CHAPTER 6

LONG RANGE NAVIGATIONAL AIDS

PART I LORAN-C

PART II GLOBAL POSITIONING SYSTEM (GPS)

PART III DIFFERENTIAL GLOBAL POSITION SYSTEM (DGPS)

PART IV AUTOMATIC IDENTIFICATION SYSTEM (AIS)

Notes: Greater detail on the theory, principles, and operation of long range navigational aids may be found in The American Practical Navigator (Bowditch) (PUB9).

The U.S. Naval Observatory Website provides GPS user information and data at: http://www.usno.navy.mil/USNO/time/gps

The U.S. Coast Guard Navigation Center Website provides GPS, DGPS and general radionavigation user information and status at http://www.navcen.uscg.gov/

GPS status is also broadcast from WWV and WWVH (See sec. 200D and 200E).

CHAPTER 6

LONG RANGE NAVIGATIONAL AIDS

PART I LORAN-C

600A. Acronyms

– eLORAN: enhanced LORAN, the most recent version of LORAN.
–FERNS: Far East Radionavigation Service (the People's Republic of China, Japan, the Republic of Korea and the Russian Federation).
–GPS: Global Positioning System.
–ILA: International Loran Association.
–LORAN-C: LOng RAnge Navigation. The "C" is the version of LORAN.
–RTCM: Radio Technical Commission for Maritime Services.

600B. Definitions

– Baseline: the line between two radio navigation stations operating in conjunction for the determination of a line of position.
– Baseline extension: the extension of the baseline in both directions beyond the transmitters of a pair of radio stations operating in conjunction for determinations of a line of position.
– Centerline: the set of points equidistant from two reference points or lines.
–Coding Delay (CD): the interval of time after reception of the master's transmission that a secondary station waits prior to transmitting its own signal. The Coding Delay assigned to each secondary station allows stations of a chain to transmit sequentially in time and to prevent overlap of the different signal groups anywhere in the system.
–Emission Delay: the interval of time (in microseconds) between the beginning of the first pulse from the master station and the beginning of the first pulse from the secondary station in the same chain (both stations using a common time reference). The emission delay equals the sum of the baseline travel time plus the secondary coding delay.
–Group Repetition Interval (GRI): the time interval between successive pulse groups measured from the third cycle of the first pulse of any one station in the group to the third cycle of the first pulse of the same station in the following pulse group. The GRI is expressed in tens of microseconds and is the identifier for that chain and is called the "rate".
–Time Difference (TD): the interval in time between the receipt of a master station's signal and secondary station's signal from the same rate.
–TD Lines: the lines created when the time from master to secondary has elapsed and converted to distance.

600C. Modern LORAN-C and eLORAN

Today modern LORAN receivers work the same way as a GPS unit. The unit automatically acquires the land based signal, makes the calculations and displays the geographic position (Figure 600C). Some models offer the TD line data to be displayed as well, although the lines are being phased out of standard chart symbology.

Figure 600C

Although in some parts of the world LORAN-C is no longer supported, a new version called eLORAN

(enhanced LORAN) is starting to be implemented in other parts due to the need for a precise positional system as backup to GPS. This updated version increases the accuracy by precise time scales independent of satellite systems. The main difference between eLORAN and traditional Loran-C is the addition of a data channel on the transmitted signal. This sends application-specific corrections, warnings and signal integrity information to the user's receiver. The reasons for these corrections is due to the signals traveling over the surface of the earth and are subject to small propagation delays, which when corrected, make eLORAN more precise. eLORAN also has something that satellite positional equipment cannot provide, an eLORAN compass. When the receiver is used with an H-Field (Magnetic Loop) antenna it can be employed as an automatic direction-finder. It takes bearings on the transmitting stations, and calculates the ship's heading (generally with an accuracy of better than 1° and independent of the ship' movement).

600D. How LORAN-C Works (Basics only)

LORAN-C is based on measuring the time difference of specific pulses between a pair of land based radio transmitters. One station, called a Master Station, sends a unique and constant pulse (in milliseconds) to at least two secondary stations. These stations grouped together are called a Chain. Each Chain has a unique Group Repetition Interval (GRI) which determines the "rate" of each Chain. The secondary stations are given letters W, X, Y, and Z (Figure 600D.1).

Figure 600D.1

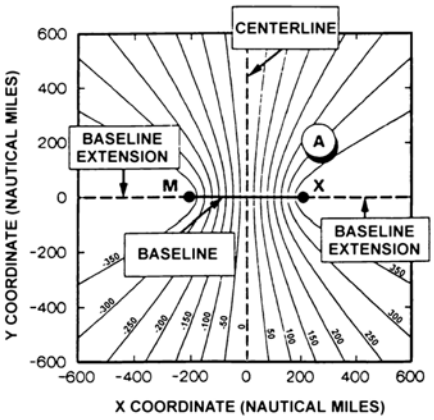


Figure 600D.2

Figure 600D.2 shows how the rates are created and labeled on some older charts. Using complex calculations hyperbolic lines are created for each rate from the Master to each of the secondary stations. Each rate is represented by a different color on the chart and labeled by the nautical miles from the centerline. The LORAN receiver acquires the distance between the vessel and the master station and displays the number on the screen for each rate that is in range.

To obtain an accurate fix, the mariner needs to select a minimum three rates at right angles of each other. The LORAN-C receiver can display these signals, and by using an interpolation card or the linear interpolator graph (Figure 600D.3) located on the side of the chart, along with TD lines on the chart, a fix is obtained.

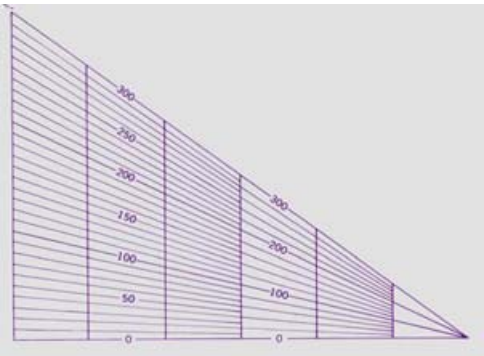
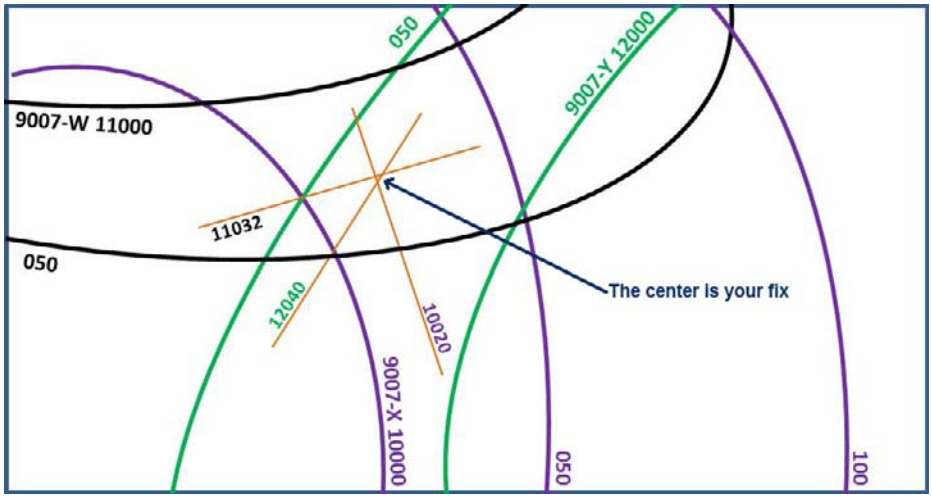


Figure 600D.3

Below is an example how LORAN-C data is used to obtain a fix (just for demonstration). Figure 600D.4 shows how the fix is obtained once measurements are plotted.



Receiver:

TD 1: 11032
TD 2: 12040
TD 3: 10020

Figure 600D.4

See Pub.9 Bowditch, Chapter 12 for more in-depth information on LORAN-C operation.

600E. LORAN-C Station Closures

– U.S. Coast Guard terminated the transmission of all U.S LORAN-C signals on 08 Feb 2010.
– Russian-American Chain terminated on 01 Aug 2010.
– Canadian LORAN-C terminated on 03 Aug 2010.

600F. Worldwide LORAN-C Station List by Chain

Chain	Station	Rate	Location
Saudi Arabian North Chain	Afif	8830-Master	23-49N 042-51E
	Salwa	8830-W	24-50N 050-34E
	Al Khamasin	8830-X	20-28N 044-35E
	Ash Shaykh Humayd	8830-Y	28-09N 034-46E
	Al Muwassam	8830-Z	16-26N 042-48E
South China Sea Chain	Hexian	6780-Master	23-58N 111-43E
	Raoping	6780-X	23-43N 116-54E
	Chongzuo	6780-Y	22-33N 107-13E
East China Sea Chain	Xuancheng	8390-Master	31-04N 118-53E
	Raoping	8390-X	23-43N 116-54E
	Rongcheng	8390-Y	37-04N 122-19E
North China Sea Chain	Rongcheng	7430-Master	37-04N 122-19E
	Xuancheng	7430-X	31-04N 118-53E
	Helong	7430-Y	42-43N 129-06E
Korean Chain[1]	P'ohang	9930-Master	36-11N 129-21E
	Kwangju	9930-W	35-02N 126-32E
	Gesashi	9930-X	26-36N 128-09E
	Nii Shima	9930-Y	34-24N 139-16E
	Ussuriysk	9930-Z	44-32N 131-38E
Northwest Pacific Chain[2]	Nii Shima	8930-Master	34-24N 139-16E
	Gesashi	8930-W	26-36N 128-09E
	Tokachibuto	8930-Y	42-45N 143-43E
	P'ohang	8930-Z	36-11N 129-21E
Russian Chain	Alexandrovsk	7950-Master	51-05N 142-42E
	Petropavlovsk	7950-W	53-08N 157-42E
	Ussuriysk	7950-X	44-32N 131-38E
	Tokachibuto	7950-Y	42-45N 143-43E
	Okhotsk	7950-Z	59-25N 143-05E
Ejde Chain	Ejde	9007-Master	62-18N 007-04W
	Jan Mayen	9007-W	70-55N 008-44W
	Bo	9007-X	68-38N 014-28E
	Vaerlandet	9007-Y	61-18N 004-42E
Bo Chain	Bo	7001-Master	68-38N 014-28E
	Jan Mayen	7001-X	70-55N 008-44W
	Berlevag	7001-Y	70-51N 029-12E
Sylt Chain	Sylt	7499-Master	54-48N 008-18E
	Lessay	7499-X	49-09N 001-30W
	Vaerlandet	7499-Y	61-18N 004-42E
Lessay Chain	Lessay	6731-Master	49-09N 001-30W
	Soustons	6731-X	43-44N 001-23W
	Anthorn	6731-Y	54-55N 003-15W
	Sylt	6731-Z	54-48N 008-18E

Korean Chain[1]: http://www.loran9930.go.kr
Northwest Pacific Chain[2]: Coordinator of Chain Operations (COCO), Tokyo, Japan, Phone: +81 0425 52 2511 ext. 58405

600G. Worldwide LORAN-C Station List by Station

Station	Location	Rate(s) Supported		Contact Information
Afif	23-49N 042-41E	8830-Master		
Al Khamasin	20-28N 044-35E	8830-X		
Al Muwassam	16-26N 042-48E	8830-Z		
Alexandrovsk	51-05N 142-42E	7950-Master		
Anthorn	54-55N 003-15W	6731-Y		
Ash Shaykh Humayd	28-09N 034-46E	8830-Y		
Berlevag	70-51N 029-12E	7001-Y		Country: Norway Phone: 789-81499 Fax: 784-92736 E-mail: post.loranc-berlevaag@mil.no
Bo	68-38N 014-28E	7001-Master	9007-X	Country: Norway Phone: 76 11 24 70 Fax: 76 11 24 80 E-mail: loran-c@vkbb.no
Chongzuo	22-33N 107-13E	6780-Y		
Ejde	62-18N 007-04W	9007-Master		Country: Denmark Phone: 298 42 30 20 Fax: 298 42 34 93 E-mail: loran@frv.dk
Gesashi	26-36N 128-09E	9930-X	8930-W	
Helong	42-43N 129-06E	7430-Y		
Hexian	23-58N 111-43E	6780-Master		
Jan Mayen	70-55N 008-44W	9007-W	7001-X	Country: Norway Phone: 32 17 79 00 Fax: 32 17 79 01 E-mail: elektronikkavdelingen@jan-moyen.no
Kwangju	35-02N 126-32E	9930-W		
Lessay	49-09N 001-30W	6731-Master	7499-X	
Nii Shima	34-24N 139-16E	8930-Master	9930-Y	
Okhotsk	59-25N 143-05E	7950-Z		
P'ohang	36-11N 129-21E	9930-Master	8930-Z	
Petropavlovsk	53-08N 157-42E	7950-W		
Raoping	23-43N 116-54E	6780-X	8390-X	
Rongcheng	37-04N 122-19E	7430-Master	8390-Y	

Station	Location	Rate(s) Supported		Contact Information
Salwa	24-50N 050-34E	8830-W		
Soustons	43-44N 001-23W	6731-X		
Sylt	54-48N 008-18E	7499-Master	6731-Z	Country: Germany Phone: 49 4651 96050 Fax: 49 4651 960555 E-mail: loranc-sylt@wsv.bund.de
Tokachibuto	42-45N 143-43E	8930-Y	7950-Y	
Ussuriysk	44-32N 131-38E	9930-Z	7950-X	
Vaerlandet	61-18N 004-42E	9007-Y	7499-Y	Country: Norway Phone/Fax: 577 31 183 E-mail: lorsta.vaerlandet@enivest.no
Xuancheng	31-04N 118-53E	8390-Master	7430-X	

600H. Obtaining LORAN-C Operation Status

Civilian customers: GMDSS messages are broadcast via NAVTEX & INMARSAT-C systems.

NAVY customers: WWNWS via HYDROPAC, HYDROLANT & HYDROARC warnings (see Chapter 3).

Online: European LORAN-C status via http://www.loran-europe.eu.

Contact station/Chain directly: see section 600G for contact information.

PART II GLOBAL POSITIONING SYSTEM (GPS)

600I. Definitions & Acronyms

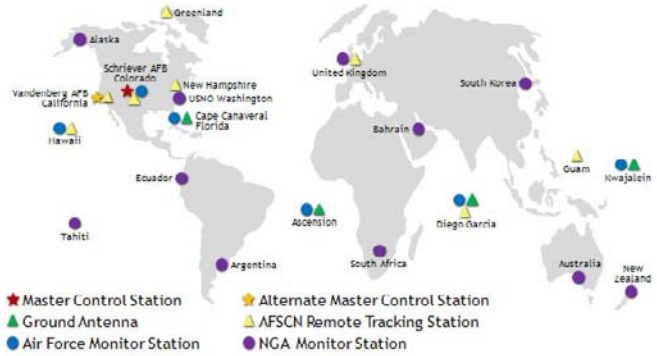
– GPS: **G**lobal **P**ositioning **S**ystem.
– NAVSTAR: **NAV**igation **S**ignal **T**iming **a**nd **R**anging.
– GLONASS: **GL**obal **NA**vigation **S**atellite **S**ystem (Russian System).
– Block: is the generation of the operational satellites.
– Plane: is the satellite's orbit.
– **P**seudo **R**andom **N**oise Code (PRN): is the unique identifying sequence code that each satellite produces. The complex code guarantees that the receiver won't accidentally pick up another satellite signal, so all the satellites can use the same frequency without jamming each other.
– Slot: is the position in the plane.

600J. GPS Basics

The U.S. System is called NAVSTAR Global Positioning System by the U.S. Air Force. This system consists of three segments. The space segment, the control segment, and the user segment.

The space segment consists of the satellites themselves operated by the U.S. Air Force. The GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200km. Each satellite circles the Earth twice a day. They are arranged into six equally-spaced orbital planes around the Earth, each containing four slots occupied by baseline satellites. This 24-slot arrangement ensures there are at least four satellites in view from virtually any point on the planet. The 24 satellites is the core amount; however, the Air Force has extra satellites due to predictable and unpredictable reasons. In June 2011, The Air Force expanded the 24 slots by repositioning six satellites allowing three of the extra satellites to become part of the constellation baseline. The now 27-slot constellation improved GPS coverage in most parts of the world.

The control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses and send commands and data to the constellation. The 2nd Space Operations Squadron of the U.S. Air Force is responsible for the 24/7 command and control of the GPS constellation. The Master Control Station at Schriever Air Force Base in Colorado Springs, Colorado, ensures continuous GPS availability and high accuracy to millions of users, both military and civilian. The control segment also consists of an alternate master control station, 12 command and control antennas and 16 monitoring sites.



Accuracy depends on various factors such as atmospheric effects and receiver quality. GPS augmentation systems provide accuracy, integrity, availability, or any other improvement to positioning, navigation, and timing that is not inherently part of GPS itself. There are a wide range of systems for the public, private sectors, and military customers. The most common augmentation system for civilian shipping and survey operations is the Differential GPS System, DGPS. There are two types; the first one is called the Nationwide Differential GPS (NDGPS) and within this system there the maritime component which is operated by the U.S. Coast Guard and the inland component is funded by the Department of Transportation (DOT). The second type of DGPS is the Global Differential GPS System (GDGPS) which have ground receivers worldwide (see section 600L).

The user segment consists of the GPS receiver equipment, which receives the signals from the GPS satellites and uses the transmitted information to calculate the user's three-dimensional position and time.

600K. Status of GPS Constellation Messages

– **Civilian Customers:**

By Phone: (1) 703 313 5907

Radio Station: WWV & WWVH *(see Chapter 2, section 200C)*

NAVTEX broadcasts: B_2 Character *(see Chapter 3, section 300C)*

INMARSAT-C broadcasts: NAVAREA IV & XII *(see Chapter 3, section D & G)*

Web: U.S. Coast Guard Constellation Status website http://navcen.uscg.gov/?Do=constellationStatus

Contact/Subscriptions: U.S. Coast Guard Navigation Center, NAVCEN MS 7310, 7323 Telegraph Road, Alexandria, VA 20598-7310, Phone: 703 313 5900

– **Military Customers:**

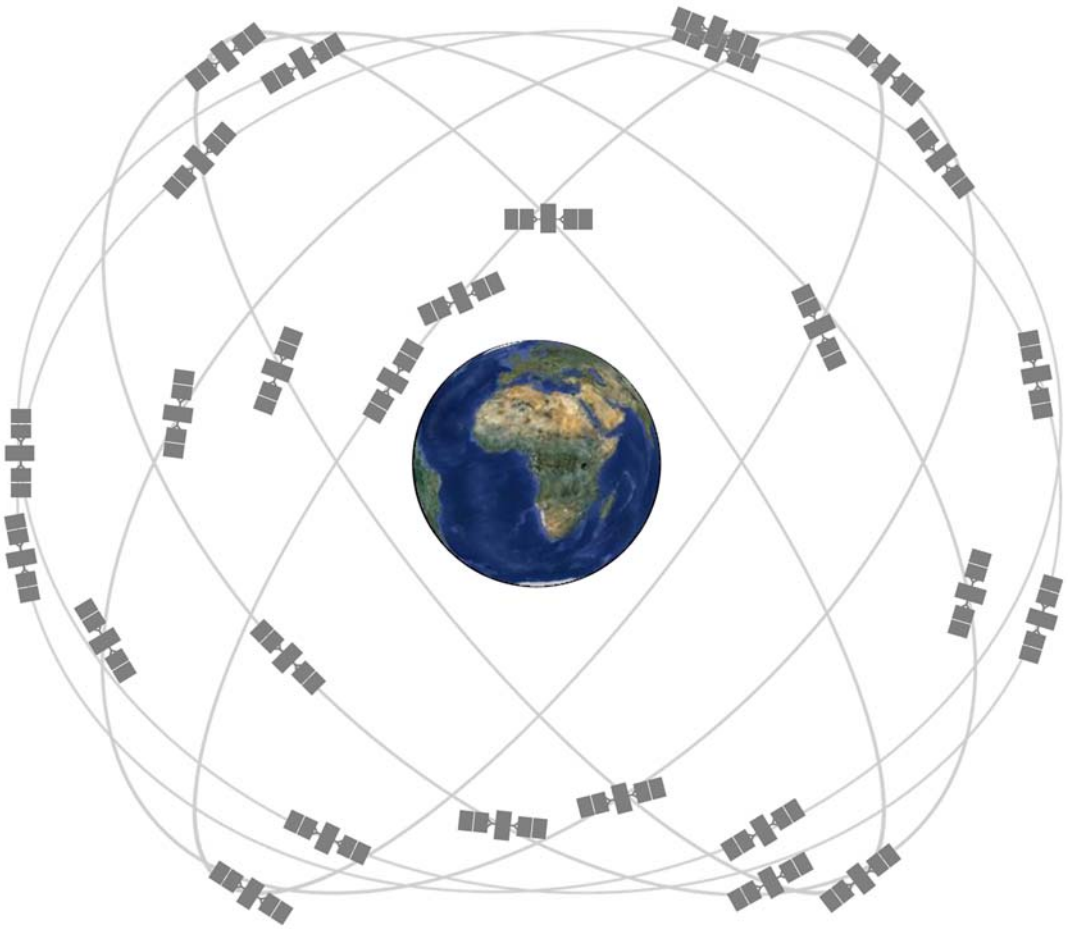
By Phone: (1) 703 313 5907

Radio Station: WWV & WWVH *(see Chapter 2, section 200D & E)*

AMHS broadcasts: NAVAREA IV, NAVAREA XII, HYDROLANT, HYDROPAC, HYDROARC *(see Chapter 3, section D & G)*

Web: U.S. Coast Guard Constellation Status website http://navcen.uscg.gov/?Do=constellationStatus

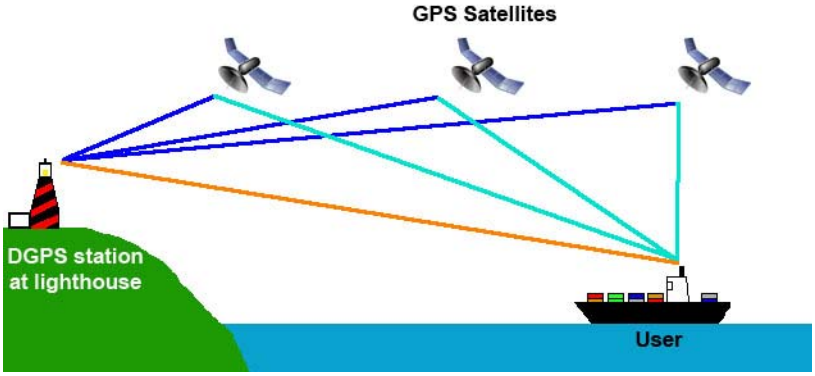
Contact/Subscriptions: GPS Operations Center, 300 O'Malley Ave, Suite 41, Colorado Springs, CO 80912-3041, Phone: 719 567 2541, DSN: 560 2541, E-mail: gps_support@schriever.af.mil



PART III DIFFERENTIAL GLOBAL POSITION SYSTEM (DGPS)

600L. DGPS Basics

Differential Global Position System (DGPS) is a service used to make GPS positions more accurate by using a fixed station as one of the Lines of Positions (LOP) when obtaining that position. When a vessel has a DGPS receiver, it collects all GPS signals in view and the differential corrections from nearby DGPS sites and displays the more accurate position.



Frequency: DGPS transmissions are broadcast in the 285 to 325 KHz band which is allocated for maritime radionavigation (radiobeacons). Marine radiobeacons which are selected for DGPS service will simultaneously broadcast DGPS and radio direction finding (RDF) signals either on the main carrier or dual carrier.

DGPS Message Types:

Type 1: DGPS corrections.
Type 2: Delta DGPS corrections.

Type 3: GPS reference station parameters. Broadcast time is 15 and 45 minutes past the hour.

Type 5: is used to notify the users if a satellite is unusable for DGPS navigation. Broadcast time is 5 minutes past the hour and every 15 minutes thereafter, only when needed.

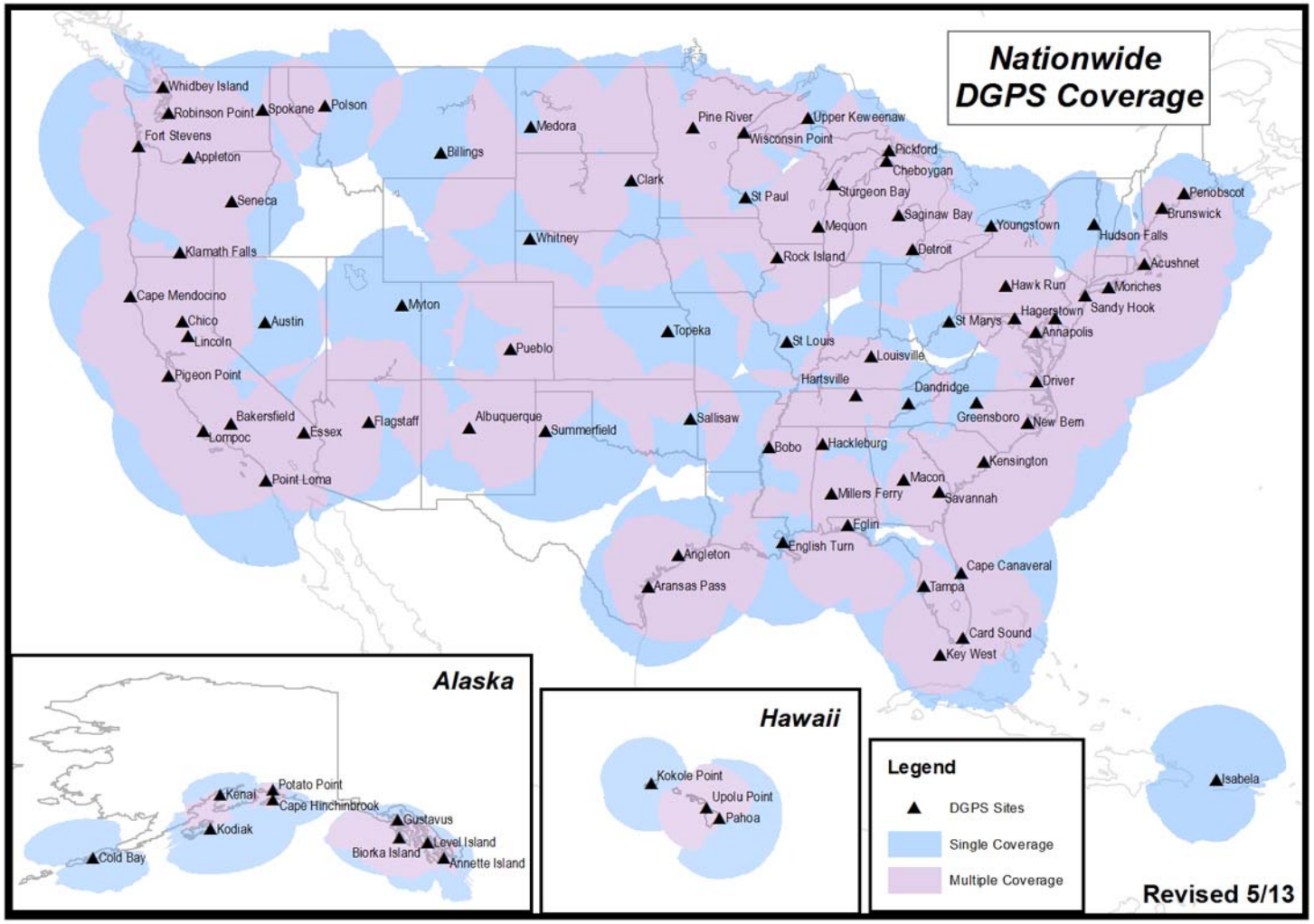
Type 6: if the reference receiver can no longer generate pseudorange corrections, type 6 messages will be broadcast in which the header will be set to indicate an unhealthy condition.

Type 7: is broadcast from a marine radiobeacon and will contain information for two or three adjacent marine radiobeacons which are part of the DGPS Network, in addition to itself. Broadcast time is at 10 minute intervals beginning at 7 minutes past the hour. When a beacon has any changes an update is issued within 2 minutes.

Type 9: serves as the exclusive message type for broadcasting pseudorange corrections. This type of message contains the freshest possible corrections because the corrections contained in each message are computed at different times. Corrections will be broadcast only for satellites at an elevation angle of 7.5 degrees or higher. Broadcasts only when needed but within strict limits. Type 16 messages will not be broadcast for a period of at least 90 seconds preceding or following a type 3, 5, or 7 message and the interval between successive type 16 messages will be no less than 3 minutes.

Type 16: provides information on the status of the local DGPS service which is not provided in other message types. Additionally, the message may provide limited information on service outages in adjacent coverage areas or planned outages for scheduled maintenance at any broadcast site. In order to keep data link loading to a minimum, only crucial information for safety of navigation will be provided.

For the waters of the United States: the U.S. Coast Guard Navigation Center operates the Nationwide Differential GPS (NDGPS) service that consists of one control center and 85 remote broadcast sites. Users can expect better than 10-meter accuracy within the coverage area. Differential corrections are based on the NAD83 (2011) position of the reference station (REFSTA) antenna. Positions obtained using DGPS should be referenced to NAD83 coordinate system only. All sites are broadcasting RTCM Type 9-3 correction messages.



600M. Where to Obtain Station Data

The National Geospatial-Intelligence Agency publishes DGPS station data within the List of Lights publications 110-116 for waters outside of the U.S. When the DGPS station is located at a light, the station data is located within the light section of the publication. A stand-alone DGPS station is listed at the end of the publication under the Differential GPS Stations section. The U.S. Coast Guard Navigation Center (NAVCEN) publishes their DGPS station data in the USCG Light List as well as the NAVCEN website under the DGPS section http://www.navcen.uscg.gov.

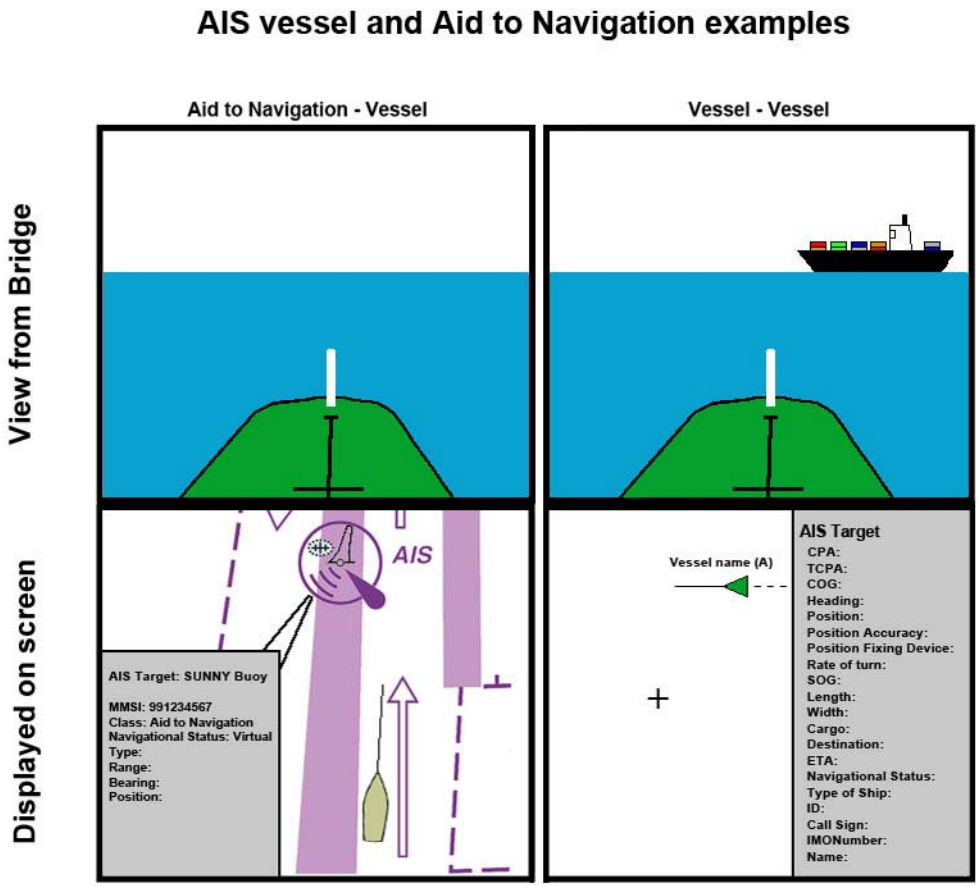
Operational outages are broadcast through the Worldwide Navigational Warning Service via GMDSS MSI broadcasts (civilian) or AMHS (military) systems as described in Chapter 3. U.S. DGPS outage information can also be obtained by Phone: 703 313 5900, E-mail: tis-pf-nisws@uscg.mil, Website: http://www.navcen.uscg.gov.

PART IV AUTOMATIC IDENTIFICATION SYSTEM (AIS)

600N. General

AIS transponders exchange data between vessels, aids to navigation (AtoN), Search and Rescue (SAR) authorities, and Vessel Traffic Services (VTS) via the very hight frequency (VHF) band and display the data on a screen (ECDIS, Radar, etc.).

–AIS on vessels
–AIS on Aids to Navigation
–AIS used for VTS



600O. Automatic Identification System (AIS) on Vessels

Regulation 19 of SOLAS Chapter V requires AIS to be fitted aboard all ships:

–300 gross tonnage and upwards engaged on international voyages
–cargo ships of 500 gross tons and upwards not engaged on international voyages
–all passenger ships irrespective of size

AIS is required to be in operation at all times except where international agreements, rules or standards provide for protection of navigational information. For more information go to http://www.imo.org. The regulation requires that AIS shall:

–Provide information, including the ship's identity, type, position, course, speed, navigational status and other safety-related information, automatically to appropriately equipped shore stations, other ships and aircraft.
–Receive automatically such information from similarly fitted ships, monitor and track ships.
–Exchange data with shore-based facilities.

AIS is now fitted on Emergency Position-Indicating Radio Beacons (EPIRB) and Search And Rescue Transponders (SART) using AIS channels.

600P. Types of AIS on Aids to Navigation (AtoN)

1) Real AIS Aid to Navigation (AtoN): AIS located on a physical AtoN.

–Type 1: Transmit (TX) only.
–Type 2: Receive (RX) & transmit (TX), but the receive part is only for remote configuration.
–Type 3: full receive (RX) & transmit (TX) capabilities.

AIS Chart 1 symbols: S17.1 &17.2

2) Synthetic AIS Aid to Navigation:

–Type 1: Monitored Synthetic AIS AtoN- transmits a message type 21 from AIS station located remotely from AtoN. The AtoN physically exists & there is a com link between the AIS & AtoN.

–Type 2: Predicted Synthetic AIS AtoN- transmits a message type 21 from AIS station located remotely from AtoN. The AtoN exists but there is no monitoring to confirm either location or status (Example/ best used on fixed aids such as lights, beacons, fish farms, platforms).

–Type 3: Virtual AIS AtoN- used in time-critical situations & dynamic areas where navigational conditions change frequently. (Ideal for areas where temporary aids are used).

–Instant, used for situations such as marking a wreck.
–Temporary, used for situations such as marking works in progress.
–Dynamic, used for situations to replace buoys marking complicated channels.
–Seasonal, used for situations to replace ice buoys.
–Permanent, used for situations to replace buoys in areas where environmental or ecological factors are an issue.

Virtual AIS Chart 1 symbols: S18.1 &18.2