CHAPTER 6

LONG RANGE NAVIGATIONAL AIDS

PART I LORAN-C

600A. General

LORAN is a long range system which operates on the principle that the difference in time of arrival of signals from two precisely synchronized transmitting stations describes a hyperbolic line of position (LOP). This time difference is measured with a LORAN receiver, and is either converted into geographic LOPs for use with nautical charts overprinted with LORAN lines or directly into latitude and longitude readouts. Since at least two LOPs must be determined to establish a position, the user must be within the range of two pairs of transmitting stations or, as is normally the case, a LORAN chain where a centrally located station serves as a timing reference for the other stations in the chain. This station is called the master station (designated M) and the secondaries are usually designated by the letters V, W, X, Y, or Z. In the United States, LORAN-C is operated by the U.S. Coast Guard. Developed in the late 1950's, LORAN-C operates on a frequency of 100 kHz. Each LORAN-C chain operates on a different pulse group repetition interval (GRI). This allows the operator to make at least two time difference (TD) measurements without changing channels on the receiver. The low frequency of LORAN-C permits usable groundwave signals over several hundred miles.

600B. Operation

The LORAN-C GRI rate structure is such that a GRI between 40,000 and 99,990 microseconds is chosen for each chain. The chain designations are four digit numbers which indicate the GRI in tens of microseconds. For example, the northeast U.S. LORAN-C chain is designated 9960 and has a GRI of 99,600 microseconds.

The accuracy of a LORAN-C fix is determined by the accuracy of the individual lines of position used to establish the fix, as well as by their crossing angle of intersection. The accuracy of the individual lines of position depends on the following factors:

– Synchronization of the transmitting stations.
– Operator skill.
– Type of receiver and its condition.
– Skill in plotting the line of position.
– Position of user relative to the transmitting stations.
– Accuracy of charts.
– Accuracy of corrections to compensate for the overland path.

Some LORAN-C receivers employ a coordinate converter function, which is designed to internally compute the latitude and longitude and directly display these values. This eliminates the need for charts overprinted with LORAN-C time difference lines. (CAUTIONARY NOTE: The conversion computation on some models is based upon an all sea water propagation path. This leads to errors if the LORAN-C signals from the various stations involve appreciable overland paths. It is recommended that operators using coordinate converters check the manufacturer's operating manual to determine if and how corrections are to be applied to compensate for overland paths.)

Each LORAN-C rate is continuously monitored to determine that proper synchronization is being maintained. When the synchronization error exceeds the advertised tolerance, the user is advised by the blinking of pulses of the affected secondary and is warned not to use the signal for navigational purposes. The blink signal will cause most receivers to indicate by an alarm that the navigational data displayed is in error. Mariners should check equipment manuals to determine if their receivers are equipped with a Blink Alarm and, if not, should exercise caution when near known hazards or when in restricted waters.

LORAN-C position determinations on or near the baseline extensions are subject to significant errors and should be avoided wherever possible. A great circle line between two LORAN stations is a baseline; the baseline extension is the extension of that line beyond either station.

LORAN-C coverage presently exists along the western coast of North America from the Bering Sea southward along the Gulf of Alaska, western Canada, and the U.S. west coast to the Mexican border. Along the eastern coast of North America, LORAN-C coverage exists from Newfoundland to the southern tip of Florida. Gulf Coast coverage exists from the southern tip of Florida to the Texas-Mexico border. Coverage of Lakes Superior, Michigan, and Huron is provided by the Great Lakes chain, rate 8970. Coverage of Lakes Huron, Erie, and Ontario is provided by the Northeast U.S. chain, rate 9960. Coverage over the central region of the U.S. is provided by the North and South Central chains, rates 8290 and 9610, respectively. For foreign LORAN-C coverage (including that described above) refer to the LORAN-C Plotting Charts diagram in the latest edition of NIMA Catalog of Maps, Charts, and Related Products Part 2-Volume I Hydrographic Products (CATP2V01U).

Detailed LORAN-C information is contained in the U.S. Coast Guard's LORAN-C User Handbook (COMDTPUB P16562.6).

NOTE: While the United States continues to evaluate the long-term need for continuation of the Loran-C radionavigation system, the Government will operate the Loran-C system in the short term. The U.S. Government will give users reasonable notice if it concludes that

Loran-C is not needed or is not cost effective, so that users will have the opportunity to transition to alternative navigation aids. With this continued sustainment of the Loran-C service, users will be able to realize additional benefits. Improvement of GPS time synchronization of the Loran-C chains and the use of digital receivers may support improved accuracy and coverage of the service. Loran-C will continue to provide a supplemental means of navigation.

For further information and/or operational questions regarding LORAN-C in the United States, contact:

COMMANDING OFFICER
U.S. COAST GUARD NAVIGATION CENTER
7323 TELEGRAPH ROAD
ALEXANDRIA VA 22315-3998

Telephone: (1) 703-313-5900.
Fax: (1) 703-313-5920.

The Navigation Information Service (NIS) is internet accessible through the U.S. Coast Guard Navigation Center Website at:
http://www.navcen.uscg.gov/
http://www.nis-mirror.com (Mirror site)

FOREIGN LORAN-C COVERAGE: In 1992, the U.S. Coast Guard, which operated LORAN-C overseas for the Department of Defense, initiated plans to accomplish transfer or closure of U.S. Coast Guard LORAN-C stations located on foreign soil. As a result of these efforts, new LORAN-C systems have developed in areas of the world previously covered by the U.S. chains.

The countries of Norway, Denmark, Germany, Ireland, the Netherlands and France have established a common LORAN-C system known as the Northwest European Loran-C System (NELS). The developing system will be comprised of nine stations forming four chains. Since 1995, two chains, Bo and Ejde, have been in experimental (continuous) operation. The Sylt chain became operational in late 1995, but users are warned of its unstable condition. The Lessay chain became operational in September 1997.

For further information regarding NELS, contact:

NELS COORDINATING AGENCY OFFICE
LANGKAIA 1
N-0150 OSLO NORWAY

Telephone: 47 2309 2476.
Fax: 47 2309 2391.
Internet: http://www.nels.org

The countries of Japan, the People's Republic of China, the Republic of Korea and the Russian Federation have established an organization known as the Far East Radionavigation Service (FERNS). Japan took over operation of the former U.S. Coast Guard stations in its territory and they are currently operated by the Japanese Maritime Safety Agency (JMSA). In 1996, five chains (Korea, North China Sea, East China Sea, South China Sea, and Russian) became operational.

600C. Receivers

There are many types of LORAN-C receivers available. Each type employs various techniques for acquiring and tracking LORAN-C signals, and for indicating the time difference or position information to the user. A LORAN-C receiver which will be useful within the limits of the Coast Guard's coverage for the U.S., and which is capable of measuring positions with the accuracy which is advertised for LORAN-C, has the following characteristics:

– It acquires the LORAN-C signals automatically, without the use of an oscilloscope.
– It identifies master and secondary groundwave pulses automatically.
– It tracks the signals automatically once they have been acquired.
– It displays two time difference readings, to a precision of at least one tenth of a microsecond, and/or latitude and longitude.
– It has notch filters to minimize the effects of radio frequency interference in the area of its operation.
– It automatically detects blink and alerts the operator.

Proper LORAN-C receiver installation is necessary to ensure optimum results. Some of the essential elements of good LORAN-C receiver installations are:

– Use of the correct antenna and antenna coupler. Mount the antenna as high as possible and away from all metal objects, stays, and other antennas. Do not connect any other equipment to a LORAN-C antenna.
– Connect both the antenna coupler and the receiver to a good ground. LORAN-C, operating at low frequency, requires proper grounding.
– Electrical and electronic interference, or noise, can come from many sources, both aboard the vessel as well as from the surrounding environment. Onboard noise comes from anything that generates or uses electricity; it is a more severe problem at 100 kHz than at higher frequencies, and it must be suppressed in order to have good results from LORAN-C. Alternators, generators, ignition systems, electrical motors, fluorescent lights, radars, and television sets are examples of interfering sources. Interference suppression may include installation of filters, shields, grounds, and capacitors. Interference suppression should be accomplished with the vessel engine running.
– Protection of the LORAN-C receiver from excessive heat, dampness, salt spray, and vibration must be ensured. Do not mount the receiver in direct sunlight or within one meter of your magnetic compass. Provide adequate ventilation.

600D. Station List

LORAN-C stations, grouped geographically by chains, are contained in the following list.

(1) No.	(2) Name	(3) Type	(4) Component	(5) Position	(6) Freq.	(7) Remarks
			NORTH PACIFIC CHAIN			
6100	**St. Paul, AK 9990 (SS1).**	LORAN-C	Master	57 09 12N 170 15 06W		
	Attu Is., AK 9990-X.		Secondary	52 49 44N 173 10 50E		
	Port Clarence, AK 9990-Y.		Secondary	65 14 40N 166 53 12W		
	Kodiak, AK 9990-Z.		Secondary	57 26 20N 152 22 11W		
			RUSSIAN (CHAYKA)-AMERICAN CHAIN			
6105	**Petropavlovsk, Russia 5980.**	LORAN-C	Master	53 07 48N 157 41 43E		
	Attu Is., AK 5980-X.		Secondary	52 49 44N 173 10 50E		
	Alexandrovsk, Russia 5980-Y.		Secondary	51 04 43N 142 42 05E		
			RUSSIAN CHAIN			
6110	**Alexandrovsk, Russia 7950.**	LORAN-C	Master	51 04 43N 142 42 05E		
	Petropavlovsk, Russia 7950-W.		Secondary	53 07 48N 157 41 43E		
	Ussuriysk, Russia 7950-X.		Secondary	44 32 00N 131 38 23E		
	Tokachibuto, Hokkaido, Japan 7950-Y.		Secondary	42 44 37N 143 43 10E		
	Okhotsk, Russia 7950-Z.		Secondary	59 25 02N 143 05 23E		
			NORTHWEST PACIFIC CHAIN			
6120	**Nii Jima, Japan 8930 (SS3).**	LORAN-C	Master	34 24 12N 139 16 19E		
	Gesashi, Okinawa, Japan 8930-W.		Secondary	26 36 25N 128 08 57E		
	Minami-tori Shima (Marcus Island), Japan 8930-X.		Secondary	24 17 08N 153 58 54E		
	Tokachibuto, Hokkaido, Japan 8930-Y.		Secondary	42 44 37N 143 43 10E		
	Pohang, South Korea 8930-Z.		Secondary	36 11 05N 129 20 27E		

(1) No.	(2) Name	(3) Type	(4) Component	(5) Position	(6) Freq.	(7) Remarks
			KOREA CHAIN			
6122	**Pohang, South Korea 9930.**	LORAN-C	Master	36 11 05N 129 20 27E		
	Kwangju, South Korea 9930-W.		Secondary	35 02 24N 126 32 27E		
	Gesashi, Okinawa, Japan 9930-X.		Secondary	26 36 25N 128 08 57E		
	Nii Jima, Japan 9930-Y.		Secondary	34 24 12N 139 16 19E		
	Ussuriysk, Russia 9930-Z.		Secondary	44 32 00N 131 38 23E		
			NORTH CHINA SEA CHAIN			
6124	**Rongcheng, China 7430.**	LORAN-C	Master	37 03 52N 122 19 26E		
	Xuancheng, China 7430-X.		Secondary	31 04 08N 118 53 10E		
	Helong, China 7430-Y.		Secondary	42 43 12N 129 06 27E		
			EAST CHINA SEA CHAIN			
6126	**Xuancheng, China 8390.**	LORAN-C	Master	31 04 08N 118 53 10E		
	Raoping, China 8390-X.		Secondary	23 43 26N 116 53 45E		
	Rongcheng, China 8390-Y.		Secondary	37 03 52N 122 19 26E		
			SOUTH CHINA SEA CHAIN			
6128	**Hexian, China 6780.**	LORAN-C	Master	23 58 04N 111 43 10E		
	Raoping, China 6780-X.		Secondary	23 43 26N 116 53 45E		
	Chongzuo, China 6780-Y.		Secondary	22 32 35N 107 13 22E		
			GULF OF ALASKA CHAIN			
6130	**Tok, AK 7960 (SL4).**	LORAN-C	Master	63 19 43N 142 48 31W		
	Kodiak, AK 7960-X.		Secondary	57 26 20N 152 22 11W		
	Shoal Cove, AK 7960-Y.		Secondary	55 26 21N 131 15 19W		
	Port Clarence, AK 7960-Z.		Secondary	65 14 40N 166 53 12W		

(1) No.	(2) Name	(3) Type	(4) Component	(5) Position	(6) Freq.	(7) Remarks
	WEST COAST CANADA CHAIN					
6140	**Williams Lake, B.C., Canada 5990 (SH1).**	LORAN-C	Master	51 57 59N 122 22 02W		
	Shoal Cove, AK 5990-X.		Secondary	55 26 21N 131 15 19W		
	George, WA 5990-Y.		Secondary	47 03 48N 119 44 39W		
	Port Hardy, B.C., Canada 5990-Z.		Secondary	50 36 30N 127 21 28W		
	WEST COAST U.S. CHAIN					
6150	**Fallon, NV 9940 (SS6).**	LORAN-C	Master	39 33 07N 118 49 56W		
	George, WA 9940-W.		Secondary	47 03 48N 119 44 39W		
	Middletown, CA 9940-X.		Secondary	38 46 57N 122 29 44W		
	Searchlight, NV 9940-Y.		Secondary	35 19 18N 114 48 17W		
	EAST COAST CANADA CHAIN					
6160	**Caribou, ME 5930 (SH7).**	LORAN-C	Master	46 48 27N 67 55 37W		
	Nantucket, MA 5930-X.		Secondary	41 15 12N 69 58 39W		
	Cape Race, Nfld., Canada 5930-Y.		Secondary	46 46 32N 53 10 28W		
	Fox Harbor, Nfld., Canada 5930-Z.		Secondary	52 22 35N 55 42 28W		
	NEWFOUNDLAND EAST COAST CHAIN					
6165	**Comfort Cove, Nfld., Canada 7270.**	LORAN-C	Master	49 19 54N 54 51 43W		
	Cape Race, Nfld., Canada 7270-W.		Secondary	46 46 32N 53 10 28W		
	Fox Harbor, Nfld., Canada 7270-X.		Secondary	52 22 35N 55 42 28W		
	GREAT LAKES CHAIN					
6170	**Dana, IN 8970.**	LORAN-C	Master	39 51 08N 87 29 12W		
	Malone, FL 8970-W.		Secondary	30 59 39N 85 10 09W		
	Seneca, NY 8970-X.		Secondary	42 42 51N 76 49 33W		
	Baudette, MN 8970-Y.		Secondary	48 36 50N 94 33 18W		
	Boise City, OK 8970-Z.		Secondary	36 30 21N 102 53 59W		

(1) No.	(2) Name	(3) Type	(4) Component	(5) Position	(6) Freq.	(7) Remarks
			NORTHEAST U.S. CHAIN			
6180	**Seneca, NY 9960 (SS4).**	LORAN-C	Master	42 42 51N 76 49 33W		
	Caribou, ME 9960-W.		Secondary	46 48 27N 67 55 37W		
	Nantucket, MA 9960-X.		Secondary	41 15 12N 69 58 39W		
	Carolina Beach, NC 9960-Y.		Secondary	34 03 46N 77 54 46W		
	Dana, IN 9960-Z.		Secondary	39 51 08N 87 29 12W		
			SOUTHEAST U.S. CHAIN			
6190	**Malone, FL 7980 (SL2).**	LORAN-C	Master	30 59 39N 85 10 09W		
	Grangeville, LA 7980-W.		Secondary	30 43 33N 90 49 43W		
	Raymondville, TX 7980-X.		Secondary	26 31 55N 97 50 00W		
	Jupiter, FL 7980-Y.		Secondary	27 01 59N 80 06 53W		
	Carolina Beach, NC 7980-Z.		Secondary	34 03 46N 77 54 46W		
			EJDE CHAIN			
6205	**Ejde, Faroe Is., Denmark 9007.**	LORAN-C	Master	62 17 59N 7 04 26W		
	Jan Mayen Is., Norway 9007-W.		Secondary	70 54 51N 8 43 56W		
	Bo, Norway 9007-X.		Secondary	68 38 06N 14 27 47E		
	Vaerlandet, Norway 9007-Y.		Secondary	61 17 49N 4 41 46E		
			BO CHAIN			
6215	**Bo, Norway 7001.**	LORAN-C	Master	68 38 06N 14 27 47E		
	Jan Mayen Is., Norway 7001-X.		Secondary	70 54 51N 8 43 56W		
	Berlevag, Norway 7001-Y.		Secondary	70 50 43N 29 12 15E		
			SYLT CHAIN			
6220	**Sylt, Germany 7499.**	LORAN-C	Master	54 48 29N 8 17 36E		
	Lessay, France 7499-X.		Secondary	49 08 55N 1 30 17W		
	Vaerlandet, Norway 7499-Y.		Secondary	61 17 49N 4 41 46E		

(1) No.	(2) Name	(3) Type	(4) Component	(5) Position	(6) Freq.	(7) Remarks
			LESSAY CHAIN			
6225	**Lessay, France 6731.**	LORAN-C	Master	49 08 55N 1 30 17W		
	Soustons, France 6731-X.		Secondary	43 44 23N 1 22 49W		
	Sylt, Germany 6731-Z.		Secondary	54 48 29N 8 17 36E		
			NORTH SAUDI ARABIAN CHAIN			
6240	**Afif, Saudi Arabia 8830.**	LORAN-C	Master	23 48 37N 42 51 18E		
	Salwa, Saudi Arabia 8830-W.		Secondary	24 50 02N 50 34 13E		
	Al Khamasin, Saudi Arabia 8830-X.		Secondary	20 28 02N 44 34 53E		
	Ash Shaykh Humayd, Saudi Arabia 8830-Y.		Secondary	28 09 16N 34 45 41E		
	Al Muwassam, Saudi Arabia 8830-Z.		Secondary	16 25 56N 42 48 05E		
			INDIA (BOMBAY) CHAIN			
6260	**Dhrangadhara 6042.**	LORAN-C	Master	23 00 14N 71 31 39E		
	Veraval 6042-W.		Secondary	20 57 07N 70 20 13E		
	Billimora 6042-X.		Secondary	20 45 40N 73 02 17E		
			INDIA (CALCUTTA) CHAIN			
6270	**Balasore 5543.**	LORAN-C	Master	21 29 08N 86 55 18E		
	Patpur 5543-W.		Secondary	20 26 48N 85 49 47E		
	Diamond Harbor 5543-X.		Secondary	22 10 18N 88 12 25E		

PART II DECCA

610A. General

Decca is a high accuracy, medium range radio navigational aid intended for coastal and landfall navigation. An important characteristic of the system is the simplicity and speed in taking a precise fix, facilitated by the Decca receiver's three integrated coordinate meters, which continuously, automatically, and simultaneously display all position line information. When a fix is required, all that is necessary is to read off the two relevant position coordinate values indicated, and apply them to a Decca latticed navigation chart, an operation that can be completed in under 1 minute.

The system operates as a stable frequency, continuous wave phase comparison system with transmissions of 70 kHz to 130 kHz. The Decca transmitting chains consist of a master station (A) and two or three slave stations designated Red (B), Green (C) and Purple (D), each about 60-120 miles from the master. The continuous wave transmissions from the slave stations are rigidly phase-locked to those from the master, and transmission frequencies are all harmonically related: Master 6F, Red 8F, Green 9F and Purple 5F, where F is a fundamental frequency of around 14.2 kHz

These transmissions are received by the special Decca Navigator ship-borne receiver, and frequency multiplying circuits therein produce phase comparison frequencies of 24F for the Master and Red transmissions, 18F for the Master and Green transmissions, and 30F for the Master and Purple transmissions.

Three phase meters, called Decometers, which are part of the receiving equipment, simultaneously indicate the phase difference at these comparison frequencies received from the master station and each of the slave stations. The line of constant phase is a hyperbola focused on a master/slave pair. For each master/slave pair there is a stable family of hyperbolae geometrically related to the position of the stations.

The hyperbolic lattice lines of zero phase difference are printed in the respective colors, red, green, or purple, on the Decca charts. The interval between successive zero phase hyperbolae is termed a Decca lane. The position of the ship can be easily and continuously plotted on the lattice chart at the intersections of the Decometer readings.

The Decometers measure only the decimal fraction of each lane and mechanically integrate the whole lane value. Initially, the correct lane value is determined by lane identification transmissions, utilizing as a comparison frequency the basic frequency (1F). The correct large number setting of each color is indicated in succession on either one common lane identification digital readout in the case of a MARK 21 receiver or one common lane identification meter in the case of MARK 12/MARK V receivers, and is then set on the Decometer. This common 1F comparison frequency determines the lane number within a zone whose width on the baselines between the master and slave stations is the same for all colors. Each zone contains 24 red lanes, 18 green lanes, or 30 purple lanes. The width of each lane on the baseline is approximately: 450 meters (red); 590 meters (green); and 350 meters (purple).

For unambiguous presentation the zones are lettered and the lanes numbered outwards from the master station. Each group of ten zones is lettered from A to J, and the lanes in each zone are numbered: 0 to 23 (red); 30 to 47 (green); and 50 to 79 (purple).

The correct zone letter must be determined by other navigational methods and by reference to the appropriate Decca latticed chart. As the zones are about 6 miles in width on the baselines, and as this width increases away from the baselines, the accepted position of the ship is generally not critical for this purpose.

610B. Chain Numbers

There are 11 groups of basic frequencies, numbered 0 to 10. In each of these 11 basic groups, 6 master frequencies, lettered A to F, are derived to provide for existing and future chains. Thus, in Group 0, normal master frequencies in kHz are: 0A 84.100; 0B 84.105; 0C 84.110; and, separated by 0.090 kHz, 0D 84.190; 0E 84.195; and 0F 84.200. The frequency interval between each numbered group is 0.180 kHz; e.g., the English Chain No. 5B has a master frequency of 85.000 kHz. Group 10 includes only the A, B, and C frequencies. Decca MARK 12 or MARK 21 receivers can be switched to each of these 63 frequencies. Earlier receivers can be switched to the numbers only, where they will receive A, B, or C frequencies, but cannot receive the D, E, or F transmissions.

When correctly set up, Decca will give a continuous record of position. Lane slip (or incorrect lane identification), giving errors in position may, however, result from:

– Interruption or disturbance in transmissions.
– Incorrect referencing of receiver.
– Interference: either excessive Decca sky-wave signals, external radio, snow static, or electrical storms.

610C. Accuracy

The accuracy obtained from Decca is dependent upon the distance from the transmitters and the angle of cut of the lattice lines. Used correctly and under favorable conditions, the system is capable of a high degree of accuracy, and positions correct to within ±50 yards can be obtained up to 50 miles from the transmitting stations. In limited areas the chains are capable of being used for surveys and ship trials.

In daylight hours at the longer ranges (i.e., 250 to 450 miles) an improvement in fixing accuracy is possible in areas of adjacent Decca chains. This is done by crossing a position line of one chain with that of another, providing the angle of cut is substantially better than in either chain by itself. This technique is referred to as inter-chain fixing and should only be employed with a Decca MARK 12 or MARK 21 type receiver when operating from a multi-phase (MP) type lane identification Decca chain. Specially latticed Multi-Chain Decca charts are available for this technique in the areas where it should be beneficial.

Two types of errors, fixed and variable, are inherent in the system and are explained below.

610D. Fixed Errors

The speed of propagation of the Decca transmissions from the master and slave stations is affected by the conductivity of the terrain, e.g., it is lower over land than over the sea. The advancing wave fronts are thus not exactly hyperbolic, as they would be in a uniform medium, but are slightly irregular; the lines of constant phase difference in these overlapping patterns therefore produce irregular hyperbolic position lines. This system of irregular position lines is, however, stable in position, as the Decca chains are continuously monitored and the phase locking of the slave stations held rigid. The hyperbolic lattices shown on the charts are calculated using a mean speed of propagation obtained by averaging the calculated probable velocities at numerous points over the coverage of the chain. The difference between the actual position of a hyperbolic position line and its theoretically calculated position (i.e., the position given on the chart) is known as the fixed error.

This fixed error, or pattern correction, varies with locality. Where the Decca chain coverage is almost wholly over water, the speed of propagation differs only slightly from that adopted for the calculation of the lattices, and the resultant fixed errors are small. Where, however, the chain extends over large mountainous land masses or islands, as in the North Scottish chain, the actual speed of propagation varies markedly in different localities; the resultant fixed errors are appreciable, and can exceed ± 0.5 lanes.

The variation in the speeds of propagation can cause simultaneous observations of all three Decometers to produce three separate two-color fixes. In the area of overlap of adjoining chains, observation of each separate chain can similarly produce different fixes.

Observations to determine these fixed errors of the chains, i.e., the corrections to be applied to observed Decometer readings to make them agree with the theoretical lattice on the charts, have usually been carried out during the acceptance trials. The resultant fixed errors at certain positions, generally about 3 miles offshore, along the coastal coverage of the chains, and including the approaches to all the important ports are given in detail in the Operating Instructions and Marine Data Sheets issued by Racal-Decca Marine Navigator Limited.

When no information regarding fixed errors is available, the charted Decca lattices should be used with caution, especially near the coast and in restricted waters.

At one time it was anticipated that adequate observations would be made of the fixed errors, and that the corrections would be included in the lattices printed on the charts. Experience has shown, that in general, this task is not practicable; it is unlikely that the theoretical lattices shown on British Admiralty charts will ever be corrected. However, the Swedish Hydrographer has published Swedish charts with adjusted Decca lattices incorporating the results of extended observations in the Baltic, and these have been copied on the Admiralty latticed charts of the Swedish Chain.

610E. Variable Errors

A proportion of the transmitted signal is reflected from the ionosphere and interferes with the direct or groundwave signal. The coefficient of reflection varies with time of day, season of the year, and the geographical location of the transmitters and receivers. At night, or in daylight at extreme range, this skywave signal may become sufficiently strong to cause an inaccurate reading on the Decometer. This causes a variable error which can become considerable at extreme ranges, and is greater at night than by day and is worse in the winter than in summer.

These variable errors are explained in detail, and portrayed in contour form in Operating Instructions and Marine Data Sheets issued by Racal-Decca Marine Navigator Limited.

Mariners are strongly cautioned that, at distances of over 150 miles from the transmitting stations, particularly at night or dusk, the signals may be too weak to work the lane identification meter correctly. This can lead to sudden lane slipping and the loss of one or more lanes. Decca should not be relied upon as the sole aid to navigation in these circumstances.

610F. Notes

Ships fitted with receivers without lane identification facilities must know their position accurately when initially setting up the meters and when resetting them for any reason (for example, after failure of the transmitter or receiver, or when the ship enters the approved coverage area). The possibility of lane-slipping must also be borne in mind. Steps should be taken at all times to check that lanes have not slipped, e.g., by checking with the dead reckoning plot at regular intervals.

Ships fitted with MARK V and later receivers will, in the appropriate areas, be able to make use of the lane identification facilities provided. It is emphasized that before using lane identification, reference should be made to the following paragraphs and to Racal-Decca Marine Navigator Limited’s special instructions.

Some Decca Chains emit two different sets of lane identification signals during each 1 minute transmission cycle. These are known as the MARK V and the multipulse lane identification systems. Details of these systems are to be found in the Operating Instructions and Marine Data Sheets which are issued to all Decca users.

Standard MARK V marine receivers (QM5, QM9, and QM10) are not designed to receive the multipulse lane identification system, but MARK 12 (QM12) receivers can operate in either the MARK V or the multipulse mode. The latest MARK 21 receivers receive only the multipulse mode.

In night conditions, the high probability of incorrect MARK V type lane identification may be reduced at ranges over 150 miles from the transmitting stations. Provided the instructions are followed rigidly, lane identification facilities in these conditions should ensure that information from the correct reading is used.

Earlier receivers do not incorporate the necessary circuits or meters to display lane identification signals, but a slight kick of the Decometer pointers will be observed on these receivers, as well as on MARK V (QM5, QM9, or QM10), at the start of each lane identification transmission. This may be neglected, since it in no way affects the performance of the receiver as a navigational aid.

Any break or disturbance of the normal transmissions of Decca stations is broadcast as a Decca Warning by coast radio stations in the vicinity.

These warnings are issued because the transmission failure may result in lane loss by Decca Navigator receivers. Whether a lane is lost or not depends on the position, course, and speed of the vessel at the time, and the duration of the failure. In some cases more than one lane may be lost.

Two types of warnings are used; here are examples:

DECCA HOKKAIDO CHAIN RED TRANSMISSION INTERRUPTED 1315 TO 1330 GMT TENTH APRIL CHECK LANE NUMBER.
(This warning implies that the whole number red lane reading is liable to be in error and that special care should be taken to check the Decca position indicated.)

DECCA HOKKAIDO CHAIN RED PATTERN DISTURBED 1315 GMT CHECK LANE NUMBER.
(This message is sent when any pattern has been disturbed by severe interference with the ground station, which is likely to have caused the gain or loss of a lane.)

Any faults in lane identification transmissions will be apparent if the instructions for their use given in Racal-Decca Marine Navigator Limited’s Data Sheets are followed, and no procedure for promulgation by broadcast is necessary.

610G. Station List

Decca stations, grouped geographically by chains, are contained in the following list. An approximate idea of coverage can be determined through the chain names and station locations.

NOTE: All Decca Station frequencies are in kilohertz.

(1) No.	(2) Name	(3) Type	(4) Component	(5) Position	(6) Freq.	(7) Remarks
			SALAYA CHAIN 2F			
6772	**Kodal (A).**	DECCA	Master	22 52 27N 69 24 00E	84.555	
	Kuranga (B).		Red Slave	22 03 28N 69 10 30E	112.740	
	Dhuvav (C).		Green Slave	22 28 49N 70 07 43E	126.832	
	Naliya (D).		Purple Slave	23 15 04N 68 49 00E	70.462	

PART III SATELLITE NAVIGATION

620A. General

Satellite navigation presently consists of two global systems. Each may be considered a refinement of celestial navigation, using artificial earth-orbiting satellites to form an electronic “constellation”, serviced by land-based control and tracking stations, and passively “sighted” by mobile receivers. Both systems provide precise, global, and continuous position-fixing capabilities, in all weather, to a properly equipped user.

The U.S. Air Force system is the NAVSTAR Global Positioning System (GPS). GPS development began in 1973 and reached full operational capability in 1995. (The U.S. Navy system, the Navy Navigation Satellite System (NAVSAT, also known as Transit) became operational in 1964 and ceased operation as a positioning and timing system on December 31, 1996. Users should recognize that navigational equipment using the NAVSAT system should no longer be used since any signals received will no longer provide valid position or timing references.)

The Russian system is the Global Navigation Satellite System (GLONASS). GLONASS became fully operational in January 1996.

620B. GPS

GPS is a highly precise satellite-based radionavigation system providing three-dimensional positioning, velocity, and time information. GPS is an all-weather system with continuous and worldwide coverage. GPS consists of three segments: space, control, and user.

The Space Segment is composed of 24 operational satellites in six orbital planes. The satellites operate in circular 20,200 km (10,900 nm) orbits at an inclination angle, relative to the equator, of 55˚ and with a 12-hour period. The satellites are spaced in orbit so that at any time, a minimum of six satellites are observable from any position on earth, providing instantaneous position and time information.

Each satellite transmits on two L band frequencies: 1575.42 MHz (L1) and 1227.6 MHz (L2). Three pseudo-random noise (PRN) ranging codes are in use:

- The coarse/acquisition (C/A) code has a 1.023 MHz chip rate, a period of one millisecond, and is used primarily to acquire the P-code.
- The precise (P) code has a 10.23 MHz rate, a period of seven days, and is the principal navigation ranging code.
- The Y-code is used in place of the P-code whenever the anti-spoofing (A-S) mode of operation is activated.

L1 carries a P-code and a C/A-code. L2 carries the P-code. A navigation data message is superimposed on the codes. The same navigation data message is carried on both frequencies. This message contains satellite ephemeris data, atmospheric propagation correction data, and satellite clock bias.

Selective Availability (SA), the denial of full accuracy, is accomplished by manipulating the navigation message orbit data (epsilon) and/or the satellite clock frequency (dither). Anti-spoofing (A-S) guards against fake transmissions of satellite data by encrypting the P-code to form the Y-code.

The Control Segment consists of five monitor stations, three of which have uplink capabilities, located in Colorado, Hawaii, Kwajalein, Diego Garcia, and Ascension Island. The monitor stations use a GPS receiver to passively track all satellites in view, accumulating ranging data from the satellites’ signals. The information from the monitor stations is processed at the Master Control Station (MCS), located in Colorado Springs, Colorado, to determine satellite orbits and to update the navigation message of each satellite. The updated information is transmitted to the satellites via ground antennas. The ground antennas, located at Kwajelein, Diego Garcia, and Ascension Island, are also used for transmitting and receiving satellite control information.

The User Segment consists of antennas and receiver-processors that provide positioning, velocity, and precise timing to the user. The GPS receiver makes time-of-arrival measurements of the satellite signals to obtain the distance between the user and the satellites. The distance calculations, known as pseudoranges, together with range rate information, are converted to yield system time and the user’s three-dimensional position and velocity with respect to the satellite system. A time coordination factor then relates the satellite system to earth coordinates. A minimum of four pseudoranges are needed to produce a three-dimensional fix (latitude, longitude, and altitude). GPS receivers compute fix information in terms of the World Geodetic System (1984), which may need datum shift correction before it can be accurately plotted on a chart.

There are three different types of receivers. Sequential receivers track only one satellite at a time, computing a fix after a series of pseudoranges have been sequentially measured; these receivers are inexpensive but slow. Continuous receivers have at least four channels to process information from several satellites simultaneously; these process fix information the fastest. Multiplex receivers switch at a fast rate from satellite to satellite, receiving and processing data from several satellites simultaneously, producing a fix by a sort of “round-robin” process.

GPS provides two levels of service for position determination:

- The Standard Positioning Service (SPS) for general public use. (Until 1 May 2000, the SPS signal accuracy was intentionally degraded to protect U.S. national security interests through the process of Selective Availability.)
- The encoded Precise Positioning Service (PPS) primarily intended for use by the Department of Defense.

Accuracy of a GPS fix varies with the capability of the user equipment. SPS is the standard level of positioning and timing accuracy that is available, without restrictions, to any user on a continuous worldwide basis. SPS provides positions with a horizontal accuracy of approximately 100 meters. (This accuracy specification includes the effects of SA.) PPS provides full system accuracy to designated users. Selective Availability was set to zero (ceased) as of midnight (EDT) 1 May 2000. Users should experience a GPS horizontal accuracy of 10-20 meters or better.

NOTE: It has come to the attention of the U.S. Coast Guard and Federal Communications Commission that certain consumer electronics-grade active VHF/UHF marine television antennas are causing operational degradation in the performance of GPS receivers. This interference may be realized as a display of inaccurate position information or a complete loss of GPS receiver acquisition and tracking ability and the interference interactions have been reported up to 2000 feet from the interference source. This interference has been associated in some instances with temperature extremes or proximity to a television broadcast site.

If you are experiencing recurring outages or degradation of your GPS receiver you should perform an on-off test of your TV antenna. If turning off the power to the antenna results in improvement in the GPS receiver performance, the antenna may be the source of interference in the GPS band. In that case, you should contact the manufacturer of the antenna and identify the symptoms. If the test is not positive and the GPS interference persists, you may contact the U.S. Coast Guard, Office of Spectrum Management at:

E-mail: CGComms@comdt.uscg.mil

or through the Coast Guard Navigation Information Service at:

Telephone: (1) 703-313-5900.
E-mail: nisws@navcen.uscg.mil.

620C. DGPS

The U.S. Coast Guard Navigation Center operates the Maritime Differential GPS (DGPS) Service and the developing Nationwide DGPS Service, consisting of two control centers and over 60 remote broadcast sites. The service broadcasts correction signals on marine radiobeacon frequencies to improve the accuracy of and integrity to GPS-derived positions. The U.S. Coast Guard DGPS Service provides 10-meter (2 dRMS) navigation accuracy in all established coverage areas, integrity alarms for GPS and DGPS out-of-tolerance conditions within 10 seconds of detection, and an availability of 99.7% per month. Typically the positional error of a DGPS position is 1 to 3 meters, greatly enhancing harbor entrance and approach navigation. The system provides service for coastal coverage of the continental U.S., the Great Lakes, Puerto Rico/U.S. Virgin Islands, portions of Alaska and Hawaii, and a greater part of the Mississippi River Basin.

This service achieved Full Operational Capability (FOC) on 15 March 1999. The Coast Guard advises that Coast Guard DGPS broadcasts should not be used under any circumstances where a sudden system failure or inaccuracy could constitute a safety hazard. Users are further cautioned to use all available navigational tools to ensure proper evaluation of positioning solutions.

DGPS reference stations determine range errors and generate corrections for all GPS satellites in view. The DGPS signals are broadcast, using existing Coast Guard radiobeacons, on frequencies in the 285-325 kHz band. Monitor stations independently verify the quality of the DGPS broadcast. A complete list of U.S. Coast Guard DGPS broadcast sites is available from the Navigation Center.

For further information and/or operational questions regarding GPS or DGPS, contact:

COMMANDING OFFICER
U.S. COAST GUARD NAVIGATION CENTER
7323 TELEGRAPH ROAD
ALEXANDRIA VA 22315-3998

Telephone: (1) 703-313-5900.
Fax: (1) 703-313-5920.

The Navigation Information Service (NIS) is internet accessible through the U.S. Coast Guard Navigation Center Website at:

http://www.navcen.uscg.gov/
http://www.nis-mirror.com (Mirror site)

620D. GLONASS

The Russian Global Navigation Satellite System (GLONASS), similar to GPS, is a space-based navigation system that provides continuous, global, all-weather, precise position, velocity and time information. The space segment consists of 24 satellites in three orbital planes at an altitude of 19,100 km. The satellites operate in circular orbits with an inclination of 64.8˚ and a period of 11h 15m. All satellites transmit simultaneously, using two carrier frequencies in the L band, to allow users to correct for ionospheric delays of the transmitted signals. However, each satellite is allocated a particular frequency within the band, determined by the frequency channel number of the satellite. These different frequencies allow the user's receiver to identify the satellite. The L1 band ranges from 1602.5625 MHz to 1615.5 MHz in increments of 0.5625 MHz, while the L2 band ranges from 1246.4375 MHz to 1256.5 MHz in increments of 0.4375 MHz. Superimposed to the carrier frequency, the GLONASS satellites modulate their navigation message by using either or both a precision (P) code and/or and a coarse/acquisition (C/A) code. The satellites also transmit ephemeris data, an almanac of the entire constellation, and correction parameters to the time scale. The coordinate system of the GLONASS satellite orbits is defined by the PZ-90 system, formerly the soviet Geodetic System 1985/1990.

The Coordinational Scientific Informational Center (CSIC) of the Russian Space Forces provides official information on GLONASS status and plans, information and scientific method services to increase the efficiency of GLONASS applications. For further information contact:

CSIC OF RUSSIAN SPACE FORCES
PO BOX 14
MOSCOW 117279
RUSSIA

Telephone: 7 095 333 72 00.
Fax: 7 095 333 81 33.
E-mail: sfcsic@space.ru.

Internet: http://www.rssi.ru/SFCSIC/english.html/