) H	North America	11
224 (112-C) A	North Atlantic	12
224 (112-C) B	North Atlantic	12
224 (112-C) C	North Atlantic	12
224 (112-C) D	North Atlantic	12
224 (117-C) B	East Pacific	17
224 (117-C) C	East Pacific	17
224 (117-C) D	East Pacific	17
224 (118-C) A	South Atlantic	18
224 (118-C) B	South Atlantic	18
224 (118-C) D	South Atlantic	18
224 (201-C) A	Northern Europe	01
224 (201-C) B	Northern Europe	01
224 (201-C) C	Northern Europe	01
224 (201-C) D	Northern Europe	01
*224 (201-C) H	Northern Europe	01
224 (204-C) A	Alaska	04
224 (204-C) B	Alaska	04
224 (204-C) C	Alaska	04
224 (204-C) D	Alaska	04
*224 (204-C) H	Alaska	04
224 (205-C) A	Canada	05
224 (205-C) B	Canada	05
224 (205-C) C	Canada	05
224 (205-C) D	Canada	05
*224 (205-C) H	Canada	05
224 (206-C) A	Greenland	06
224 (206-C) B	Greenland	06
224 (206-C) C	Greenland	06
224 (206-C) D	Greenland	06
*224 (206-C) H	Greenland	06
224 (210-C) A	Central Pacific	10
224 (210-C) B	Central Pacific	10
224 (210-C) C	Central Pacific	10
224 (210-C) D	Central Pacific	10
*224 (210-C) H	Central Pacific	10
224 (211-C) A	North America	11
224 (211-C) B	North America	11
224 (211-C) C	North America	11
224 (211-C) D	North America	11
*224 (211-C) H	North America	11
224 (212-C) A	North Atlantic	12
224 (212-C) B	North Atlantic	12
224 (212-C) C	North Atlantic	12
224 (212-C) D	North Atlantic	12
*224 (214-C) H	Indian Ocean	14
224 (215-C) C	Australia	15
*224 (215-C) H	Australia	15

*Omega Lattice Tables for pairs involving station H (Japan) will not be usable until the station becomes operational. The on-air date will announced in the Notice to Mariners.

LORAN-C CHAIN DATA

The information on loran chains is provided primarily to indicate coverage areas. The information on U.S. Coast Guard chains is sufficient for use as the data base in a computerized solution for latitude and longitude from time differences. See the "Loran-C User Handbook" published by the Coast Guard (CG-462, Aug 1974) for spheroid and propagation information. The information on the U.S.S.R. chains is based on derived information. Before use is made of these systems for navigation, the data should be confirmed and refined.

Privately owned chains are presently in operation in the Gulf of Mexico and Java Sea, and planned for operation in the North Sea, Celtic Sea and Hudson's Bay. The USCG and USAF will be installing chains utilizing this same low power commercial equipment, to cover respectively, the St. Mary's River and Southwestern US test ranges. We are attempting to obtain further information.

The information on planned chains is tentative and must be confirmed with the owner or operator before use is made of the information. In particular, site locations are not confirmed. The names of towns indicate only general areas. Where a latitude and longitude are given, the site location is determined, but the final survey may not have been made.

Mediterranean Sea Chain - Rate 7990 (SLI)

Station Name	Location	Function Power	Coding Delay & Baseline Length
Simeri Chichi Italy	38°52'20.23"N 16°43'06.39"E	Master 250kW	- - - - - -
Lampedusa Italy	35°31'20.80"N 12°31'29.96"E	X Sec. 400kW	11,000μs 1755.98μs
Kargabarun, Turkey	40°58'20.22"N 27°52'01.07"E	Y Sec. 250kW	29,000μs 3273.23μs
Estartit, Spain	42°03'36.15"N 03°12'15.46"E	X Sec. 250kW	47,000μs 3999.76μs

Northwest Pacific Chain - Rate 9970 (SS3)

Station Name	Location	Function Power	Coding Delay & Baseline Length
Iwo Jima, Bonin Is.	24°48'04.22"N 141°19'29.44"E	Master 3.0 MW	- - - - - -
Marcus Island	24°17'07.79"N 153°58'53.72"E	W Sec. 3 MW	11,000μs 4284.11μs
Hokkaido, Japan	42°44'37.08"N 143°43'10.50"E	X Sec. 400 kW	30,000μs 6685.12μs
Gesashi, Okinawa	26°36'24.79"N 128°08'55.99"E	Y Sec. 400 kW	55,000μs 4463.24μs
Yap Caroline Is.	09°32'45.84"N 138°09'55.05"E	Z Sec. 3.0 MW	75,000μs 5746.79μs

North Atlantic Chain - Rate 7930 (SL7)

Station Name	Location	Function Power	Coding Delay & Baseline Length
Angissoq, Greenland	59°59'17.19"N 45°10'27.47"W	Master 1 MW	- - - - - -
Sandur, Iceland	64°54'26.07"N 23°55'20.41"W	W Sec. 1.5 MW	11,000μs 4068.07μs
Ejde, Faroe Islands	62°17'59.64"N 07°04'26.55"W	X Sec. 400 kW	21,000μs 6803.77μs
Cape Race, Newfoundland	46°46'31.88"N 53°10'29.16"W	Z Sec. 2 MW	43,000μs 5212.24μs

Norwegian Sea Chain - Rate 7970 (SH3)

Station Name	Location	Function Power	Coding Delay & Baseline Length
Ejde, Faroe Islands	62°17'59.64"N 07°04'26.55"W	Master 400 kW	- - - - - -
Bo Norway	68°38'06.55"N 14°27'48.46"E	X Sec. 250 kW	11,000μs 4048.16μs
Sylt, Germany	54°48'29.24"N 08°17'36.82"E	W Sec. 400 kW	26,000μs 4065.69μs
Sandur, Iceland	64°54'26.07"N 23°55'20.41"W	Y Sec. 1.5 MW	46,000μs 2944.47μs
Jan Mayen, Norway	70°54'51.63"N 08°43'56.57"W	Z Sec. 250 kW	60,000μs 3216.20μs

North Pacific Chain - Rate 5930 (SH7)

Station Name	Location	Function Power	Coding Delay & Baseline Length
St. Paul Alaska	57°09'12.10"N 170°15'07.44"W	Master 400 kW	- - - - - -
Attu, Alaska	52°49'44.40"N 173°10'49.40"W	X Sec. 400 kW	11,000μs 3875.17μs
Port Clarence Alaska	65°14'40.35"N 166°53'12.95"W	Y Sec. 1.8 MW	28,000μs 3068.97μs
Sitkinak, Alaska	56°32'19.71"N 154°07'46.32"W	Z Sec. 400 kW	42,000μs 3284.83μs

U.S. East Coast Chain - Rate 9930 (SS7)

Station Name	Location	Function Power	Coding Delay & Baseline Length
Carolina Beach, NC	34°03'36.50"N 77°54'47.29"W	Master 1 MW	- - - - - -
Jupiter, Florida	27°01'58.85"N 80°06'53.59"W	W Sec. 400 kW	11,000μs 2695.51μs
Cape Race, Newfoundland	46°46'31.88"N 53°10'29.16"W	X Sec. 2 MW	28,000μs 8389.57μs
Nantucket, Massachusetts	41°15'12.29"N 69°58'39.10"W	Y Sec. 400 kW	49,000μs 3541.33μs
Dana Indiana	39°51'08.30"N 87°29'12.75"W	Z Sec. 400 kW	65,000μs 3560.73μs
Wildwood New Jersey	38°56'58.59"N 74°52'01.94"W	Test Sec. 400 kW	82,000μs 2026.19μs

Central Pacific Chain - Rate 4990 (S1)

Station Name	Location	Function Power	Coding Delay & Baseline Length
Johnston Is. Hawaii	16°44'43.85"N 169°30'31.63"W	Master 300 kW	- - - - - -
Upolo Point, Hawaii	20°14'50.24"N 155°53'08.78"W	X Sec. 300 kW	11,000μs 4972.38μs
Kure, Midway Is.	28°23'41.11"N 178°17'29.83"W	Y Sec. 300 kW	29,000μs 5253.08μs

Maritimes (test) Chain - Rate 5990 (SH1), USCG

Station Name	Location	Function Power	Coding Delay & Baseline Length
Caribou, Maine	46°48'27.90"N 67°55'37.97"W	Master 300 kW	- - - - - -
Nantucket, Massachusetts	41°15'12.29"N 69°58'39.10"W	X Sec. 400 kW	
Cape Race, Newfoundland	46°46'31.88"N 53°10'29.16"W	Y Sec. 2 MW	

West Coast Chain, operational 1/77

Station Name	Location	Function Power	Coding Delay & Baseline Length
Fallon, Nevada	39°33'18"N 118°49'40"W	Master 500 kW	
Moses Lake Washington	47°03'N 119°40'W	Sec. 2 MW	
Middletown, California	38°47'07"N 122°29'40"W	Sec. 500 kW	
Searchlight, Nevada	35°19'18.37"N 114°48'14.00"W	Sec. 1 MW	

Vancouver Chain, operational 1/77

Station Name	Location	Function Power	Coding Delay & Baseline Length
Williams Lake, B.C.	51°58'N 122°22'W	Master 500 kW	
Shoal Cove, Annette, AK	55°26'N 131°15'W	Sec. 1 MW	
Moses Lake, Washington	47°03'N 119°40'W	Sec. 2 MW	

Gulf of Alaska Chain, operational 1/77

Station Name	Location	Function Power	Coding Delay & Baseline Length
Tok Junction, Alaska	63°19'28.06"N 142°48'58.05"W	Master 1 MW	
Narrow Cape, Kodiak, AK	57°26'N 152°20'W	Sec. 500 kW	
Shoal Cove, Annette, AK	55°26'N 131°15'W	Sec. 1 MW	

Western USSR Chain - Rate 8000 (SLO)

Station Name	Location	Function Power	Coding Delay Baseline Length
Oriol	53°56'N 36°05'E	Master 500 kW	- - - - - -
Petrovavodesk	61°48'N 34°19'E	W Sec. 500 kW	10,000μs
Kuibychev	53°11'N 49°46'E	X Sec. 500 kW	25,000μs
Simferopol	44°58'N 32°02'E	Y Sec. 500 kW	50,000μs
Baranovichi	53°08'N 26°01'E	Z Sec. 500 kW	65,000μs

St. Mary's River - Rate 4970 - USCG, Operational Fall 1975

Station Name	Location	Function Power	Coding Delay & Baseline Length
Gordon Lake Ontario, Canada	46°24'30"N 83°52'00"W	Master 100W	
Johnswood Drummond Is., Michigan	45°57'20"N 83°37'15"W	X Sec. 100W	
Pickford, Michigan	46°03'54"N 84°21'43"W	Y Sec. 100W	
Gros Cap Ontario, Canada	46°36'00"N 84°30'00"W	Z Sec. 100W	

Gulf of Mexico Chain, operational 1/78

Station Name	Location	Function Power	Coding Delay Baseline Length
Malone, Florida	30°59'38"N 85°10'11"W	Master	
Raymondville, Texas	26°31'54"N 97°49'58"W	Sec.	
Grangeville, Louisiana	30°43'34"N 90°49'41"W	Sec.	
Jupiter, Florida	27°01'58.85"N 80°06'53.59"W	Sec. 400 kW	
Carolina Beach, NC	34°03'46.50"N 77°54'47.29"W	Sec. 1 MW	op 7/79

Central European Chain - Rate 3970 (L3), USAF, Loran-D

Station Name	Location	Function Power	Coding Delay & Baseline Length
Baumholder, Germany	49°36'18.813"N 07°19'38.277"E	Master 5 kW	- - - - - -
Hokes Mook, Germany	53°39'13.867"N 08°43'46.508"E	X Sec. 5 kW	11,000μs
Eching, Germany	48°15'48.929"N 11°37'49.263"E	Y Sec. 5 kW	25,000μs

Fort Hood Chain - Rate 4970 (S3), US Army, Loran-D

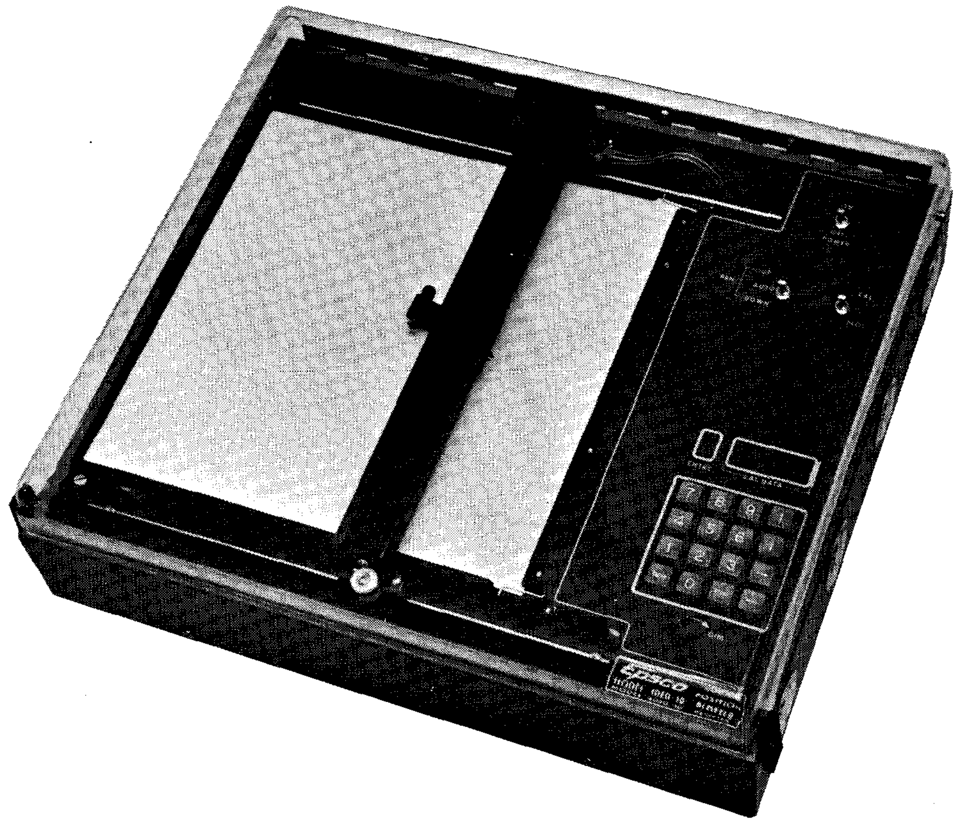
Station Name	Location	Function Power	Coding Delay Baseline Length
Summerville, Texas	30°20'11.966"N 96°32'32.826"W	Master 150 W	- - - - - -
Canyon Lake, Texas	29°54'22.512"N 98°13'40.627"W	X Sec. 150 W	11,000μs
Navarro Mill Dam, Texas	31°57'36.960"N 96°41'18.163"W	Y Sec. 150 W	23,000μs

Eastern USSR Chain - Rate 5000 (SO)

Station Name	Location	Function Power	Coding Delay Baseline Length
Okhotsk			
Vladivostok			
Kamchatka Penninsula			

Gulf of Mexico - Rate 4864 - Industrial Radiolocation Service

Station Name	Location	Function Power	Coding Delay Baseline Length
Perry, LA	29°56'02".416N 92°09'22".019W	Master 200W	
Triumph, LA	29°20'27".564N 89°27'59".844W	X Sec. 100W	
San Louis Pass, Texas	29°05'52".747N 95°06'30".133W	Y Sec. 100W	



RECENT LORAN RELATED PAPERS

One of the objectives of this Journal is to provide a forum for dissemination of state-of-art concepts of the loran system. In order to achieve this objective, the editorial committee has compliled a list of papers published in various journals and conferences over the past year. Every effort has been made to make this list complete and if we have missed any, we apologize. We urge members to send us the abstract of papers they may have recently published or that may be of value to the community.

NEW DEVELOPMENTS IN RADAR AND RADIO SENSORS FOR AIRCRAFT NAVIGATION, Walter R. Fried; IEEE Transactions on Aerospace and Electronic Systems, Vol. AES-10, No. 1, January 1974

Recent developments in airborne Doppler and ground mapping navigation radars and ground and satellite based radio-systems are described. Simultaneous lobing and slope tracking techniques can remove the well-known Doppler sea bias error in fast and slowly moving vehicles. Doppler velocity information can be extracted from coherent forward-looking mapping radars, and high position fixing accuracy can be achieved by synthetic aperture radars. In radionavigation systems, such as loran, Omega, and satellite systems, direct-ranging and differential techniques greatly reduce the geometric dilution and propagation effects which have plagued conventional radionavigation systems. The advantages gained by mixing of the data from these and other navigation sensors in a digital multisensor system are discussed and approaches for processing these data are suggested.

AN AUTOMATIC TIMING RECEIVER SYSTEM BASED ON THE LORAN-C NAVIGATIONAL NETWORK, Goran P. R. Netzler; IEEE Transactions of Aerospace and Electronic Systems, Vol. AES-10, No. 3, May 1974

This paper describes some new concepts in dealing with the circuitry for Loran-C automatic timing systems. The conventional analog techniques associated with phase-adjusting networks have been replaced by an incremental digital phase-shifting device. The Loran-C period generator includes facilities for delay compensation by means of an epoch monitor producing a 1-Hz output coincident with the master station TOC (time of coincidence). The required initial time information has to be accurate within + 20ms. The automatic format identification and decoding equipment together form a system which takes into account the information of every Loran-C pulse. Owing to the use of digital signal treatment, the synchronization accuracy is limited only by the resolution of the incremental phase shift. The automatic cycle selection device is based on sampling techniques where the derivative of the envelope is calculated. The time of coincidence has to be precalculated and fed into the thumbwheel memory of the epoch monitor, which is automatically initiated when the synchronizing operations are concluded. For VLBI purposes and transcontinential use, the accuracy of this system will be better than 1 μs when post corrections, supplied by the U.S. Naval Observatory, are taken into account.

THE BEHAVIOUR OF LORAN-C GROUNDWAVES IN MOUNTAINOUS TERRAIN by Douglas C. Pearce and John W. Walker; Proceedings of the NATO AGARD Electromagnetic Wave Propagation Panel Symposium, Netherlands, March 1974

The behaviour of both the horizontal H-component and the vertical E-component of a Loran-C ground wave has been measured in the vicinity of an isolated terrain anomaly, Nittany Mountain, near State College, Pennsylvania. Time difference measurements were made with Army manpack receivers at 42 sites of good geodetic control in the area. The magnetic component of the ground wave was sensed with a ferrite array antenna while the vertical component was sensed with a whip antenna. Significant local warpages of the loran grid, apparently associated with the presence of the mountain, were observed with each antenna configuration. However, the warpage patterns were not identical for each field component, implying a somewhat different perturbation of each polarization component by the terrain anomaly. These results suggest that a field calibration of a loran grid in a region of a terrain anomaly will depend somewhat on the antenna type used.

RECENT ANALYTICAL INVESTIGATIONS OF ELECTROMAGNETIC GROUND WAVE PROPAGATION OVER INHOMOGENEOUS EARTH MODELS, James R. Wait; Proceedings of the IEEE, Vol. 62, No. 8, August 1974

A consolidated review is presented of recent analytical studies of electromagnetic waves propagating over inhomogeneous surfaces. Emphasis is on smooth boundaries that can be characterized by a local surface impedance. A general integral equation formulation is developed for this situation. A number of special cases are then considered and various methods of solution are described. Various concrete examples are presented, particularly with regard to effects that occur at coastlines. Extensions to certain types of terrain features are also treated using the closely related mode-matching method. Some controversial aspects of very recent work on the subject are described briefly.

MEETING THE MARITIME REQUIREMENTS IN UNITED STATES WATERS, D.T. Haislip and A. Goldsmith; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 2, Summer 1974

In the United States, Statute 14 USC 81 assigns responsibility for aids to the U.S. Coast Guard. Established aids provide the user with position determination capabilities—to avoid hazards, reach destination or to maintain a fixed location. The maritime environment is divided into the high seas, the coastal/confluence zone (CCZ), and the harbor/harbor entrance zone (HHE). The major unsatisfied area is the coastal confluence zone and the Department of Transportation (DOT) has recommended that this zone be given priority consideration by providing it an adequate radionavigation aid system. Taking into account accuracy, coverage operating experience, availability of equipment and cost, it has been proposed that Loran-C be the designated system. A portion of the system is already in existence and will remain so for considerable time in response to Department of Defense (DOD) requirements. Installation of Loran-C to cover the entire Coastal Confluence Zone and the Great Lakes, will enable U.S. Government funding of the existing Loran-A System to be phased out in a reasonable length of time.

FULLY AUTOMATIC LORAN-C FOR COMMERCIAL AIRLINES, J. Hopkins; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 2, Summer 1974

This paper addresses one of the alternatives being considered by U.S. Airlines as a replacement for Loran-A in the event this service is discontinued. Loran-C coverage exists over a large portion of the airline route structure and the current evaluations are aimed at determining the suitability of Loran-C for airline service. Of special interest is the performance of new low cost fully automatic cycle matching Loran-C receivers compared with existing envelope matching Loran-A/C receivers.

A REVIEW AND APPLICATIONS OF VLF AND LF TRANSMISSIONS FOR NAVIGATION AND TRACKING, J.M. Beukers; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 2, Summer 1974

A review of existing Very Low Frequency and Low Frequency transmissions that can be used for navigation, position and location, tracking and rendezvous is given. This includes the USSR Loran-C system, the USSR Very Low Frequency navigational aid (VLF), the international Omega system, the U.S. Navy VLF communications system, and those transmissions employed in the international time dissemination network. The characteristics of these various systems are discussed in relation to various applications. The potential and limitations to accuracy of the various systems are presented.

A number of applications are described. In particular, the use of retransmission techniques for positioning of remote objects and differential techniques for enhancing accuracy are discussed.

A piece of equipment is described which has been designed to utilize signals transmitted by the various navigation systems and an intermix of these transmissions. The simultaneous use of two or more systems to remove ambiguity and determine absolute position is described. The paper concludes that the VLF and LF transmissions are compatible and should co-exist and are not necessarily redundant.

Several references are given which include descriptions of the various systems and studies that have been performed analyzing and comparing performance.

PROPAGATION OF A LORAN PULSE OVER IRREGULAR, INHOMOGENEOUS GROUND, J. Ralph Johler and Samuel Horowitz; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974

A numerical solution of an integral equation representation of the ground wave over irregular, inhomogeneous earth has been employed to calculate amplitude and phase of the propagated continuous wave as a function of frequency. A computer simulation again using numerical methods, transforms this result to the time domain yielding the impulse response. Then the impulse response is convolved with the Loran-C pulse function, that has been transformed from the time domain to the frequency domain. Our final result demonstrates the propagation of both pulse envelope and the cycles under the envelope in the presence of irregular, inhomogeneous ground. Although the Loran-C pulse propagation has been studied in detail, the method is applicable to the propagation of most any shape pulse over irregular, inhomogeneous ground. In the particular case of the Loran-C pulse, we conclude that the discrepancy or time difference between the pulse envelope and cycle is a unique function of the particular type of terrain over which the wave propagates, and it is, at the present state of the art, necessary to introduce such terrain into the propagation theory to give a unique prediction of the pulse propagation time.

LORAN C AVM URBAN REPEATABILITY, R. Stapleton; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

A brief history of the results of previous Loran-C Automatic Vehicle Monitoring System Test Demonstrations is presented. The test method is then examined in view of the characteristics of the Loran grid in an urban center. The concept of repeatability and repeatability accuracy is then presented and some conclusions are drawn. Finally a test is then presented and some conclusions are drawn. Finally a test program is structured which will measure the repeatability accuracy of Loran-C in an urban environment. The results of such a test are then presented and explained.

REAL-TIME COMPENSATION OF LORAN C/D PROPAGATION VARIATIONS BY PROPORTIONAL CONTROL, Robert L. Frank and David L. McGrew; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

Variations in Loran measurements have been observed which are ascribed to weather effects. By the use of an algorithm based on assuming a uniform variation in velocity of propagation in the service area plus measurements of time-difference at master and secondary stations, the time of the Loran transmissions can be controlled to minimize the variations in a selected portion of the service area. Data is presented showing variations resulting with and without control; with control, the effect is quite similar to the use of a local monitor. Methods of computer automation of control are described which minimize the need for communication between stations, yet provide real-time correction without recourse to weather observations.

PROGRESS REPORT ON THE GROUP/PHASE TEST, James A. Perschy and Richard R. Smith; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

This paper reports the progress to date on implementation of the Group/Phase Test which described in a paper read to the 2nd Annual WGA Convention. The test is designed to explore the hypothesis that accurate knowledge of the envelope-to-cycle difference, measured at the receiver, can be used to make real-time corrections for the secondary phase factor. Included are descriptions of the test instrumentation, the expected quality of the data and the format of data tapes.

SPATIAL AND TEMPORAL ELECTRICAL PROPERTIES DERIVED FROM LF PULSE GROUND WAVE PROPAGATION MEASUREMENTS, Robert H. Doherty; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

Loran-C/D signals do not propagate precisely at the speed of light. They are slowed slightly by earth irregularities, earth impedance surface refractive index and lapse rate of the refractive index. This slowing of the loran propagation time is commonly referred to as secondary phase correction.

The secondary phase correction can be measured by observing the phase at a known location. The secondary phase can be predicted from theoretical propagation computer programs. This paper attempts to show our progress in relating the theoretical predictions to the measured variations.

LORAN-C PHASE CODE AND RATE MANIPULATION FOR REDUCED CROSS-CHAIN INTERFERENCE, Cdr. William F. Roland; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

This paper provides a tutorial discussion on the methods used in studying cross-chain effects. The discussion includes assumed definitions of Loran-C signals, a discussion of cross-correlation, and the use of cross correlation in the search and settle processes.

These principles are then used to demonstrate useful features of the Loran-C signals, such as the ability of receivers to discriminate against long delayed skywaves. Then the techniques are used to demonstrate that a certain class of signals can be constructed which has a phase code and group repetition interval such that the cross correlation with the sampling of a receiver tracking standard Loran-C signals is zero.

The recommendation is made that privately operated Loran-C chains be required to utilize these codes.

HOW TO HARVEST THE FULL POTENTIAL OF LORAN-C, Leo F. Fehlner; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

It is unfortunate that Loran-C was not named "Accunav," because who would suspect that a LOng RAnge Navigation system could be capable of the ACCUrate NAVigation required for aircraft final approach to a runway or ship navigation in a river? Nevertheless, Loran-C has been used successfully for over the last few years, and recently, the channel keeping ability of Loran-C has been demonstrated in a Coast Guard cutter. This paper describes the potential of Loran-C for providing precision navigation and time service. It also touches on the improvements required in user equipment to exploit this potential.

PREDICTED PERFORMANCE OF AN OPTIMALLY INTEGRATED LORAN/INERTIAL AIRCRAFT NAVIGATION SYSTEM, Joseph F. Kasper, Jr., Daniel E. Gentry and Joseph A. D'Appolito; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

Detailed statistical models for the errors affecting an integrated Loran/Inertial navigation set are presented; included in the modeled error sources are loran receiver noise and propagation anomalies, inertial system sensor errors and gravitational uncertainties. Based on these models and the assumption of optimal Kalman integration, predictions of rms system position, velocity and heading errors are obtained for a flight scenario typical of tactical aircraft operations. These predictions can serve as a lower bound on the performance of any Loran/Inertial navigation set. Results are given in terms of a system error budget, to facilitate identification of dominant error contributors. Analyses which treat the question of sensitivity to proper error modeling are also included.

PERFORMANCE OPTIMIZATION OF LINEAR LORAN RECEIVERS OPERATING IN A NON-GAUSSIAN ATMOSPHERIC NOISE ENVIRONMENT, Larry Postema; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

This paper investigates the characteristics of non-gaussian atmospheric noise, and its effects on the performance of linear loran receivers. The characteristics of atmospheric noise observed at Eglin AFB, Florida, during July of 1974, are presented. These are compared to the characteristics of atmospheric noise observed by another investigator on August 11, 1971 at Wildwood, New Jersey, just prior to the onset of a severe thunderstorm. The effects of observed atmospheric noise on receiver performance in both the Search and Synchronization, and Track modes is investigated. A scheme for improving the receiver track performance in atmospheric noise is presented along with the results of an IBM 370 digital simulation used to optimize the referenced scheme. Laboratory investigations were conducted to substantiate the results of simulation. These investigations used state-of-the-art AN/ARN-101 Loran Receiver equipment, a dynamic loran signal simulator, and an LSI built atmospheric noise source. The results of these investigations are presented. Finally, a means of reducing the effects of atmospheric noise on the receiver operation in the Search and Synchronization mode is presented along with the results of related laboratory investigations.

A SIMPLIFIED ALGORITHM FOR ACCURATE AIRBORNE COMPUTATION OF LORAN SECONDARY PHASE, Dr. Ronald J. Fredricks; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

This paper describes a simplified algorithm for improving the absolute accuracy of Loran-C radionavigation that is compatible with a small airborne data processor. The technique involves the use of a polynomial fit of loran secondary phase to the variables distance, altitude, vertical atmospheric lapse factor, ground index of refraction and effective wave impedance, Δ_E. The latter quantity was introduced by Johler of ITS to account for the fact that the propagation paths are, in general, over irregular inhomogeneous ground. A second set of polynominals maps Δ_E in terms of latitude and longitude for each station over a given area which may be 10,000 sq. mi. or larger. Some a-priori data points are required. These may be measured empirically as time differences vs. positions and/or calculated on a large digital computer using the wave integral equation and the known path topologies. Accurate calculation of the secondary phases using the above fitting polynominals in turn allows the subsequent loran-to-position coordinate conversion to be extremely accurate on an absolute basis. A demonstration of this technique in the Eglin Air Force Base vicinity using a-priori ground measurements give a prediction capability standard deviation of 0.18 μs on either of the time differences. Comparison of recent TD airborne data from the ARN/101 flight tests with the predicted values verified this capability in practice.

LORAN-C FOR EMERGENCY COMMUNICATIONS, Walter N. Dean; **Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.**

Loran-C is presently in use for navigation over large areas of the North Atlantic and Pacific. The U.S. Department of Transportation announced in May the adoption of Loran-C for navigation in the coastal confluence of the U.S., and plans to install Loran-C transmitters all around the continental U.S.

Emergency communications in the U.S. presently consists of the National Warning System (NAWAS) utilizing telephone lines. A new system, DIDS, has been proposed, which would use a number of high power low frequency transmitters to communicate with special receivers.

The Loran-C transmitters to be installed could be used to serve as an emergency communications system in a number of ways. A low data rate system, which can use extremely simple receivers, was demonstrated by the Coast Guard ten years ago. It operates by dropping alternate pulses in each group of eight.

Another system, nicknamed Clarinet Pilgrim, transmits teletype information by pulse-position modulation of the Loran-C signals. Such a system could be used to broadcast emergency teletype messages.

It is also shown that it is possible to broadcast voice utilizing the Loran-C transmitting antennas without interference to or from the Loran-C transmissions.

SEMI-AUTOMATED ORIENTATION by James T. Doherty, Jr. Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

The United States Coast Guard operates the United States' domestic and overseas Loran-A and C radionavigation systems. Beginning in the mid-1960s a long range program, based on atomic standard oscillators and solid state technology, has been conducted to improve these services while simultaneously reducing operating costs. A major milestone in this program was reached in 1974 with the first field evaluation of semi-automated Loran-A and C equipment. This equipment, a hybrid of solid state low-level signal generation, timing and control systems with older vacuum tube transmitters allows most loran stations to operate without "live" watchstanding.

The equipment performs four basic functions: the three-fold redundant oscillators are cross-checked for phase errors, the six-fold redundant signal timing clocks are cross checked for error, the radiated signal is checked for minimum power and parameter tolerances, and all monitoring equipment is integrated into a master status/alarm panel. In addition, several routine equipment adjustments can be entered by the operator controlling the system from a remote location.

Our report describes these equipments, their method of operation, and the on-line operating experience gained to date.

LOW COST NAV PROCESSING FOR LORAN-C by Arthur R. Tuppen; Presented at the 3rd Annual Convention of the Wild Goose Association, N.J., October 1974.

Investigations and development of a Loran feasibility model, which were conducted to determine the impact of microcomputer concepts on performance and cost of radionavigation equipment, have demonstrated that the performance requirements for both austere and sophisticated Loran-C or Omega users to be satisfied within the economic value to these users. Continuing development of MOS/LSI and bi-polar semiconductor technology has provided microcomputer sets, central processor units and compatible semiconductor memories whose architecture is in accordance with the requirements for radionavigation processing. Indications are that microcomputer sets in accord with military standards will be in production in 1975. The result of this feasibility demonstration was a microprocessor configuration which served as a base for consideration of a low cost Omega navigator and a combined Loran/Omega navigator. The resultant configurations for these navigations has the potential to satisfy user cost objectives for either Loran-C or Omega navigation equipment, and a combined navigator functions such as conversion to latitude and longitude, and steering can be provided at minimal cost to the user.

RADIONAVIGATION ACTIVITIES WITHIN THE DEPARTMENT OF DEFENSE, R.N. Parker; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 2, Summer 1974

The opportunity to significantly improve radionavigation capability is discussed. The main issues concern the military requirement for exploiting this technical opportunity and of the several viable alternatives which should be pursued. The advantages of a satellite-based system are analyzed and compared with other technical approaches. The paper suggests that a satellite-based system offers enough potential capability and relatively low risk to justify a feasibility demonstration program.

PRACTICAL ELECTRONIC POSITION FIXING FOR SMALL CRAFT, R.W. Merriam; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 2, Summer 1974

The uncertainty of the future of a suitable electronic position fixing system for small craft is reported. The importance of the small craft part of the maritime community is established. The six essential parameters of a suitable small craft electronic position fixing device are given. Five systems, Satellite, Inertial, Omega, Loran-C, and Loran-A are examined for their ability to satisfy these required parameters. Loran-A best meets the requirements, Loran-C is a close second.

LORAN-C EXPANSION: IMPACT ON PRECISE TIME/TIME INTERVAL, LCDR J.F. Roeber; Proceedings of the Sixth Annual Precise Time and Time Interval (PTTI) Planning Meeting, Washington, D.C., December 1974

On 16 May 1974, the Secretary of Transportation and Commandant of the Coast Guard announced that Loran-C had been chosen as the navigation system to serve the U.S. Coastal Confluence Zone.

At the present time, reliable CONUS Loran-C groundwave timing coverage extends westward only about as far as Boulder, Colorado. This paper illustrates the groundwave hyperbolic and timing coverage which will result from the planned CONUS expansion. Time frames are provided.

While not directly related to the subject of the paper, a status report on the planned reduction in Loran-C PTTI tolerances is presented.

DESIGN AND OPERATION OF A LORAN-C TIME REFERENCE STATION, Kenneth Putkovich; Proceedings of the Sixth Annual Precise Time and Time Interval (PTTI) Planning Meeting, Washington, D.C., December 1974

The purpose of this paper is to explore some of the practical questions that arise when one decides to use Loran-C in a time reference system. Since the subject of Loran-C PTTI has been covered extensively in the literature (see bibliography), a minimum of time is devoted to the concept and implementation of precise time on Loran-C. An extensive effort is made to provide practical information on establishing and operating a reference station. This paper covers four important areas in this regard.

1. The design, configuration and operational concepts which should be considered prior to establishing a reference station using Loran-C.

2. The options and tradeoffs available regarding capabilities, cost, size, versatility, ease of operation, etc., that are available to the designer.

3. What measurements are made, how they are made, and what they mean.

4. The experience the U.S. Naval Observatory Time Service Division has had in the design and operation of such stations.

In general, an attempt is made to answer basic questions which arise when Loran-C is being considered for use in a time reference system.

A GENERAL DESCRIPTION OF LORAN-C: PRESENT AND POTENTIAL APPLICATIONS, Robert H. Doherty; Proceedings of the Sixth Annual Precise Time and Time Interval (PTTI) Planning Meeting, Washington, D.C., December 1974

Loran-C is a low frequency (100 kHz) pulse navigation system. The pulse format and phase stability of the system are of paramount importance for both navigation and time synchronization using this system.

The need for a low frequency loran system was born out of the short comings of the standard loran system used during World War II. The first successfully tested predecessor to Loran-C was CYTAC, tested by the U.S. Air Force in the early and mid 1950's. This was a tactical bombing system.

Present Loran-C installations, operated by the U.S. Coast Guard cover much of the northern hemisphere. A recent government wide decision has declared that Loran-C will be the U.S. coastal confluence navigation system for the immediate future. Therefore Loran-C stations are presently being installed or planned to cover the entire U.S. coast line.

In addition to standard navigation and timing applications of Loran-C, auxiliary navigation and timing applications are presently being considered or are potentially available. These include differential Loran-C for high precisioning, urban vehicle or residence location by the AEC, the FBI and the Census Bureau, off shore drilling, and collision avoidance by ships or aircraft.

Finally the unique nature of the Loran-C pulse transmissions allows one to separate ground wave and skywave transmission. Also the pulse provides a transient capable of validating transient propagation theory. Therefore the Loran-C transmissions have proven to be very effective diagnostic tools for testing propagation theories. Continued efforts in this direction will undoubtedly lead to improved prediction and calibration procedures for use with all Loran-C systems.

CURRENT DEVELOPMENTS IN LORAN-D, R.L. Frank; Navigation: Journal of the Institute of Navigation, Vol. 21, No. 3, 1974

Loran-D is a highly accurate pulsed hyperbolic navigation system similar to and compatible with Loran-C, but designed for military tactical use. The helicopter—transportable—transmitter stations have quickly erectable antennas using new tower technology. A signal range over half that of Loran-C is achieved by the fortunate propagation characteristics of 100 kHz waves, by a modified compatible signal format and by improved transmitter solid state technology. Deployments of the stations in the U.S. and Europe are described. The potential uses of Loran-D include: gap filler in Loran-C coverage, a transportable survey system, and long range navigation coverage for many civilian applications.

HOW TO HARVEST THE FULL POTENTIAL OF LORAN-C, L.F. Fehlner and T.A. McCarty; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 3, 1974

This paper describes the potential of Loran-C for providing precision navigation and time service. It also touches on the improvements required in user equipment to exploit this potential.

With improved trasmitters and improved receivers, taken together, a single fix accuracy can be expected to be less than 14 meters, CEP; the 14 meter value occurring at the outer fringes of the service area (about 1400 kilometers from the farthest transmitter). The improvements required of the transmitters are (1) accurate control of the transmitted wave form, and (2) accurate control of the time of occurrence of the zero crossings of the carrier. Improvements required of the receivers involve (1) more thorough rejection of noise, (2) increase in internal precision, (3) lower probability of false cycle identification, and (4) implementation of the group/phase velocity technique of distance measuring.

Loran-C service can include distribution of epoch time to stationary users with an accuracy of 2 microseconds; and to moving users with an accuracy of 5 microseconds (both 3 standard deviations).

THE IMPACT OF THE CHOICE OF FREQUENCY AND MODULATION ON RADIONAVIGATION SYSTEMS, J.R. Johler; Navigation: Journal of The Institute of Navigation, Vol. 21, No. 3, Fall 1974

The choice of frequency for radionavigation is a subject of considerable depth and is inextricably intertwined with requirements for range, accuracy, reliability, cost and impact on competitive services using radiowaves. The basic information for passing judgment on these items comprises the limitations imposed by nature on the system. These limitations are the laws of physics governing the propagation of radiowaves.

We note in particular that great ranges and hence large coverage areas can be obtained at opposite ends of the spectrum in the OMEGA and SATELLITE systems. We find that great accuracy is accomplished with the groundwave propagation mechanism in the form of Loran-C and Loran-D. We observe that the choice of modulation is critical if high accuracy of position is an objective or requirement.

THE IMPACT ON CANADA OF THE UNITED STATES DECISION TO DEPLOY LORAN-C FOR THEIR COASTAL AND CONFLUENCE REGION, R.M. Eaton; Canadian Aeronautics and Space Institute Sumposium on Navigation & Resources Management, Ottawa, November 1974

Three years of experience at the Bedford Institute of Oceanography have shown that range-measuring Loran-C is a precise, long-range method of survey positioning. Results indicate that in hyperbolic mode, as a standard radio aid to navigation, it will give an average position repeatability of $\pm$250 m and geographic accuracy (predictability) of $\pm$1200 m (conservative estimate, at 95% confidence level). The signal can be tracked at 1200 n.m. over sea water and about 1000 n.m. over land. Cycle ambiguity can be resolved at 750 n.m. over water; further tests are needed to establish the maximum range for cycle resolution at sea and on land, and especially in the Arctic.

A very preliminary review of the Canadian requirement for navigation aids suggests that 200 m repeatability and 1000 m geographic accuracy will be needed. The most immediate urgency is on the Atlantic Continental Shelf and for exploration in the Arctic. A thorough and comprehensive study is recommended to establish users' needs over the next 15-20 years, and then to determine the most effective navaid combination, carrying out technical tests as necessary.

Loran-C is one candidate to fill the Canadian requirement, and Canada has perhaps a year to decide how to interface with the imminent expansion of Loran-C by the United States Coast Guard on the Pacific and Atlantic Coasts and over the Great Lakes.

DIRECT-RANGING LORAN MODEL IDENTIFICATION AND PERFORMANCE PREDICTIONS, Bahar J. Uttam, Joseph A. D'Appolito; IEEE Transactions of Aerospace and Electronic Systems, Vol. AES-11, No. 3, May 1975

With the availability of modern data processing techniques and low-cost stable time references, the use of loran in a direct-ranging mode offers certain potential advantages. In order to generate reliable direct-ranging loran (DRL) performance projections and system designs, however, accurate system error models are required. This paper first describes the processing of airborne flight data from a DRL receiver to identify models for significant DRL system errors. These models are then used in a Kalman filter covariance simulation to generate performance predictions for an optimally integrated DRL system. Comparisons with conventional hyperbolic loran are also given. DRL is shown to be capable of substantially improved position accuracy over that of conventional hyperbolic loran, especially in regions of poor geometry. A stationary ground-align technique for improving DRL performance is also discussed.

VEHICLE LOCATION WITH LORAN-C, Willie Vogeler; Carnahan Conference on Crime Countermeasures, Louisville, Kentucky, May 1975

Implementation of the Loran-C radionavigation system on a nationwide basis was directed by the U.S. Government on 16 May 1974. This action will expand signal coverage to include almost all of the United States. With expanded signal service areas, Loran-C now becomes a leading candidate for rural, suburban and urban vehicle monitoring capability. Fifteen years of experience by sea and air users has proven Loran-C to be reliable and accurate for determining location.

OCEANIC AIR ROUTE NAVIGATION WITH ENVELOPE MATCH LORAN-C, Patrick R.J. Reynolds, Report No. FAA-RD-74-205, Department of Transportation, Washington, D.C., December 1974

A Loran-C envelope matching receiver (Edo Model 600T) was evaluated as a potential replacement for Loran-A. The unit was installed on a Pan American 707 aircraft and data were collected primarily on North Atlantic routes. Results of this program indicate that where Loran-C coverage exists in adequate availability and geometry it may be considered a conditionally acceptable substitute for Loran-A as a pilot-operated updating reference for Doppler navigation systems on oceanic air routes.

OCEANIC AIR ROUTE NAVIGATION WITH CYCLE MATCHING LORAN-C, William S. Gillis, Report No. FAA-RD-75-74, Department of Transportation, Washington, D.C., January 1975

A Loran-C cycle matching receiver (Decca Model ADL-81) was evaluated in line service to determine its qualification as a potential replacement for Loran-A. The receiver and associated components were installed on an Eastern Air Lines L1011 aircraft and data were collected by a qualified navigator on the routes between the U.S. Mainland and Puerto Rico. Results of the program indicate that cycle matching Loran-C is a satisfactory substitute for Loran-A where usable signals are available. The equipment under evaluation, provided excellent accuracy and required less flight crew attention than is normally demanded by the present Loran-A systems.

LORAN ASSOCIATED BUSINESSES

The following is a list of businesses which relate to Loran interests. Every effort was made to ensure that no one was left off the list, however the response to our newsletter request for company names, contacts, and brief descriptors was poor. When no response was received, we attempted to get the information by letter or phone. If this was unsuccessful, we named a WGA member employed by the company as a contact and then made up as good a descriptor as possible within our knowledge. Anyone desiring to add, change, or delete a listing in the next edition of the Journal should contact the Editor as soon as possible.

Advanced Technology Systems
2425 Wilson Blvd.
Arlington, VA 22906

Aerospace Systems, Inc.
One Vine Brook Park, Suite 202
Burlington, MA 10803
John Zvara, 617-272-7517
Analysis, computer simulation and flight test of navigation guidance, control and display systems.

Amecom Div. Litton Systems Inc.
5115 Calvert Road
College Park, MD 20720
Claude Pasquier, 301-864-5600
Development and manufacture of electronic systems including radionavigation transmitting and receiving systems.

Analytical Systems Engineering Corp.
25 Ray Ave.
Burlington, MA 01803
Michael B. Rukin, 617-272-7910
Provide systems engineering services in the fields of communication and navigation.

Austron, Inc.
1915 Kramer Lane
Austin, TX 78758

Beukers Laboratories Inc.
30 Orville Drive
Bohemia, NY 11716
John M. Beukers, 516-567-5100
Development and manufacture of radiosonde and radionavigation specializing in retransmission and remote tracking.

Cambridge Engineering
P.O. Box 66
Cambridge, VT 05444
Martin C. Poppe, Jr., 802-644-5196
Electronic Systems, consultation and development.

Collins Radio Company
Dallas, TX 75207
Fred J. Spencer, 214-690-5193
Manufacture and sales of airborne radio equipment, including the AN/APN - 199 Loran-C receiver.

Communications Associates, Inc.
200 McKay Road
Huntington Station, NY 10801
Gerald A. Gutman, 516-271-0800
Manufacture and sales of marine communications and navigation systems.

CRDL
P.O. Box 1056
Boulder, CO 80302
Robert Doherty
Consultants in radiowave propagation.

Computing Devices Company of Canada
P.O. Box 8508
Ottawa, Ontario, Canada
Sale of loran and Decca Navigator systems.

Dahl Loran Service
46 No. Water Street
New Bedford, MA 02740
Harold Dahl, 617-997-7961
Loran sales and service for vessels and aircraft, consultant for users and manufacturers.

Decca Survey Systems, Inc.
P.O. Box 22397
Houston, TX 77027
C.D. Paget-Clarke, 713-783-8220
Radionavigation services for hydrographic survey.

Digital Marine Electronics Corporation
Civil Air Terminal
Bedford, MA 01730
Charles J. Malaquias, Jr., 617-274-7130
Manufacturers of marine electronic equipment including Loran-A and Loran-C receivers.

EDO Commercial Corporation
65 Marcus Drive
Melville, NY 11746
R.A. Pasciuti, 516-293-4000
Manufacturers of seaplane floats, airborne Loran systems, solid-state chronometers, R-NAV, ground proximity warning systems and VOR/DME/ILS systems.

E-Systems, Inc.,
P.O. Box 6030
Dallas, TX 75222
Johnnie Walker, 617-861-9050
Intelligence/Recce, command/control, electronic warfare, communications, guidance, controls and navigation, aircraft overhaul and modification.

EPSCO, Inc.
411 Providence Highway
Westwood, MA 02090
Bernard Ambroseno
Manufacture of electronic systems including Loran-C receivers, simulators, and guidance devices.

Electro-Nav, Inc.,
1201 Corbin Street
Elizabeth Marine Terminal
Elizabeth, NJ 07201
Sales, service and installation of marine electronic systems.

Robert L. Frank
16500 North Park Drive, Apt. 720
Southfield MI 48075
Tele: 313-559-8208
Electronic systems consultant.

Griffith Marine Navigation Inc.,
134 North Ave.
New Rochelle, NY 10801
Ray Yturraspe, 212-828-5524
Sales, service and installation for VHF radio telephone, radar, depth sounders, loran, Omega, wind and speed instruments and autopilots.

HPL Engineering
49 Cleopatra Drive
Ottawa, Ontario Canada
C.B. Jefferies
Radionavigation system studies and equipment sales.

Hartman Division of ATO Inc.
360 Wolfhill Road
Huntington Station, NY 11746
Robert Romandetto
Development and production of electronic systems.

Integra
P.O. Box 455
Cupertino, CA 95014
Werner Schuerch, 408-252-1495
Consulting services, development and manufacturing of special navigation equipment.

Internav Inc.
8 Preston Court
Bedford, MA 01730
John Currie, 617-275-2970
Development and manufacture of radionavigation, monitor, survey, and timing receivers for Loran-C.

ITT Avionics Div.
100 Kingsland Road/390 Washington Ave.
Clifton, NJ 07014 /Nutley, NJ 07110
James Van Etten
Development and manufacture of electronic systems including radionavigation transmitting and receiving systems.

Krupp Atlas-Electronick
Div. of Krupp International Inc.
P.O. Box 58218
Houston, TX 77058

Lear Siegler, Inc.,
Instrument Division
4141 Eastern Ave., SE
Grand Rapids, MI 49508
H.R. Walton, 616-241-8651
Designs and builds complex modular digital avionics systems to solve navigation, weapon delivery and reconnaissance problems.

The Magnavox Company
Fort Wayne, IN 46802
W.N. Dean, Sr. Staff Engineer
Manufacturers of AN/BRN-5 Loran Receiver for Poseidon/Trident Submarines, AN/FRQ-17 transmitter control set (Clarinet Pilgrim) R-1663/UR digital data receiver.

Megapulse, Inc.
8 Preston Ct.,
Bedford, MA 01730
Edward L. McGann, 617-275-2010
Development and manufacture of Loran-C and D transmitting equipment.

Micrologic, Inc.
9436 Irondale Ave.
Chatsworth, CA 01311
Calvin Culver, 213-998-1216
Manufacturer of commercial marine Loran-C receivers, featuring automatic operation with direct ranging and secondary only operation.

MIECO, Division of Polarad Electronics Corp.
109 Beaver Court
Cockeysville, MD 21030
S.R. Berger, 301-667-4660
Manufacturer of Loran-A and C receivers, Omega receivers, and telephone and voice scramblers.

Morrow Electronics-International Inc.,
P.O. Box 7064
4740 Ridge Drive NE
Salem, OR 97303
Robert D. Morrow, Jr., 503-393-2550
Manufacturers of Loran-A and C receivers with manual and automatic tracking.

Nautical Electronics Company, Inc.,
7095 Milford Industrial Road
Baltimore, MD 21208
David A. Hutzler, 301-484-3284
Manufacturers of Loran-A and C cycle matching receivers.

Navigation Systems, Inc.
884 Monard Drive
Silver Spring, MD 20910
Carl Andren
Development and manufacture of airborne and marine radionavigation equipment including Loran-C.

Offshore Navigation Inc.
P.O. Box 23504
Harahan, LA 70183
Bill Marchall
Radionavigation services for hydrographic survey.

Plessey Radar Ltd.,
Addlestone
Weybridge, Surrey KT152PW
England
A.M. Patrick, Weybridge 47282
Manufacture and sales of marine communications navigation and radar systems.

Redifon Limited
P.O. Box 451
Carlton House
Lower Regent Street
London SW1Y4LS England
W. Blanchard, Tele: 01-874-7281
Manufacturer and sales of marine communications and navigation systems.

Spears Associates, Inc.,
188 Needham Street
Newton, MA 02164
M.F. Spears, 617-965-2800
ELF/VLF/LF communications and navigation techniques for extremely sensitive reception.

Sperry Systems Management
Marcus Road
Great Neck, NY 11020
Design and management of electronics systems.

SRD Labs
645 McGlincey Lane
Cambell, CA 95008
Bruce G. Gato, 408-371-2666
Manufacturers of manual, tracking and fully automatic Loran-A and C receivers primarily for fishboat, workboat and pleasure craft industry.

Singer-Kearfott
150 Totowa Road
Wayne, NJ 07470
Development and manufacture of navigation and guidance systems.

The Analytic Sciences Corporation
6 Jacob Way
Reading, MA 01867
James L. O'Hare, 617-944-6850
Applied research in navigation, guidance, and control, in defense, space and public systems.

Tracor, Incorporated
65000 Tracor Lane
Austin, TX 78721
Harry L. Thomas, 512-926-2800
Development and manufacture of electronic systems for navigation and frequency measurement.

TRW, Inc.
3 New England Executive Park
Burlington, MA 01803
B.H. Evans
Electronic system design and management.

Watkins Associates
P.O. Box 205
North Dayton Station
Dayton, OH 45404
Billy J. Watkins, 513-236-2330
Provides representative/marketing consultant services to avionics companies interested in DOD programs.

Simrad, AS
P.O. Box 6114
Etterstand
Oslo 6 Norway
Manufacture and sales of marine electronic systems.

Teledyne Systems Company
19601 Nordhope Street
Northridge, CA 01324
L. Speelman, 213-886-2211, Ext. 22080
Development and manufacture of communication, navigation, and data processing electronics systems.

Telcom, Inc.
8027 Leesburg Pike
Vienna, VA 22180
L.P. Tuttle,
Specializing in low-cost Loran-C receivers, telecommunications systems and engineering consulting services, nationally and internationally.

William L. Polheumus
Box E
Burlington, VT 05444
Consultant in navigation and guidance systems design and implementation.

Western Geophysical
Box 2469
Houston, TX 77001
Radionavigation services for hydrographic survey.

Revised July, 1975

CONSTITUTION

ARTICLE I

NAME

The name of this association shall be the "Wild Goose Association".

ARTICLE II

AIMS AND PURPOSES

The Wild Goose Association is formed to provide an organization for individuals who have a common interest in loran and who wish to foster and preserve the art of loran, to promote the exchange of ideas and information in the field of loran, to recognize the advances and contributions to loran, to document the history of loran, and to commemorate fittingly the memory of fellow Wild Geese.

ARTICLE III

COMPOSITION OR NATURE

The Association shall be composed of individuals meeting the membership requirements and shall not be used for the dissemination of partisan principles, nor for the promotion of the candidacy of any person seeking public office or preferment, nor for promotion of any commercial enterprise.

ARTICLE IV

MEMBERSHIP

SECTION 1. MEMBERSHIP. There shall be two (2) classes of membership, Regular and Honorary; and the members shall be divided between such classes according to their respective eligibilities as defined in Sections 2 and 3 of this Article. Membership shall be on annual or lifetime basis.

SECTION 2. REGULAR MEMBER. Any individual who has made or is making a significant contribution to loran is eligible for membership. Application shall be presented to the Board of Directors, which shall approve or reject the same by a majority vote of those present.

SECTION 3. HONORARY MEMBER. Honorary membership may be awarded by unanimous approval of the Board of Directors to an individual who has made an outstanding contribution to loran.

ARTICLE V

MEMBERSHIP FEES

SECTION 1. INITIATION FEES AND ANNUAL DUES. In order to provide funds for operating the Association, Dues and Fees may be established to cover the expenses.

SECTION 2. Fees and Dues will be established by the By-Laws to this Constitution.

ARTICLE VI

OFFICERS AND DIRECTORS

SECTION 1. OFFICERS. The officers of the Association shall be President, Vice-President, Secretary, and Treasurer. All officers shall be dues-paying members of the Association.

SECTION 2. ELECTED OFFICERS. The President shall be elected by the Membership of the Association to serve for a period of one (1) year and thereafter until his successor is duly chosen. No person may be elected to the office of President for more than two (2) consecutive terms.

SECTION 3. APPOINTED OFFICERS. The Vice-President, Secretary, and Treasurer shall be appointed by the elected President. The appointments shall be made from among the elected Directors of the Association, and they shall serve for a period of one (1) year and thereafter until their successors have been chosen for the new presidential term.

SECTION 4. ELECTED DIRECTORS. There shall be twelve (12) elected Directors and they shall be elected for a period of three (3) years. One-third (1/3) of the total membership of elected Directors shall be elected each year. The initial Directors shall be designated as one (1) year, two (2) year, and three (3) year Directors, to allow for the election of one-third (1/3) of the Directors each year. Term of office to be served by the initial groups of Directors shall be determined by drawing lots by the founding Directors. All Directors shall be dues-paying members of the Association.

SECTION 5. VOTING. All Regular Members of the Association shall exercise the right of voting. Voting will be by mail, and the annual election will be held as prescribed in the By-Laws.

SECTION 6. VACANCIES

a. Vacancies occurring among elected officials between the time of the annual election and the start of the term of office shall be filled by the candidate or candidates for the office next in line according to votes received.

b. Vacancies occurring among elected officials after the start of the term of office shall be appointed by the Board of Directors.

ARTICLE VII

BOARD OF DIRECTORS

SECTION 1. COMPOSITION. The Board of Directors shall be composed of the President of the Association, the twelve (12) elected Directors of the Association, and the Immediate Past President of the Association.

SECTION 2. POWERS. The administrative authority of the Association shall be vested in the Board of Directors.

ARTICLE VIII

ANNUAL CONVENTION

The Convention shall be held annually at a time and place fixed by the Board of Directors and in accordance with the By-Laws.

ARTICLE IX

STANDING COMMITTEES

The Association may provide by its By-Laws for such Standing Committees as may be deemed necessary. The President, annually, shall appoint the Chairman of each Committee.

ARTICLE X

SPECIAL COMMITTEES

Either the Association's Membership, duly assembled, or the Board of Directors or President may create special Committees and define their respective powers and duties.

ARTICLE XI

DISCIPLINE

SECTION 1. ACTION, HOW TAKEN. The Board of Directors, after notice and a proper hearing, may by majority vote suspend or revoke the membership privileges of any Member.

SECTION 2. CAUSES FOR ACTIONS. Any member of the Association may be suspended or expelled for misconduct reflecting unfavorably upon the Association.

ARTICLE XII

AMENDMENTS

SECTION 1. The Constitution may be amended by two-thirds vote of the members voting.

SECTION 2. Proposed changes will be placed on a Ballot and mailed to the membership after approval by the Board of Directors.

ARTICLE XIII

AWARDS

Awards for significant contributions in furtherance of the aims and purposes of the Wild Goose Association may be authorized by appropriate provision in the By-Laws.

ARTICLE XIV

REGIONAL CLUBS

Regional clubs in furtherance of the aims and purposes of the Wild Goose Association may be organized as authorized by appropriate provision in the By-Laws.

ARTICLE XV

PUBLICATIONS

Publications that serve to further the aims and purposes of the Wild Goose Association may be organized as authorized by appropriate provision in the By-Laws.

BY-LAWS

ARTICLE I

OFFICERS

SECTION 1. THE PRESIDENT. The President shall exercise the powers and perform the duties assigned to him by the Constitution and By-Laws and be the Chief Executive Officer of the Association and Chairman of the Board of Directors, as such, subject to the Constitution and By-Laws, he shall generally supervise the management of its affairs. He shall have full power to enforce the provisions of the Constitution, By-Laws, and the will of the Annual Convention. He shall preside at the Annual Convention. He shall appoint all necessary committees and shall perform such other duties as are usually incident to the office.

SECTION 2. VICE PRESIDENT. The Vice President shall preside in the absence or disability of the President. The duties of the Vice President shall be such as may be assigned by the President.

SECTION 3. THE SECRETARY. The Secretary shall keep a record of the proceedings of the Board of Directors, of annual meetings of the Association, and of all other matters of which a record shall be ordered by the President, the Board of Directors, or the Association. He shall perform such other duties as may be assigned to him by the Constitution and By-Laws of the Association, the President and the Board of Directors, and shall perform such other duties as are usually incident to the office.

SECTION 4. THE TREASURER. The Treasurer shall collect and disburse all funds of the Association and be the custodian of such funds. He shall keep regular accounts in the books belonging to the Association. He shall make annual reports at each National Convention upon the condition of the Treasury and at such other times as shall be required by the Board of Directors or by the President. He shall perform such other duties as may be assigned to him by the Constitution and the By-Laws of the Association, and shall perform such other duties as are usually incident to the office.

ARTICLE II

BOARD OF DIRECTORS

SECTION 1. MEETINGS. The Board of Directors shall meet at such times and places as shall be designated by the President. The Secretary shall call a special meeting upon the written request of five (5) or more members of the Board. The Secretary shall notify all directors of all meetings in advance.

SECTION 2. QUORUM. Seven (7) members shall constitute a quorum of the Board of Directors. Absent members of the Board of Directors shall be counted as present at meetings, but only as to those matters with respect to which the vote, in writing, of such absent members, is received by the Secretary of the Association prior to the meeting.

SECTION 3. POWERS. In addition to such powers as are specifically conferred upon it by the Constitution or any By-Laws, the Board of Directors shall be responsible for the general management of the affairs of the Association, and may make such regulations as it deems advisable, not inconsistent with the Constitution and By-Laws. It shall keep a record of its proceedings in minute books which shall be maintained at the office of the Secretary.

SECTION 4. REMOVAL. A Director may be removed from office for lack of participation in the affairs of the Board upon an affirmative vote of two-thirds (2/3) of the members of the Board of Directors.

ARTICLE III

STANDING COMMITTEES

SECTION 1. AUTHORIZED COMMITTEES. The Standing Committees of the Association shall be as follows:

Awards Committee
Constitution Committee
Convention Committee
Executive Committee
Historical Committee
Membership Committee
Nominating and Election Committee

SECTION 2. CHAIRMEN OF STANDING COMMITTEES. The President shall appoint the chairman of each committee from among the membership. Members of the Board of Directors should be selected for chairmen of committees where they can be effective; however, their selection is not mandatory unless specifically required by these By-Laws.

SECTION 3. MEETINGS. Each Standing Committee shall hold meetings at such times as may be specified, after due notice to its members, by its Chairman, by the President of the Association, or upon the request in writing of a majority of its members.

SECTION 4. REPORTS. Each Standing Committee shall keep a record of its proceedings and shall make a written report of its activities to the Secretary of the Association.

SECTION 5. REMOVAL. Any member of a Standing Committee may be removed from office (except members of the Executive Committee), by the Committee Chairman with the concurrence of the President, or by the written request of two-thirds (2/3) of the committee members.

SECTION 6. DUTIES. Each Standing Committee shall be charged with the duties assigned to it by the Constitution and By-Laws of the Association or by the President or Board of Directors and shall perform such other duties as are usually incident to committees of its particular function. Any question which may arise as to the jurisdiction of a Committee shall be determined by the President.

SECTION 7. APPROPRIATIONS. The Chairman of any Committee may make application to the Executive Committee for appropriation of funds for the work of such Committee. No committee shall have authority to incur any indebtedness or pecuniary obligation for which the Association shall be responsible except to the extent previously authorized by the Board of Directors, or by the Executive Committee.

ARTICLE IV

NOMINATING AND ELECTION COMMITTEE

SECTION 1. CHAIRMAN. The chairman shall be a member of the Board of Directors.

SECTION 2. MEMBERSHIP. The chairman shall appoint an even number of members, not less than two (2) nor more than six (6), to serve on the Committee.

SECTION 3. NOMINATIONS. Nominations to any office to become vacant may be made in writing by any member of the Association, provided it is accompanied by a short biographical sketch of the person to be nominated, suitable for release to the general membership and a complete but concise justification for nomination.

SECTION 4. SELECTION.

a. The Nominating and Election Committee shall solicit and review all nominations and shall select not less than two (2) nor more than five (5) candidates for President, and not less than eight (8) nor more than twelve (12) candidates for the Board of Directors.

b. The Chairman of the Committee shall submit the Nominating and Election Committee nominations to the President of the Association for Board of Directors action not later than 1 April of each year.

c. The Board of Directors shall act upon the recommendations of the Nominating and Election Committee and may add candidates.

SECTION 5. ELECTIONS.

a. Ballots will allow write-in votes for all offices. Ballots will be mailed to the membership between the first (1) and thirty-first (31) of May and only those ballots received in the Association mail box by 1400 on the thirtieth (30) of June shall be counted. Ballots will be returned in the ballot envelopes provided, and they shall not be opened prior to close of the election on thirty (30) June, and then only at such time and place as there are three (3) members of the Nominating and Election Committee present.

b. Results of the election will be provided to the Secretary of the Association not less than fifteen (15) July. Results shall show each candidate and the number of votes received.

c. The Nominating and Elections Committee shall establish the validity of ballots and shall exercise the discretion necessary to resolve voting discrepancies. Offices will be filled by candidates receiving the largest number of votes.

d. Immediately after counting, the ballots will be delivered to the Secretary. The ballots will remain in the Secretary's jurisdiction for possible recount until after the next Annual Convention, at which time they will be destroyed.

ARTICLE V

EXECUTIVE COMMITTEE

SECTION 1. CHAIRMAN. President of the Wild Goose Association.

SECTION 2. MEMBERSHIP. The Executive Committee shall be composed of the President, Vice President, Secretary, and Treasurer.

SECTION 3. The Executive Committee shall be responsible for the business affairs of the Association. They shall insure that the resolutions of the Board are properly administered and that actions requiring authorization between meetings of the Board of Directors are authenticated and approved.

ARTICLE VI

CONVENTION COMMITTEE

SECTION 1. CHAIRMAN. The Chairman shall be any member of the Association.

SECTION 2. MEMBERSHIP. The Chairman shall appoint an even number of members, not less than two (2) nor more than six (6), to serve on the Committee.

SECTION 3. DUTIES. The Convention Committee shall plan and conduct an annual convention in September or October of each calendar year at a place and date approved by the Board of Directors. Installation of all officers shall take place at this convention.

ARTICLE VII

MEMBERSHIP FEES

SECTION 1. INITIATION FEES AND ANNUAL DUES. Regular membership fees and dues shall be paid on the following basis:

a. Initiation Fee $10.00. This includes dues for the first year.

b. Annual Dues. $7.50 per year.

c. Honorary Members shall be exempt from Initiation Fees and Annual Dues.

d. Regular Life Memberships shall be $100.00. No initiation fee is required in case of Life Membership.

ARTICLE VIII

AMENDMENTS

SECTION 1. The By-Laws may be amended with the concurrence of two-thirds (2/3) of the members of the Board of Directors.

SECTION 2. Members of the Board will be provided a copy of all proposed changes and given thirty (30) days after date of mailing to respond. Yeas and Nays shall be recorded by the Secretary, including each member's vote.

ARTICLE IX

AWARDS COMMITTEE

SECTION 1. CHAIRMAN. The Chairman shall be any member of the Association.

SECTION 2. MEMBERSHIP. The Chairman shall appoint an even number of members, not less than two (2) nor more than six (6), to serve on the committee.

SECTION 3. DUTIES. The Awards Committee shall be responsible for administering the Awards Program of the Association in accordance with the Constitution and By-Laws. The Committee will prepare a report describing the authorized awards and detailing criterial and procedures for nomination and selection. After approval by the Board of Directors, this report will be distributed to the membership.

ARTICLE X

CONSTITUTION COMMITTEE

SECTION 1. CHAIRMAN. The Chairman shall be any member of the association.

SECTION 2. MEMBERSHIP. The Chairman shall appoint an even number of members, not less than two (2) nor more than six (6), to serve on the Committee.

SECTION 3. DUTIES. The Constitution Committee shall be responsible for proper preparation and administration of proposed changes to the Constitution for presentation to the membership, and proposed changes to the By-Laws for presentation to the Board of Directors. Further, the Constitution Committee will prepare a report detailing procedures for forming Regional Clubs and providing a sample club Charter and Constitution. After approval by the Board of Directors, this report will be distributed to the membership.

ARTICLE XI

AWARDS

SECTION 1. The following non-monetary awards are authorized to further the aims and purposes of the Wild Goose Association:

Medal of Merit:
To be awarded to a person or persons for a particular contribution of outstanding value to the development or fostering of loran. This award shall normally be given only after the exceptional nature of the contribution is clearly recognized.

Paper Award:
To be awarded to a member of the Wild Goose Association for the best paper published on the general subject of loran.

Service Award:
This award will be given to members who distinguish themselves by service to the Wild Goose Association.

President's Award:
To be awarded to the person, persons, or organization as designated by the President of the Association with consent of the Board of Directors. The Award shall be presented at the annual banquet.

ARTICLE XII

REGIONAL CLUBS

SECTION 1. Regional Clubs shall be chartered by the Board of Directors to further the aims and purposes of the Wild Goose Association.

SECTION 2. The area of jurisdiction for each club shall be appropriately designated. All Association members in the designated jurisdiction will be eligible for club membership.

SECTION 3. Regular members who desire to form a club shall make application for a charter to the Constitution Committee in accordance with the current procedures established by the Committee. The Chairman of the Constitution Committee shall forward the application and proposed Club Constitution with the Committee's recommendations to the Board of Directors for action. When approved by the Board of Directors, the President of the Association shall issue the Charter. The Charter shall be retained by the Club until such time as the Club may become inactive, at which time the Charter will be returned to the Association.

SECTION 4. Each Regional Club shall upon issue of the Charter be provided with funds from the Association in the amount of $1.00 per Club member for the purpose of partially defraying the Club operating expenses. Such funds shall be further provided to each active Regional Club on April 1 upon application to and certification by the Membership Committee of the Association as to the current status of membership.

ARTICLE XIII

RADIONAVIGATION JOURNAL

SECTION 1. PURPOSE. To provide to the membership of the Wild Goose Association and to the loran community at large a compendium of current Association and loran information and related topics. It is intended that the Journal will be updated and published annually, closely following the annual elections (approximately July of each year), to provide to the membership an annual report of the significant activities, accomplishments, and objectives of the Association. It is further intended that the Journal will serve the interest of the loran community by providing a compendium of loran information and reference data deemed to be of interest to the Community at large.

SECTION 2. JOURNAL COMMITTEE. A special committee shall be constituted to effect the compilation, editing and publication of the Journal. The President of the Association shall annually appoint the Editor of the Journal, who will serve as Chairman of the Committee. The Editor shall appoint not less than two (2) nor more than six (6) members to serve on the Committee.

SECTION 3. FINANCE. The Journal is intended to be financially self-supporting through the sale of advertising space and copies of the Journal to the loran community at large. The Editor of the Journal may make application to the Executive Committee for the funds necessary to publish a specific issue of the Journal and may make application to the Treasurer for the funds necessary for the administration of the Journal Committee (i.e.: mailings, telephone, etc.). Such application shall be supported by a detailed budget. The Committee shall not have authority to incur any indebtedness or pecuniary obligation for which the Association shall be responsible except to the extent previously authorized by the Executive Committee, or by the Board of Directors.

SECTION 4. CONTENTS. Prior to final editing and publication, the Chairman of the Committee shall submit to the Executive Committee for approval a detailed listing of the contents of the forthcoming issue.

SECTION 5. DISTRIBUTION. At publication, a copy of the Journal shall be provided to each member of the Association at no cost. Copies shall be made available for sale to the loran community at large at prices to be determined by the Chairman of the Committee and approved by the Executive Committee, or Board of Directors.

WGA MEMBERSHIP LIST

We have attempted to compile a WGA Membership List and the member's affiliation.To those members included in this list without an affiliation, we apologize. We do not know their current affiliation and would urge them to contact the editorial or membership committee to provide the pertinent information.

Roald Aarset
Simrad, as
Frank Abate
Republic Electronics
Gordon R. Anderson
Electronic Communications Inc.
Carl Andren
Navigation Systems Inc.
Capt. Edward J. Ard
US Coast Guard
Donald W. Baake
Teledyne Systems Co.
Tom Baine
Offshore Navigation Inc.
Robert L. Baker
Charles J. Baltzer
Austron Inc.
Peter F. Barry
Hartman Systems
Donald E. Bartlett
Sperry Gyroscope Div.
Robert P. Bartlett
Epsco Inc.
Dr. Charles C. Bates
US Coast Guard
William R. Bazzarre
John W. Beakes
William J. Becker
US Air Force
Thurman C. Becker
LCOL John F. Beran
US Air Force
Larry Berberich
John M. Beukers
Beukers Labs Inc.
Wally Blanchard
Redifon Telecommunications Ltd.
Murray Block
ITT Avionics Div.
J. Bode
Austron Inc.
C. Lawrence Bradley
The Analytic Sciences Corp.
Ed Bregstone
US Coast Guard
William E. Brennan
Teledyne Systems Co.
Earl Brown
Canadian Center for Inland Waters
Herb Brown
Internav Inc.
Keith Bruhl
Beukers Labs Inc.
Loren E. Brunner
US Coast Guard (ret)
Gilbert A. Buccola
Lawrence Burke
John G. Busharis
Bjorn Carlsen
Simrad Inc.
Hardy M. Caton
Tracor Inc.
Frederick J. Chambers
Teledyne Systems Co.
Peter Chappell
Mel Chaskin
US Air Force
Kenon T. Chism
US Coast Guard
James M. Cloeren
Austron Inc.
John L. Coco
US Air Force
RADM Peter V. Colmar
Boeing Co.
Duncan Cox
Charles Starke Draper Labs Inc.
Maj Richard G. Cronquist
US Air Force
CDR James F. Culbertson
US Coast Guard
Calvin Culver
Micrologic Inc.
Paul M. Cunningham
Charles Cusack
Donald B. Daniel
Thomas E. Daniels
US Army
Harry Davis
Consultant
Martin C. Day
Amecom Div.
Walter N. Dean
Magnavox Inc.
Herbert Deich
John J. Del Giorno
US Coast Guard
John A. DeLisio
Lear Siegler Instrument Div.
Norman C. Dickerson Jr.
Amecom Div.
Angelo Dimitriou
Lear Siegler Instrument Div.
LT James T. Doherty
US Coast Guard
Robert H. Doherty
Consultant
Merton S. DuBois
US Army
CDR Robert F. Dugan
US Coast Guard

Edward Durbin
Kaiser Aerospace and Electronics Co.
R.M. Eaton
Bedford Institute
Thomas H. Eggers
Bernard T. Ellis Jr.
ITT Avionics Div.
Robert W. Elsner
Lear Siegler Astronautics Div.
Charles J. England
Institute of Telecommunications Sciences
Harold E. Englert
Donald B. Erisman
US Coast Guard
Bowman H. Evans
TRW Systems Div.
Leo F. Fehlner
Applied Physics Lab
Donald Feldman
US Coast Guard
Charles F. Feltham
Dynell Electronics Corp.
LCDR Walter B. Ferm
US Coast Guard
William G. Fitzsimmons
Bruce Francis
Austron Inc.
Robert L. Francisco
Epsco Inc.
Aaron Frank
Robert L. Frank
Consultant
Wilbert Frantz
Warren J. Frederick
Megapulse Inc.
Dr. Ronald J. Fredericks
Lear Siegler Instrument Div.
Eugene O. Frye
William J. Garmany
ITT Avionics Div.
Dan Gentry
Aerospace Systems Inc.
Andrew Georgia
Singer-Kearfott Div.
Robert Goddard
Internav Inc.
Arnold Goldman
Hartman Systems
LCDR Gil R. Goodman
US Coast Guard
Robert V. Gould
Sperry Systems Management Div.
Dennis J. Granato
DMA Hydrographic Center
S.T. Grant
Bedford Institute
James A. Graydon
US Air Force
Charles W. Gruber
ITT Avionics Div.
Gerald A. Gutman
Communications Associates Inc.
David T. Haislip
US Coast Guard
Harry Halamandaris
Teledyne Systems Co.
Arthur S. Hanby Jr.
University of Delaware
John E. Hanna
DMA Hydrographic Center
Robert C. Hanson
MAJ James A. Hardin
US Air Force
LCDR Roger W. Hassard
US Coast Guard
Gifford Hefley
Joseph Heinen
ITT Avionics Div.
James W. Henderson
CAPT Harold T. Hendrickson
US Coast Guard (ret)
Capt. R. I. Hetherington
Royal Canadian Forces
Lloyd D. Higginbotham
US Air Force
William H. Hilbun III
ITT Avionics Div.
David C. Hiser
Sperry Rand Corp.
George R. Hitchcock
David E. Hoagland
Hewlett Packard Corp.
Richard F. Hoffman
Maganavox Corp.
Robert J. Holden
Digicon Inc.
Harold Holland
HWH Electronics Corp.
John Hopkins
Teledyne Systems Co.
CWO Ralph C. Howland
US Coast Guard
Joseph L. Howard
US Air Force
Terrance J. Hughes
Robert Hutzleman
David Hutzler
Nautical Electronics Co., Inc.
Duane C. Hyovalti
Institute of Telecommunications Sciences
Robert R. Jacalone
Northrop Electronics Corp.
John C. Jacobsen
Sperry Gyroscope Div.
Dagfinn Jahr
Simrad, as
Jacquelyn V. Jaworski
US Air Force
C.B. Jeffery
Consultant
Paul R. Johannessen
Megapulse Inc.
Richard Johnson
Republic Electronics

Vernon L. Johnson
ITT Avionics Div.
A.E. Jones
Navigation Systems Inc.
Leon E. Jones
Navigation Systems Inc.
Nick Judge
Tracor Inc.
Fred Karkalik
DR. J.F. Kasper, Jr.
The Analytic Sciences Corp.
CAPT Wilfred F. Keating, Jr.
US Air Force
Charles M. Kenney
ITT Avionics Div.
LCDR Phillip J. Kies
US Coast Guard
George Kieves
Sperry Gyroscope Div.
D.E. Klein
Sperry Systems Management Div.
LCOL John S. Kurtak
US Air Force
CDR Bruce G. Lauther
US Coast Guard
William Lee
Charles Stark Draper Labs Inc.
LCOL Daniel R. Leonard
US Army
Herbert Lindsay, Jr.
Ronald F. Linzey
ITT Avionics Div.
CAPT Alfred P. Manning
US Coast Guard
Ernest H. Manuel
ITT Avionics Div.
SSGT Albert E. Marino
US Air Force
George F. Martin
Advanced Electronics Dev. Inc.
Emil J. Mateker, Jr.
Carl S. Mathews
S.W. McCall, Jr.
Thomas A. McCarty
Applied Physics Lab
Frank W. McDermott
ITT Avionics Div.
Edward L. McGann
Megapulse Inc.
David McGrew
Sperry Gyroscope Div.
Kenneth W. McLarty
Lear Siegler Instrument Div.
William F. McNeil
ITT Avionics Div.
Carlene M. Mellecker
Institute of Telecommunications Sciences
Robert W. Merriam
Merriam Instruments
William C. Merrill
Magnavox Research Labs

Donald J. S. Merton
Communications Associates Inc.
Frank A. Messina
ITT Avionics Div.
Walter R. Meyers
Navigation Systems Inc.
J.A. Micali
Kollsman Instrument Co.
James Meranda
Teledyne Systems Co.
Guy W. Mizell
Walsh Electric Co. Inc.
LCDR Francis W. Mooney
US Coast Guard
John C. Morgan
Lear Siegler Inc.
Ray Morrow, Jr.
Morrow Electronics Corp.
Hon. John M. Murphy
US Representative (NY)
Laurence W. Murphy
The Magnavox Co.
Donald A. Naples
US Coast Guard
Anton Neuburger
Amecom Div.
Frank O. Nicholas
Benmar Div of CETEC
CDR Thomas P. Nolan
US Coast Guard
Thomas N. Nyman
The Mitre Corp.
William J. O'Brien
Decca Navigator Co., Ltd.
LT David L. Olson
US Coast Guard
Joseph J. Ostrowski
CW3 Maynard Overall
US Army
Joseph A. Parini
Lear Siegler Instrument Div.
Philip H. Parsons
Richard A. Pasciuti
Edo Commercial Corp.
Frank J. Pasquariello
Singer-Kearfott Div.
Claude J. Pasquier
Amecom Div.
Harry W. Patch
US Navy
DR Douglas C. Pearce
US Army
RADM Helmer S. Pearson
US Coast Guard (ret)
Patrick J. Perna
ITT Avionics Div.
M.F. Perry
Consultant
James A. Perschy
Alan H. Phillips
Sperry Systems Management Div.

S.N. Piasecki
Navigation Systems Inc.
Eugene F. Pickel
Lear Siegler Instrument Div.
LCDR Stephen P. Plusch
US Coast Guard
William L. Polhemus
Consultant
Martin C. Poppe
Consultant
LT Henry C. Post
US Coast Guard
Jack Provenzano
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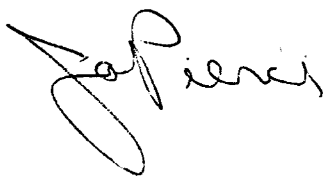
'Tis not the years have taken toll

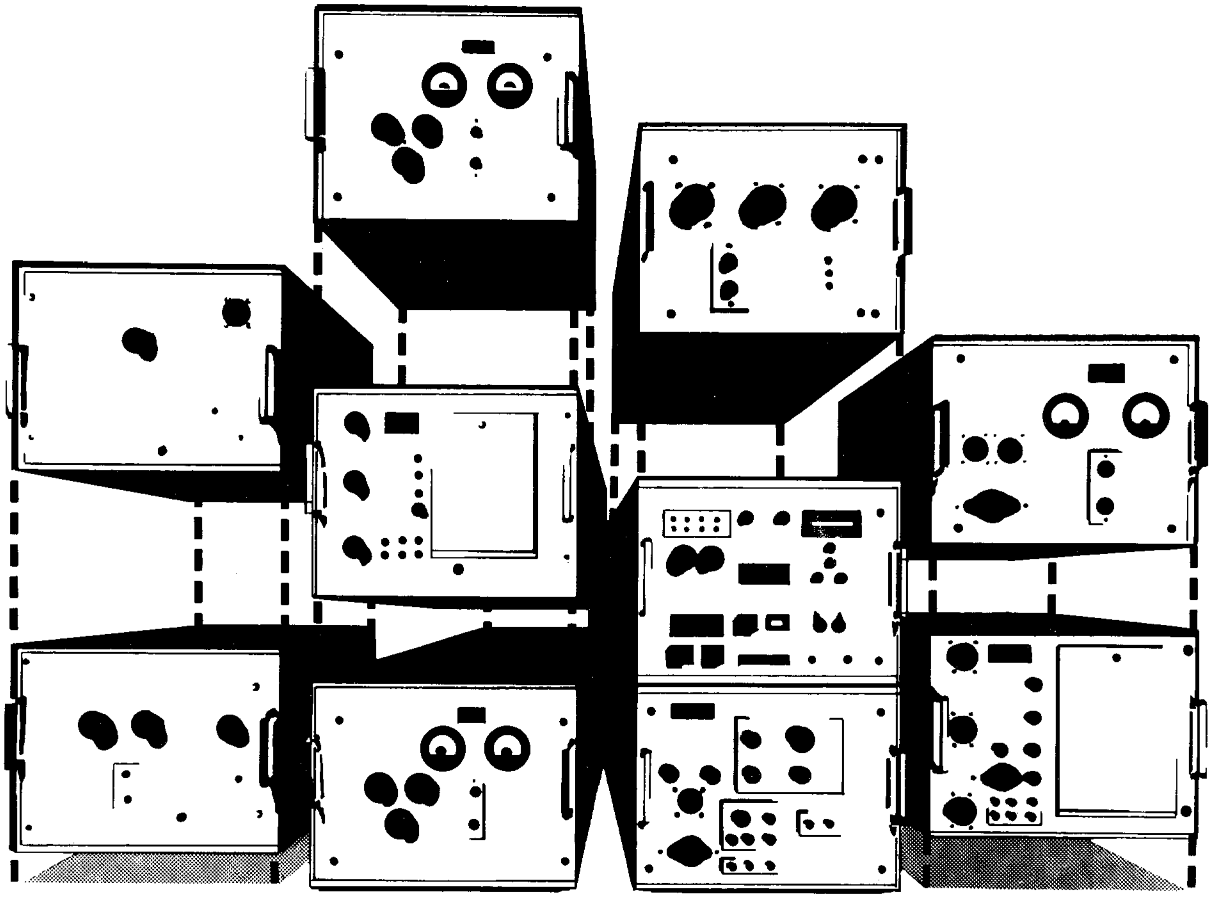
Upon the garnish of my poll.

Loran stole half my hair away

And Radux turned the balance gray.

 , about 1955

FROM MEGAPULSE



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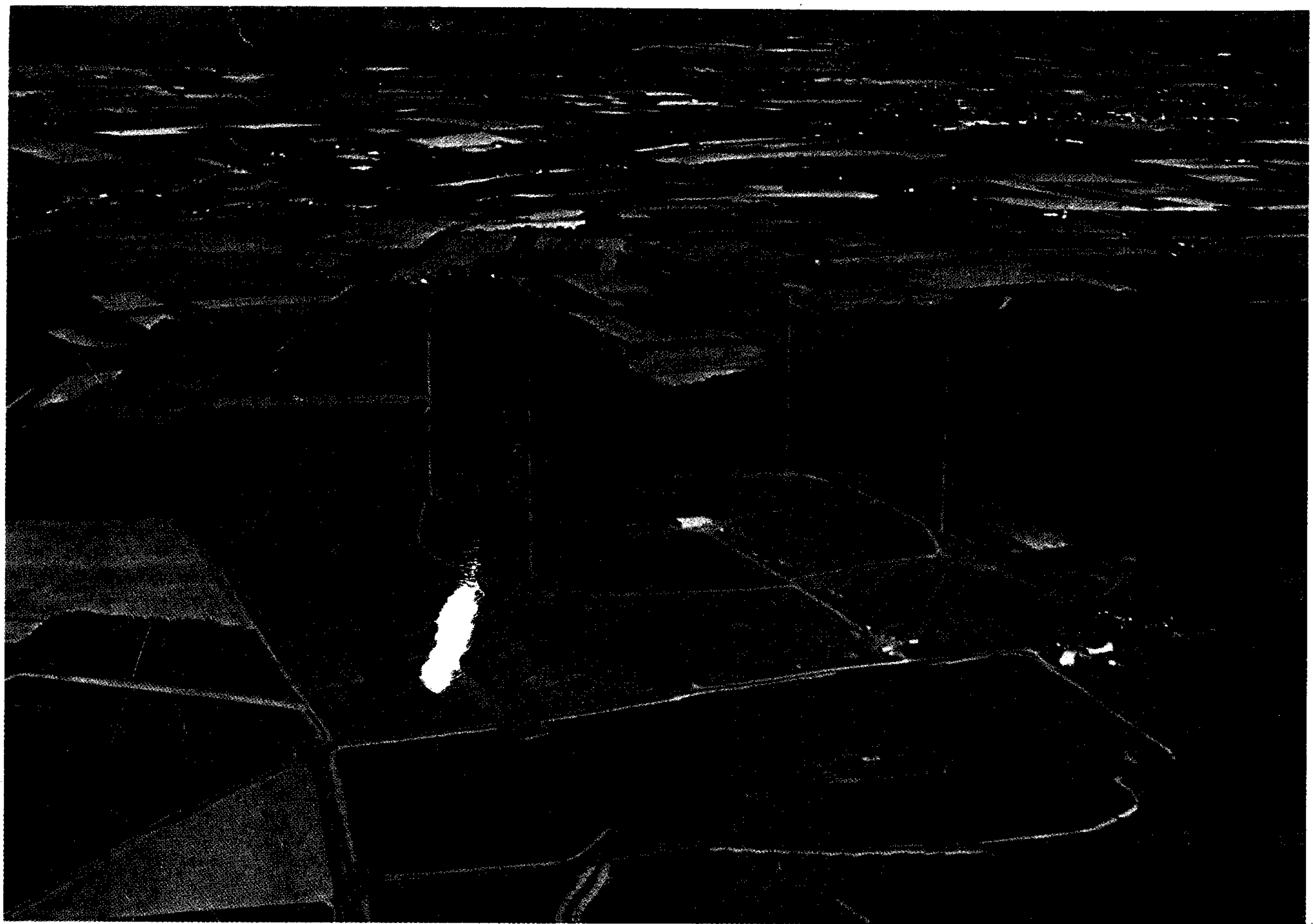

U.S. Coast Guard Loran Test Facility, Caribou, Me.

Wild Goose Association Charter

The Wild Goose Association is formed to provide an organization for individuals who have a common interest in Loran and who wish to foster and preserve the art of Loran, to promote the exchange of ideas and information in the field of Loran, to recognize the advances and contributions to Loran, to document the history of Loran, and to commemorate fittingly the memory of fellow Wild Geese.