N M E A

NATIONAL MARINE ELECTRONICS ASSOCIATION

NMEA 0183

STANDARD FOR INTERFACING MARINE ELECTRONIC DEVICES

Version 2.00

January 1, 1992

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NMEA Interface Standards are intended to serve the public interest by facilitating interconnection and interchangeability of eqipment, minimizing misunderstanding and confusion between manufacturers, and assisting purchasers in selecting compatiblr equipment.

Standards are adopted by NMEA without regard to whether or not their adoption may involve patents on articles, materials or processes. By such action, NMEA does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting these Standards.

This Standard defines electrical signal requirements, data transmission protocol and timing, and specific sentence formats for a 4800 baud serial data bus. Each bus may have only a single TALKER but may have multiple LISTENERS.

Because of differences in baud rate and other transmission parameters, NMEA 0183 data is not directly compatible with NMEA 0180 or NMEA 0182 Standards.

Equipment that is specified by IMO to meet the SOLAS regulations is governed by the requirements of IEC doc. TC80/WG6. The IEC Standard is aligned closely with the NMEA 0183 Standard. Where possible, differences between the two documents, and sections that pertain specifically to IEC requirements, are indicated herein by the symbol "*" in the margin.

Information on the availability of these standards will be found on the following page.

Availability and Updates of the Standard

This standard may be modified by action of the NMEA Interface Standards Comittee as the need arises.

Updates to this Standard are published periodically in:

Marine Electronics - The Official Journal of the NMEA
330 W. Canton Avenue
Winter Park, FL 32789
U.S.A.

For additional or updated copies of this standard, contact:

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For copies of IEC STandard doc. TC80/WG6, contact:

International Electrotechnical Commission
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P.O. Box 131
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1. Introduction

1.1 Scope

This standard is developed to permit ready and satisfactory data communication between electronic marine instruments, navigation equipment and communications equipment when interconnected via an appropriate system.

1.2 Intended Application and Limitations on Use

This standard is intended to support one-way serial data transmission from a single TALKER to one or more LISTENERs. This is data in printable ASCII form and may include information such as position, speed, depth, frequeny allocation, etc. Typical messages might be 20 to 80 characters in length and generally require transmission no more often than once per second.

The electrical definitions in this standard are not intended to accommodate high-bandwidth applications such as radar or video imagery, or intensive databased or file transfer applications.

Since there is no provision for garanteed delivery of messages

and only limited error checking capability, this standard should be used with caution in critical applications.

1.3 Definitions

1.3.1 General

Common terms are defined in Apendix IV, Glossary, of this Standard. Where there is a conflict terms shall be interpreted wherever possible in accordance with the references in Section 1.4.

1.3.2 TALKERs

A TALKER is any device which sends data to other devices within this specification. The type of TALKER is identified by a 2-character mnemonic as listed in Section 6.2 (Table 4).

1.3.3 LISTENERs

A LISTENER is any device which receives data from another device within this specification.

1.4 References

1.4.1 American National Standards Institute:

A. ANSI X 3.15 1976 ANSI Character Structure and Character Parity Sense for Serial-by-Bit Communication

B. ANSI X 3.16 1976 ANSI for Bit Sequencing of the ANS Code or Information Interchange in Serial-By-Bit Data Transmission.

C. ANSI X 3.14 1977 ANSI Code for Information Interchange

1.4.2 Electronic Industries Association Standards:

A. EIA-422-A December 1978 (CCITT X.27/V.11)

1.4.3 International Electrotechnical Commission:

A. IEC 945, Marine Navigational Equipment - General Requirements

B. IEC doc. TC80/WG6

1.4.4 American Practical Navigator, Defence Mapping Agency Hydrographic/Topographic Center, Publication No. 9, DMA Stock No. NVPUB9V1, Volumes I and II

1.4.5 Interface Control Document, Navstar GPS Space Segment/Navigation User Interface. Rockwell International Corporation Document No. ICD-GPS-200 Revision B (November 30, 1987).

2. Manufacturer's Documentation

Operator's manuals or other appropriate literature provided for equipment that is intended to meet the requirements of this standard shall contain the following information:

1. Identification of the A and B signal lines.

2. The output drive capability as a TALKER.

3. A list of approved sentences, noting unused fields, Proprietary sentences transmitted as a TALKER, and transmission interval for each sentence.

4. The load requirements as a LISTENER.

5. A list of sentences and associated data fields that are required as a LISTENER.

6. The current software and hardware revision if this is relevant to the interface.

7. An electrical description or schematic of the LISTENER/TALKER input/output circuits citing actual components and devices used, including connector type and part number.

8. The Version No. and Date of Update of the standard for which compliance is assured.

3. Hardware Specification

One TALKER and multiple LISTENERS may be connected in parallel over an interconnecting wire. The number of LISTENERS depends on the output capability and input drive requirements of individual devices.

3.1 Interconnecting Wire

Interconnection between devices may be by means of a two-conductor, shielded, twisted-pair wire.

3.2 Conductor Definitions

The conductors referred to in this standard are the signal lines "A" and "B", and shield.

3.3 Electrical Connections/Shield Requirements

All signal line "A" connections are connected in parallel with all device "A" connections and all signal line "B" connections

are connected in parallel with all device "B" connections. The shield should be connected to the TALKER chassis and should not be connected at any LISTENER. However, the shield should be continuos (unbroken) between all listeners.

* A continuous DC path between TALKER and LISTENER signal grounds
* is required as provided for by EIA-422 if EIA-422 receivers are
* used in IEC applications. This path is generally part of the
* equipment safety (or chassis) grounding system.

3.4 Connector

No standard connector is specified. Wherever possible readily available commercial connectors should be used. Manufacturers shall provide means for user identification of the connections used.

3.5 Electrical Signal Characteristics

This section describes the electrical characteristics of transmitters and receivers.

3.5.1 Signal State Definitions

The idle, marking, logical "1", OFF or stop bit state is defined by a negative voltage on line "A" with respect to line "B".

The active, spacing, logical"0", ON or start bit state is defined by a positive voltage on line "A" with respect to line "B".

Note that the above "A" with respect to "B" levels are inverted from the voltage input/output requirements of standard UARTs and that many line drivers and receivers provide a logical inversion.

3.5.2 TALKER Drive Circuits

No provision is made for more than a single TALKER to be connected to the bus. The drive circuit used to provide the signal "A" and the return "B" shall meet, at a minimum, the requirements of EIA-422-A (December 1978).

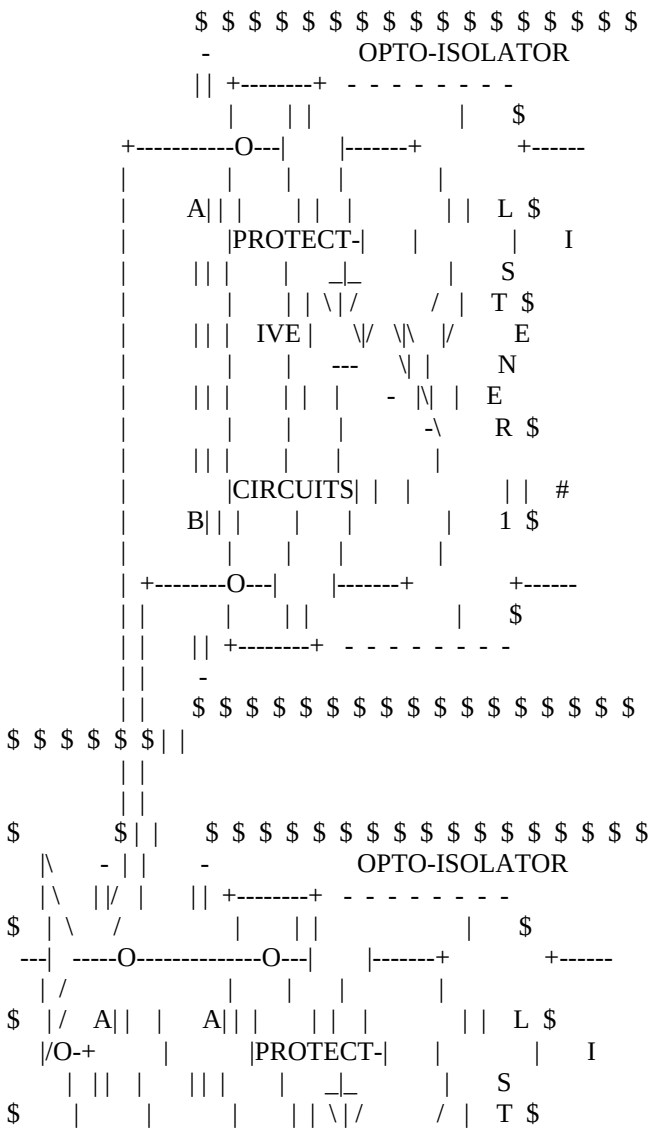
3.5.3 LISTENER Receive Circuits

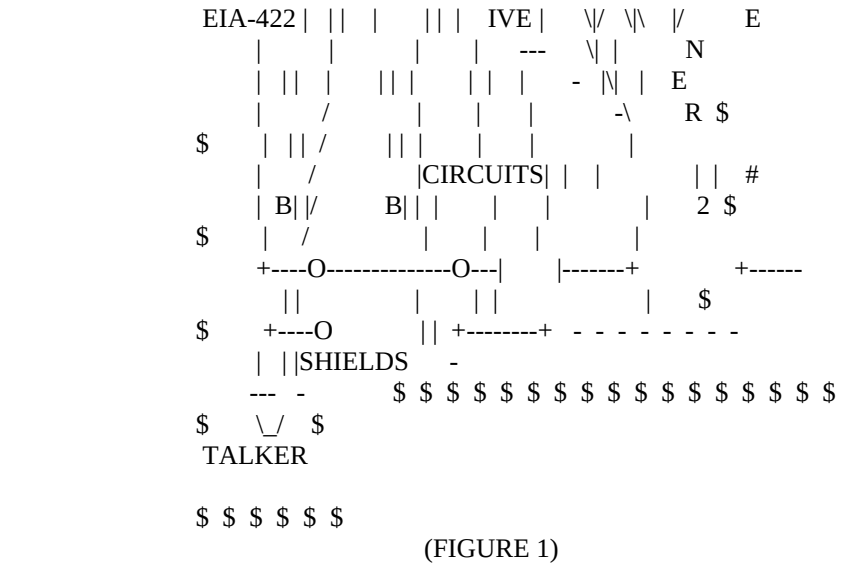
Multiple LISTENERs may be connected to a single TALKER. The LISTENER receive circuit shall consist of an optoisolator and should have protective circuits to limit current, reverse bias and power dissipation at the optodiode as shown in Figure 1. Reference is made to example circuits in Section 7.0 of this Standard.

The receive circuit shall be designed for operation with a minimum differential input voltage of 2.0 volts and shall not take more than 2.0 mA from the line at that voltage.

For reasons of compatibility with equipment designed to earlier versions of this standard, it is noted that the 'idle, marking, logical "1", OFF or stop bit state' had previously< been defined to be in the range -15 to +0.5 volts. The active, spacing, logical "0", ON or start bit state' was defined to be in the range +4.0 to +15 volts while sourcing not less than 15mA.

* In places of this optoisolator receive circuit the IEC alternately
* allows the use of a differential-receiver that meets the require-
* ments of EIA-422-A (December 1978). This configuration is not
* compatible with equipment designed to meet previous versions of
* this standard that made use of single-ended unbalanced drive
* circuits.





(FIGURE 1)

3.5.4 Electrical Isolation

Within a LISTENER there shall be no direct electrical connection between the signal line, "A", return line, "B", or shield and ship's ground or power. Isolation from ships ground is required.

3.5.5 Maximum Voltage on Bus

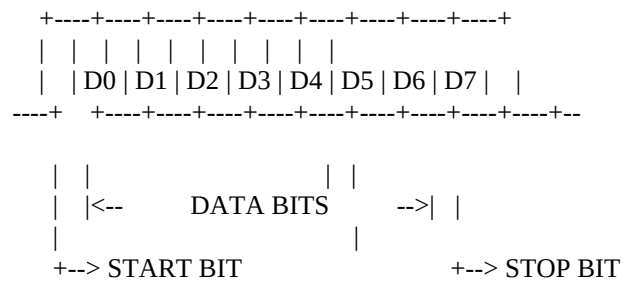
The maximum applied voltage between signal lines "A" and "B" and between either line and Ground will be in accordance with the EIA-422 specification.

For protection against miswiring and for use with earlier TALKER designes, all receive curcuit devices should be capable of with-standing 15 volts between signal lines "A" and "B" and between either line and ground for an indefinite period.

4. Data Transmission

Data is transmitted in serial asynchronous form in accordance with ANSI standards (reference paragraph 1.4.1). The first bit is a start bit and is followed by data bits, least-significant-bit first as illustrared by Figure 2. The following parameters are used:

Baud rate 4800
Data bits 8 (d7 = 0)
Parity None
Stop bits One



(FIGURE 2)

5. Data Format Protocol

5.1 Characters

All transmitted data shall be interpreted as ASCII characters. The most significant bit of the 8-bit character shall always be transmitted as zero (d7 = 0).

5.1.1 Reserved Characters

The reserved character set consist of those ASCII characters shown in Section 6.1 (Table 1). These characters are used for specific formatting purposes, such as sentence and field delimiting, and may not be used in data fields.

5.1.2 Valid Characters

The valid character set consist of all printable ASCII characters (HEX 20 to HEX 7E) except those defined as reserved charcters. Section 6.1 (Table 2) lists the valid character set.

5.1.3 Undefined Characters

ASCII values not specified as either "reserved characters" or "valid characters" are excluded and may not be transmitted at any time.

5.1.4 Character Symbols

When individual characters are used in this standard to define units of measure, indicate the type of data field, type of sentence, etc. they will be interpreted according to the character symbol table in Section 6.1 (Table 3).

5.2 Fields

A Field consists of a string of valid characters, or no characters (null field), located between two appropriate delimiter characters.

5.2.1 Address Field

An address field is the first field in a sentence and follows the "$" delimiter, it serves to define the sentence. Characters within the address field are limited to digits and upper case letters. The address field may not be a null field. Only sentences with the following three types of address fileds may be transmitted:

5.2.1.1 Approved Address Field

Approved address fields consist of five characters defined by this standard. The first two characters are the TALKER Identifier, listed in Section 6.2 (Table 4). The next three characters form the Sentence Formatter used to define the format and the type of data. Section 6.2 (Table 5) and Appendix I list approved Sentence Formatters.

5.2.1.2 Query Address Field

The query address consists of five characters and is used for the purpose of requesting transmission of a specific sentence on a separate bus from an identified TALKER.

The first two characters are the TALKER Identifier of the device requesting data, the next two characters are the TALKER Identifier of the device being addressed and the final character is the query character "Q".

5.2.1.3 Proprietary Address Field

The proprietary address field consists of the proprietary charcter "P" followed by a three-character Manufacturer's Mnemonic Code, used to identify the TALKER issuing a proprietary sentence, and any additional characters as required. A list of valid Manufacturer's Mnemonic Codes is contained in Appendix III.

5.2.2 Data Fields

Data Fields in approved sentences follow a "," delimiter and contain valid characters in accordance with the formats illustrated in Section 6.2 (Table 6). Data fields in proprietary sentences contain only valid characters but are not defined by this standard.

Because of the presence of variable data fields and null fields, specific data fileds may only be located within a sentence by observing the field delimiters ",". Therefore it is essential for the LISTENER to locate fields by counting delimiters rather than counting total numbers of characters received from the start of the sentence.

5.2.2.1 Variable Length Fields

Although some data fields are defined to have fixed length, many are of variable lenght in order to allow devices to convey information and to provide data with more or less precission, according to the capability or requirements of a particular device.

Variable length fields may be alpha-numeric or numeric fileds. Variable numeric fields may contain a decimal point and may contain leading or trailing "zeros".

5.2.2.2 Data Field Types

Data fields may be alpha, numeric, alphanumeric, variable length, fixed length, fixed/variable (with a portion fixed in length while the remainder varies). Some fields are constant, with their value dictated by a specific sentence definition. The allowable field types are summarized in section 6.2 (Table 6), Field Type Summary.

5.2.2.3 Null Fields

A null field is a field of length zero, i.e. no character are transmitted in the field. Null fields shall be used when the value is unreliable or not available.

For example, if heading information were not available, sending data of "000" is misleading because a user cannot sidtinguish between "000" meaning no data and a legitimate heading of "000". However, a null field, with no characters at all, clearly indicates that no data is being transmitted.

Null fileds with their delimiters can have the following appearance depending on where they are located in the sentence:

",," ",*" ",<CR><LF>"

The ASCII NULL character (HEX 00) shall not be used as the null field.

5.2.3 Checksum Field

A checksume filed may optionally be transmitted in any sentence.

However some approved sentences specifically require the checksum field. The checksum field is the last field in a sentence and follows the checksum delimiter character "*".

The checksum is the 8-bit exclusive OR (no start or stop bits) of all characters in the sentence, including "," delimiters, between but not including the "$" and the "*" delimiters.

The hexadecimal value of the most significant and least significant 4 bits of the result are converted to two ASCII characters (0-9, A-F) for transmission. The most significant character is transmitted first.

5.3 Sentences

This section describes the general structure of sentences. Details of specific sentences may specify restrictions beyond the general limitations given in this part of the standard. Such restrictions may include defining some fields as fixed length, numeric or text only, required to be non-null, transmitted with a certain frequency, etc.

The maximum number of characters in a sentence shall be 82, consisting of a maximum of79 characters between the starting delimiter "$" and the terminating <CR><LF>.

The minimum number of fields in a sentence is one (1). The first field shall be an address field containing the identity of the TALKER and the sentence formatter which specifies the number of data fields in the sentence, the type of data they contain and the order in which the data fields are transmitted. The remaining portion of the sentence may contain zero or multiple data fields.

The maximum number of fields allowed in a single sentence is limitetd only by the maximum sentence length of 82 characters. Null fields may be presented in the sentence and shall always be used if data for that field is unavailable.

All sentences bebin with the sentence start delimiter character "$" and end with the sentence termination delimiter <CR><LF>.

5.3.1 Approved Sentences

Approved sentences are those designed for general use and detailed in this Standard. Approved sentences are listed in Section 6.3 and Appendix I of the current version of the Standard. Preferred sentences are contain in Section 6.3 and these sentences should be used wherever possible. Appendix I contains sentences that may be phased-out of use, are not recommend for new designes, but may be met in practise.

An approved sentence contains, in the order shown, the following elements:

"$" HEX 24 - Start of sentence
<address field> TALKER identifier and sentence formatter
[","<data field>] Zero or more data fields
.
.
.
[","<data field>]
["*"<checksum field>] Optional checksum field
<CR><LF> Hex 0D 0A - End of sentence

5.3.1.1 Approved Sentence Structure

The following provides a summary explanation of the approved sentence structure: $aaccc,c--c*hh<CR><LF>

ASCII	HEX	DESCRIPTION
"$"	24	Start of Sentence.
aaccc		Address Field. Alphanumeric characters identifying type of TALKER, and Sentence Formatter. The first two characters identify the TALKER. The last three are the Sentence Formatter mnemonic code identifying the data type and the string formt of the successive Fields. Mnemonics will be used as far as posible to facilitate readouts by users.
","	2C	Field delmiter. Starts each Field except Address and Checksum fields. If it is followed by a null field, it is all that remainsto indicate no data in field.
c--c		Data sentence block. Follows Address field and is a series of data fields containing all of the data to be transmitted. Data field sequences is fixed and identified by 3rd and subsequent characters of the address field (the "Sentence Formatter"). Data fields may be of variable length and are preceded by delimiters ",".
"*"	2A	Optional Checksum Delimiter. Follows last Data field of the sentence. It indicates that the following two alpha-numeric characters show the HEX value of the CHECKSUM.
hh		Optional Checksum Field. The absolute value calculatedby exclusive-OR'ing the 8

data bits (no start bits or stop bits) of each character in the Sentence, between, but excluding "$" and "*". The hexadecimal value of the most significant and least significant 4 bits of the result are converted to two ASCII characters (0-9, A-F) for transmission. The most significant character is transmitted first. The "CHECKSUM" field is optional, except when indicated as mandatory.

<CR><LF> 0D 0A Terminates Sentence.

5.3.2 Query Sentences

Query sentences are intended to request Approved sentences to be transmittetd from a TALKER on a seperate bus in a form of two way communication.

The approved Query sentence contains, in the order shown, the following elements:

"$"	HEX 24 - Start of sentence
<aa>	TALKER Identifier or requester
<aa>	TALKER Identifier for device from which data is being requested
"Q"	Query character identifies Query address
","	Data field delimiter
<ccc>	Approved sentence formatter of data being requested
["*"<checksum field>]	Optional checksum field
<CR><LF>	HEX 0D 0A - End of sentence

5.3.2.1 Reply to Query Sentence

The reply on a seperate bus to a Query sentence is the Approved sentence that was requested. The use of Query sentences requires cooperation between the devices that are interconnected, a reply to a Query sentence is not mandatory and there is no specified time delay between the receipt of a query and the reply.

5.3.3 Proprietary Sentences

Proprietary sentences provide a means for manufacturers to use the sentence structure definitions of this standard to transfer data which does not fall within the scope of approved sentences. This will generally be for one of the following reasons:

-Data is intended for another device from the same manufacturer, is device specific, and not in a form or of a type of interest to the general user;

-Data is being used for test purposes prior to the adoption of approved sentences;

-Data is not of a type and general usefulness which merits the creation of an approved sentence.

A proprietary sentence contains, in the order shown, the following elements:

"$"	Hex 24 - Start of sentence
"P"	Hex 50 - Proprietary sentence ID
<aaa>	Manufacturer's Mnemonic code
[<valid characters, manufacturer's data>]	
["*"<checksum field>]	Optional checksum field
<CR><LF>	Hex 0D 0A - End of sentence

Beyond limiting overall sentence length are requiring the use of only valid characters, details of proprietary data fields will not be included in this standard and need not be submitted for approval. However it is required that such sentences be published in the manufacturer's manuals for reference.

5.3.4 Valid Sentences

Approved sentences, Query sentences and Proprietary sentences are the only valid sentences. Sentences of any other form are non-valid and shall not be transmitted on the bus.

5.3.5 Sentences Transmission Timing

Frequency of sentence transmission when specified shall be in accordance with the approved sentence definitions (Section 6.3 and Appendix I): When not specified, the rate should be consistent with the basic measurement or calculation cycle but generally not more frequently than once per second.

It is desirable that sentences be transmitted with minimum inter-character spacing, preferably as a near continuous burst, but under no circumstance shall the time to complete the transmission of a sentence be greater than 1 second.

5.3.6 Additions to Approved Sentences

In order to allow for improvements or additions, future revisions of this Standard may modify existing sentences by adding new data fields after the last data field but before the optional checksum delimiter character "*" and checksum field. LISTENERs should determine the end of the sentence by recognition of "<CR><LF>" and "*" rather than by counting field delimiters. The checksum value should be computed on all received characters between, but not including, "$" and "*" whether or not the LISTENER recognizes

all fields.

6. Data Content

6.1 Character Definitions

TABLE 1 - RESERVED CHARACTERS

	HEX	DEC	
<CR>	0D	13	Carriage return } End of sent-
<LF>	0A	10	Line feed } tence delimiter
$	24	36	Start of sentence delimiter
*	2A	42	Checksum field delimiter
,	2C	44	Field delimiter
!	21	33	Reserved for future use
\	5C	92	Reserved for future use
^	5E	94	Reserved for future use
~	7E	126	Reserved for future use

TABLE 2 - VALID CHARACTERS

	HEX	DEC		HEX	DEC		HEX	DEC
Space	20	32	@	40	64	`	60	96
Reserved			A	41	65	a	61	97
"	22	34	B	42	66	b	62	98
#	23	35	C	43	67	c	63	99
Reserved			D	44	68	d	64	100
%	25	37	E	45	69	e	65	101
&	26	38	F	46	70	f	66	102
'	27	39	G	47	71	g	67	103
(	28	40	H	48	72	h	68	104
)	29	41	I	49	73	i	69	105
Reserved			J	4A	74	j	6A	106
+	2B	43	K	4B	75	k	6B	107
Reserved			L	4C	76	l	6C	108
-	2D	45	M	4D	77	m	6D	109
.	2E	46	N	4E	78	n	6E	110
/	2F	47	O	4F	79	o	6F	111
0	30	48	P	50	80	p	70	112
1	31	49	Q	51	81	q	71	113
2	32	50	R	52	82	r	72	114
3	33	51	S	53	83	s	73	115
4	34	52	T	54	84	t	74	116
5	35	53	U	55	85	u	75	117
6	36	54	V	56	86	v	76	118
7	37	55	W	57	87	w	77	119
8	38	56	X	58	88	x	78	120
9	39	57	Y	59	89	y	79	121
:	3A	58	Z	5A	90	z	7A	122
;	3B	59	[	5B	91	{	7B	123
<	3C	60	Reserved			|	7C	124
=	3D	61	]	5D	93	}	7D	125

>	3E	62	Reserved	Reserved	
?	3F	63	_	5F	95	--------

6.1 Character Definitions
(continued)

TABLE 3 - CHARACTER SYMBOL TABLE

A Status symbol; Yes; Data Valid; Warning Flag Clear; Auto
a Alphabet character variable A through Z or a through z
B Bars (pressure, 1000 Mb equal 1 Std. Atm.); Bottom
C Celsius (Degrees); Course-up
c Valid characters; Calculating
D Degrees (of Arc)
E Error; East; Engine
F Fathoms
f Feet
G Great Circle; Green
g Good
H Compass Heading; Head-up; Hertz; Humidity
h Hours; HEX number
I Inches
J Input operation completed
K Kilometers; Km/hour
k Kilograms
L Left; Local; Lost Target
l Latitude; Liters; Liters/second
M Meters; Meters/second; Magnetic; Manual; Cubic Meters
m Minutes; message
N Nautical miles; Knots; North; North-up; Newtons
n Numeral; address
P Purple; Proprietary (only when following "$"); Position sensor; Percent
Q Query; Target-Being-Acquired
R Right; Rhumb line; Red; Relative; Reference; RADAR Tracking
S South; Statue miles; Statute miles/hour; Shaft
s Seconds
T Time difference; True; Track; Tracked-Target
t Test
U Dead Reckoning Estimate
u Sign, if minus "-" (HEX 2D)
V Data invalid; No; Warning Flag Set; Manual
W West; Water
x Numeric Character variable
y Longitude
Z Time

6.2 Field Definitions

TABLE 4 - TALKER IDENTIFIER MNEMONICS
(Address Characters 1 and 2)

TALKER DEVICE		IDENTIFIER
AUTOPILOT:	General	*AG
	Magnetic	AP
COMMUNICATIONS:	Digital Selective Calling (DSC)	*CD
	Satellite	*CS
	Radio-Telephone (MF/HF)	*CT
	Radio-Telephone (VHF)	*CV
	Scanning Receiver	*CX
DECCA Navigation		DE
Direction Finder		*DF
Electronic Chart Display & Information System (ECDIS)		EC
Emergancy Position Indicating Beacon (EPIRB)		*EP
Engineroom Monitoring Systems		ER
Global Positioning System (GPS)		GP
HEADING SENSORS:	Compass, Magnetic	*HC
	Gyro, North Seeking	*HE
	Gyro, Non-North Seeking	HN
Integrated Instrumentation		II
Integrated Navigation		IN
LORAN:	Loran-A	LA
	Loran-C	LC
OMEGA Navigation System		OM
Proprietary Code		P
Radar and/or ARPA		*RA
Sounder, depth		*SD
Electronic positioning system, other/general		TR
Sounder, scanning		SS
Turn Rate Indicator		*TI
TRANSIT Navigation System		TR
VELOCITY SENSORS:	Doppler, other/general	*VD
	Speed Log, Water, Magnetic	VM
	Speed Log, Water, Mechanical	VW
TRANSDUCER		YX
TIMEKEEPERS, TIME/DATE:	Atomic Clock	ZA
	Chronometer	ZC
	Quartz	ZQ
	Radio Update, WWV or WWVH	ZV
Weather Instruments		WI

*
Designated by I.E.C. for use with I.M.O. marine electronic devices. This is the minimum requirement for equipment that is specified by I.M.O. to meet S.O.L.A.S. regulations.

6.2 Field Definitions
(continued)

TABLE 5 - APPROVED SENTENCE FORMATTERS

6.2 Field Definitions
(continued)

6.2 Field Definitions
(continued)

TABLE 6 - FIELD TYPE SUMMARY

Field Type	Symbol	Definition
Special Format Fields:		
Status	A	Single character field: A = Yes, Data Valid, Warning Flag Clear V = No, Data Invalid, Warning Flag Set
Latitude	llll.ll	Fixed/Variable length field: degreed|minutes.decimal - 2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Longitude	yyyyy.yy	Fixed/Variable length field: degreed|minutes.decimal - 3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Time	hhmmss.ss	Fixed/Variable length field: hours|minutes|seconds.decimal - 2 fixed digits of hours, 2 fixed digits of minutes, 2 fixed digits of seconds and a variable number of digits for decimal-fraction of seconds. Leading zeros always included for hours, minutes and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.

6.2 Field Definitions
(continued)

TABLE 6 - FIELD TYPE SUMMARY

(continued)

Field Type	Symbol	Definition
Defined field		Some fileds are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following which are used to indicate field types within this standard: "A", "a", "c", "hh", "hhmmss.ss", "llll.ll", "x", "yyyyy.yy"
Numeric Value Fields:		
Variable numbers	x.x	Variable length integer or floating numeric field. optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required. (example: 73.10 = 73.1 = 073.1 = 73)
Fixed HEX field	hh__	Fixed length HEX numbers only, MSB on the left
Information Fields:		
Variable text	c--c	Variable length valid character field.
Fixed alpha field	aa__	Fixed length field of upper-case or lower case alpha characters
Fixed number field	xx__	Fixed length field of numeric characters
Fixed text field	cc__	Fixed length field of valid characters

NOTES:

1. Spaces may only be used in variable text fields.

2. A negative sign "-" (HEX 2D) is the first character in a Filed if the value is negative. The sign is omitted if value is positive.

3. Units of measure fields are appropriate characters from the Symbol Table (table 3) unless a specific unit of measure is indicated.

6.3 Approved Sentences

General format of printed sentence information:

{mnemonic} - {name}
{definition paragraph}

```
$--{sentence}
 |   |
 |   +-{field descriptions}
 +-------Start of sentence and Talker ID
```

*

Designated by I.E.C. for use with I.M.O. marine electronic devices. This is the minimum requirement for equipment that is specified by I.M.O. to meet S.O.L.A.S. regulations.

AAM - Waypoint Arrival Alarm

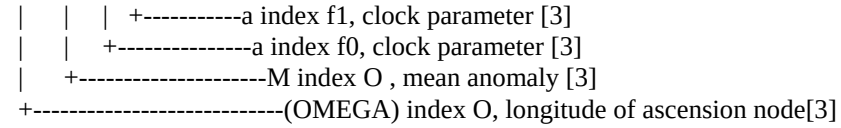
Status of arrival (entering the arrival circle, or passing the perpendicular of the course line) at waypoint c--c.

```
$--AAM,A,A,x.x,N,c--c*hh<CR><LF>
      || | | |
      || | | +---------------Waypoint ID
      || | +-------------------Units of radius, nautical miles
      || +---------------------Arrival circle radius
      | +------------------------Status: A = perpendicular passed at waypoint
      +--------------------------Status: A = arrival circled entered
```

ALM - GPS Almanac Data

Contains GPS week number, satellite health and the complete almanac data for one satellite. Multiple messages may be transmitted, one for each satellite in the GPS constellation, up to maximum of 32 messages.

```
$--ALM,x.x,x.x,xx,x.x,hh,hhhh,...
      |  | |  | |  |
      |  | |  | |  +-------e, eccentricity [3]
      |  | |  |  +-----------SV health, bits 17-24 of each almanac page [2]
      |  | |  +--------------GPS week number [1]
      |  |  +------------------Satellite PRN number, 01 to 32
      |  +---------------------Message number
      +-------------------------Total number of messages


   hh,hhhh,hhhh,hhhhhh,hhhhhh,...
   |  |   |    |     |
   |  |   |    |     +--------Omega, argument of perigee [3]
   |  |   |    +--------------SQRT(A), root of semi-major axis [3]
   |  |   +---------------------OMEGADOT, rate of right ascension [3]
   |  +--------------------------(sigma) index i, inclination angle [3]
   +-----------------------------t index OA, almanac reference time [3]


   hhhhhh,hhhhhh,hhh,hhh*hh<CR><LF>
    |     |    | |
```



Notes:

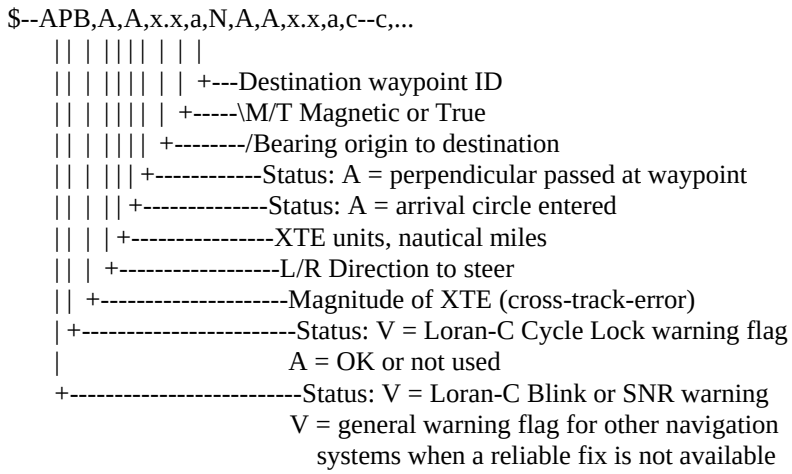
[1] Variable lengh integer, 4-digits maximum. Converted from (10) most significant binary bits of Subframe 1, Word 3. Reference Table 20-I, ICD-GPS-200, Rev. B.

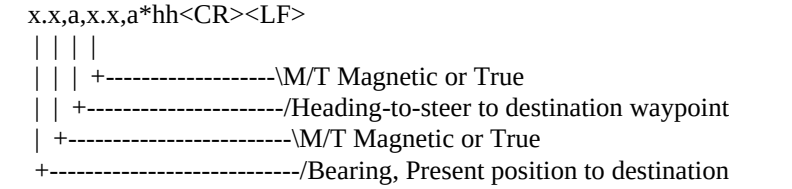
[2] Reference paragraph 20.3.3.5.1.3, Table 20-VII and Table 20-VIII, ICD-GPS-200, Rev. B.

[3] Reference Table 20-VI, ICD-GPS-200, Rev. B for scaling factors and units.

APB - Autopilot Sentence "B"

Commonly used by autopilots this sentence contains navigation receiver warning flag status, cross-track-error, waypoint arrival status, initial bearing from origin waypoint to the destination, continuous bearing from present position to destination and recommended heading-to-steer to destination waypoint for the active navigation leg of the journey.





*ASD - Autopilot System Data

I.M.O. Ref. A342 (IX). Autopilot operating parameters, alarm status commanded course and vessel heading.

(TO BE DETERMINED)

BEC - Bearing & Distance to Waypoint - Dead Reckoning

Time (UTC) and distance & bearing to, and loacation of, a specified waypoint from the dead-reckoned present position.

```
$--BEC,hhmmss.ss,llll.ll,a,...
       |      |     |
       |      |     +-------\N/S North or South
       |      +-------------/Waypoint Latitude
       +------------------------UTC of observation


yyyyy.yy,a,x.x,T,x.x,M,x.x,N,...
 |     | | | | | | |
 |     | | | | | | +--\nautical miles
 |     | | | | | +-----/Distance
 |     | | | | +--------\degrees Magnetic
 |     | | | +-----------/Bearing
 |     | | +--------------\E/W East or West
 |     | +-----------------/Waypoint longitude
 |     +--------------------\N/S North or South
 +---------------------------/Waypoint latitude


c--c*hh<CR><LF>
 |
 +-----------------------------Waypoint ID
```

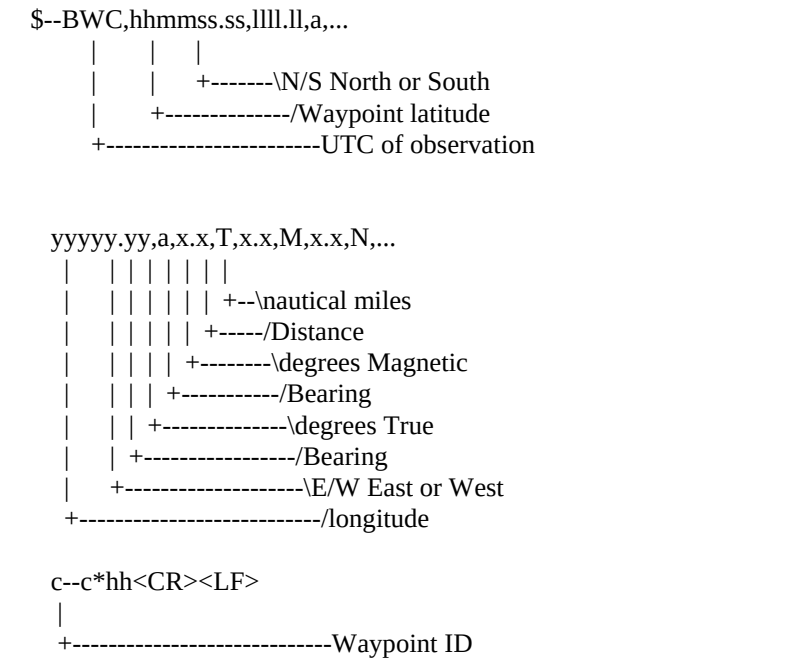

BOD - Bearing - Origin to Destination

Bearing angle of the line, calculated at the origin waypoint, extending to the destination waypoint from the origin waypoint for the active navigation leg of the journey.

```
$--BOD,x.x,T,x.x,M,c--c,c--c*hh<CR><LF>
       | | | | |   |
       | | | | |   +--------Origin waypoint ID
       | | | | +-------------Destination waypoint ID
       | | | +---------------\degrees Magnetic
       | | +-----------------/Bearing
       | +---------------------\degrees True
       +-----------------------/Bearing
```

BWC - Bearing & Distance to Waypoint - Great Circle
BWR - Bearing & Distance to Waypoint - Rhumb Line

Time (UTC) and distance & bearing to, and location of, a specified waypoint from present position. '$--BWR' data is calculated along the rhumb line from present position rather than along the great circle path.



BWW - Bearing - Waypoint to Waypoint

Bearing angle of the line, between the "TO" and the "FROM" waypoints, calculated at the "FROM" waypoint for any two arbitrary waypoints.

```
$--BWW,x.x,T,x.x,M,c--c,c--c*hh<CR><LF>
      | | | | |   |
      | | | | |   +--------FROM waypoint ID
      | | | | +-------------TO   waypoint ID
      | | | +---------------\degrees Magnetic
      | | +-----------------/Bearing
      | +---------------------\degrees True
      +-----------------------/Bearing
```

DBT - Depth Below Transducer

Water depth referenced to the transducer.

```
$--DBT,x.x,f,x.x,M,x.x,F*hh<CR><LF>
      | | | | | |
      | | | | | +---------\Fathoms
      | | | | +------------/Water depth
      | | | +---------------\Meters
      | | +-----------------/Water depth
      | +---------------------\feet
      +-----------------------/Water depth
```


DCN - Decca Position

Status and lines-of-position for a specified Decca chain.

```
$--DCN,xx,cc,x.x,A,cc,x.x,A,...
      | |  | ||  | |
      | |  | ||  |  +------\
      | |  | ||   +----------GREEN
      | |  | |+-------------/
      | |  | +---------------\       Status: Red-Master line, A = valid
      | |  +-------------------RED   :Red Line of position (LOP)
      | +----------------------/       Red Zone identifier, number-letter
      +-------------------------Decca Chain identifier


   cc,x.x,A,A,A,A,x.x,N,x*hh<CR><LF>
   |  | |||| | ||
   |  | |||| | |+---------Fix Data Basis [1]
   |  | |||| |  +----------\nautical miles
```

```
|  | ||||  +-------------/Position uncertainty
|  | |||+-----------------Purple-line navigation use, A = valid
|  | ||+------------------Green -line navigation use, A = valid
|  | |+-------------------Red   -line navigation use, A = valid
|  |  +---------------------\
|  +-------------------------PURPLE
+-----------------------------/
```

Notes:

[1] Fix Data Basis: 1 = Normal pattern
2 = Lane identification pattern
3 = Lane identification transmissions

*DPT - Depth

I.M.O. Ref. A224(VII). Water depth relative to the transducer and offset of the measuring transducer. Positive offset numbers provide the distance from the transducer to the waterline. Negative offset numbers provide the distance from the transducer to the part oft the keel of interest.

```
$--DPT,x.x,x.x*hh<CR><LF>
       |  |
       |  +---------------------Offset from transducer [1], meters:"positive" = distance
       |                                                 from transducer to
       |                                                 water-line
       |                                                "-" = distance from
       |                                                 transducer to keel
       +-------------------------Depth, meters
```

Motes:

* [1] For I.E.C applications the offset shall always be applied so as to
* provide depth relative to the keel.

*FSI - Frequency Set Information

This sentence is used to set frequency, mode of operation and transmitter power level of a radiotelephone; to read out frequencies, mode and power ant to acknowledge setting commands.

```
$--FSI,xxxxxx,xxxxxx,c,x+hh<CR><LF>
       |     |   ||
       |     |   | +----------Power level, 0 = Standby; 1 = lowest; 9 = highest
       |     |   +------------Mode of operation [1]
       |     +-----------------Receiving    frequency [2][3]
       +-----------------------Transmitting frequency [2][3]
```

Notes:

[1] Mode of operation:

d = F3E/G3E simplex, telephone	w = F1B/J2B, teleprinter/DSC
e = F3E/G3E duplex, telephone	x = A1A Morse, tape recorder
m = J3E , telephone	{ = A1A Morse, morse key/head set
o = H3E , telephone	| = F1C/F2C/F3C, FAX-machine
q = F1B/J2B FEC NBDP, TELEX/teleprinter	null for no information
s = F1B/J2B ARQ NBDP, TELEX/teleprinter	
t = F1B/J2B receive only, teleprinter/DSC	

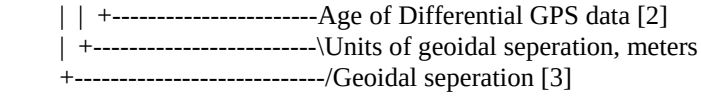
[2] Frequencies to be in 100 Hz increments.
MF/HF telephone channels to have first digit 3 followed by ITU channel numbers with leading zeros as required.
MF/HF teletype channels to have first digit 4; the second ans third digit frequency bands; and the fourth to sixth digits ITU channel numbers; each with leading zeros as required.
VHF channels to have the first digit 9 followed by channel numbers with leading zeros as required

[3] For paired frequencies zhe transmitting frequency only need to be included; null for receiving frequency field. For receive frequency only, the transmitting frequency field shall be null.

GGA - Global Positioning System Fix Data

Time, position and fix related data for a GPS receiver.

```
$--GGA,hhmmss.ss,llll.ll,a,...
       |     |    |
       |     |    +-------\N/S North or South
       |     +-------------/Latitude
       +---------------------UTC of position


yyyyy.yy,a,x,xx,x.x,x.x,M,...
 |     |||  |  | |
 |     |||  |  | +-----\Units of antenna altitude, meters
 |     |||  |  +-------/Antenna altitude above/below mean-sea-level (geoid)
 |     |||  +------------Horizontal dilution of precision
 |     || +-----------------Number of satellites in use, 00-12,
 |     ||                   may be different from the number in view
 |     | +-------------------GPS quality indicator [1]
 |     +--------------------\E/W East or West
  +---------------------------/Longitude


x.x,M,x.x,xxxx*hh<CR><LF>
| | |  |
| | |  +-------------------Differential reference station ID, 0000-1023
```



Notes:

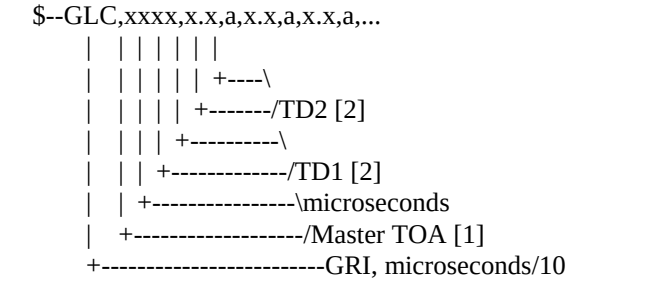
[1] GPS quality indicator: 0 = fix not available or invalid
1 = GPS fix
2 = Differential GPS fix

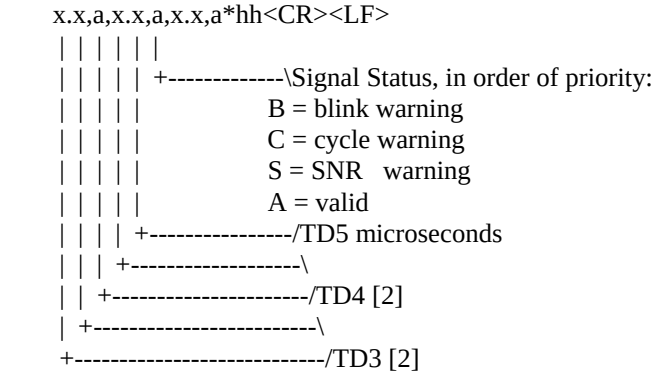
[2] Time in seconds since last SC104 Type 1 or 9 update, null field when DGPS is not used

[3] Geoidal Seperation: the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid), "-" = mean-sea-level below ellipsoid.

GLC - Geographic Position - Loran-C

Loran-C GRI, status and Time Difference (TD) lines of position for present vessel position.





Notes:

[1] Master TOA provides for direct ranging operation. It may be the actual range to Master in microseconds or be offset and

track the arrival of the Master signal.

[2] Time difference numbers are in the Loran-C Coding Delay order with null fields used when values are unavailable.

GLL - Geographic Position - Latitude/Longitude

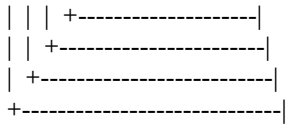
Latitude and Longitude of present vessel position, time of position fix and status.

```
$--GLL,llll.ll,a,yyyyy.yy,a,hhmmss.ss,...
      |    |  |     |  |
      |    |  |     |  +---UTC of position
      |    |  |     +------\E/W East or West
      |    |  +-------------/Longitude
      |    +-----------------\N/S North or South
      +------------------------/Latitude


A*hh<CR><LF>
|
+-------------------------------Status: A = Data valid
```

GSA - GPS DOP and Active Satellites

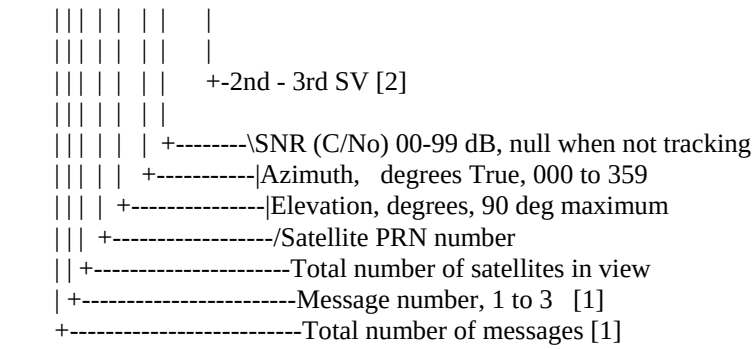
GPS receivers operating mode, satellites used for navigation and DOP values.

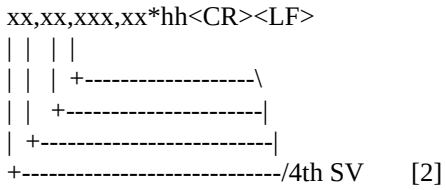
```
$--GSA,a,x,xx,xx,xx,xx,xx,xx,xx,...
      | | | | | | | | |
      | | | | | | | |  +---|
      | | | | | | |  +------|
      | | | | | |  +---------|
      | | | | |  +------------|
      | | | |  +---------------|
      | | |  +------------------|PRN numbers of satellites used in
      | | +----------------------/solution (null for unused fileds)
      | +------------------------Mode: 1 = Fix not available
      |                              2 = 2D
      |                              3 = 3D
      +--------------------------Mode: M = Manual, forced to operate in 2D or 3D mode
                                     A = Automatic, allowed to automatically switch 2D/3D


xx,xx,xx,xx,xx,x.x,x.x,x.x*hh<CR><LF>
| | | | |  |  |  |
| | | | |  |  |  +------VDOP
| | | | |  |  +----------HDOP
| | | | |  +-------------PDOP
| | | | +------------------\
```



GSV - GPS Satellites in View

Number of SVs in view, PRN numbers, elevation, azimuth and SNR value. Four satellites maximum per transmission, additional satellite data sent in second or third message. Total number of messages being transmitted and the number of the message being transmitted is indicated in the first two fields.





Notes:

[1] Satellite information may require the transmission of multiple messages. The first field specifies the total number of messages, minimum value 1. The second field identifies the order of this message (message number), minimum value 1.

[2] A variable number of 'PRN-Elevation-Azimuth-SNR' sets are allowed up to a maximum of four sets per message. Null fields are not required for unused sets when less than four sets are transmitted.

GXA - TRANSIT Position

Location and time of TRANSIT fix at waypoint "c--c":

```
$--GXA,hhmmss.ss,llll.ll,a,...
       |       |    |
       |       |    +-------\N/S North or South
       |       +-------------/Latitude
       +-----------------------UTC of position fix


yyyyy.yy,a,c--c,x*hh<CR><LF>
  |     | |  |
  |     | |  +--------------Satellite number
  |     |  +-----------------Waypoint ID
  |     +--------------------\E/W East or West
  +---------------------------/Longitude
```

*HDG - Heading, Deviation & Variation

I.M.O. Ref. A382 (X). Heading (magnetic sensor reading), which if corrected for deviation, will produce Magnetic heading, which if offset by variation will provide True heading.

```
$--HDG,x.x,x.x,a,x.x,a*hh<CR><LF>
       |  | | | |
       |  | | |  +-----------\E/W East or West [2] [3]
       |  | |  +--------------/Magnetic variation, degrees
       |  |  +-----------------\E/W East or West [1] [3]
       |   +--------------------/Magnetic deviation, degrees
       +-------------------------Magnetic sensor heading, degrees
```

Notes:

[1] To obtain Magnetic heading:
Add Easterly deviation (E) to Magnetic Sensor Reading
Subtract Westerly deviation (W) from Magnetic Sensor Reading

[2] To obtain True Heading:
Add Easterly variation (E) to Magnetic Heading
Subtract Westerly variation (W) from Magnetic Heading

[3] Variation and deviation fields will be null fields if unknown.

*HDT - Heading - True

I.M.O. Ref. A424 (XI). Actual vessel heading in degrees True produced by any device or system producing true heading.

```
$--HDT,x.x,T*hh<CR><LF>
       | |
       |  +---------------------\True
       +------------------------/Heading, degrees
```

HSC - Heading Steering Command

Command heading to steer vessel.

```
$--HSC,x.x,T,x.x,M*hh<CR><LF>
      | | | |
      | | |  +---------------\Magnetic
      | |  +------------------/Commanded heading, degrees
      |  +---------------------\True
      +-------------------------/Commanded heading, degrees
```


LCD - Loran-C Signal Data

Signal-to-Noise ratio and pulse shape (ECD) data for Loran-C signals.

```
$--LCD,xxxx,xxx,xxx,xxx,xxx,...
      |   |  |  |  |
      |   |  |  |   +-------\
      |   |  |  +-----------/S1 [1]
      |   |  +--------------\
      |   +-----------------/Master
      +-------------------------GRI, microseconds/10


     xxx,xxx,xxx,xxx,xxx,xxx,...
     |  |  |  |  |  |
     |  |  |  |  |   +--------\
     |  |  |  |   +------------/S4 [1]
     |  |  |   +----------------\
     |  |   +--------------------/S3 [1]
     |   +-----------------------\
      +----------------------------/S2 [1]


     xxx,xxx*hh<CR><LF>
     |  |
     |   +-------------------------\Secondary5 [1] Relative ECD, 000 to +-999
      +----------------------------/Secondary5 [1] Relative SNR, 000 to   999
```

Notes:

[1] Data is in the Loran-C Coding Delay order with null fields used when values are unavailable.

MTW - Water Temperature

Water temperature.

```
$--MTW,x.x,C*hh<CR><LF>
       | |
       | +---------------------\degrees C
       +-----------------------/Temperature
```

*MWV - Wind Speed and Angle

When the Reference Field is set to Relative, data is provded giving the wind angle in relation to the vessel's headig and wind speed, both relative to the (moving) vessel.
When the Reference Field is set to True, data is provided giving the wind angle relative to the vessel's heading and wind speed, both with reference to the (moving) water. True wind is the vector sum of the Relative (Apparent) wind vector and the vessel's velocity vector along the heading line of the vessel. It represents the wind at the vessel if it were stationary relative to the water and heading in the same direction.

```
$--MWV,x.x,a,x.x,a,A*hh<CR><LF>
       | | | ||
       | | | +--------------Status, A = Data Valid
       | | |  +---------------\Wind speed units, K/M/N
       | |  +------------------/Wind speed
       |  +---------------------\Reference: R = Relative
       |                              T = True
       +-----------------------/Wind angle, 0 to 360 degrees
```

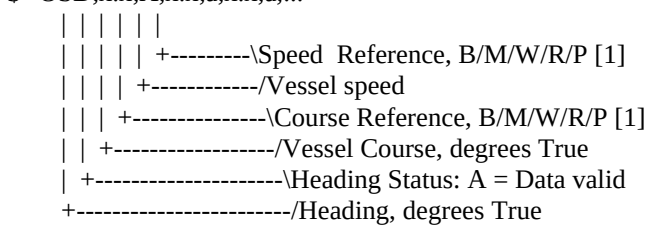
OLN - Omega Lane Numbers

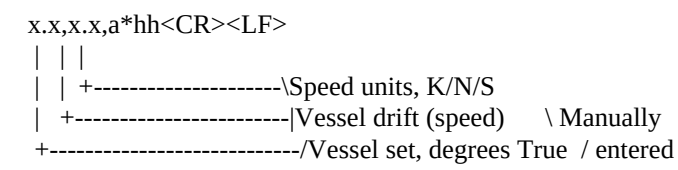
Omega Lines of Positions (LOPs).

```
$--OLN,aa,xxx,xxx,aa,xxx,xxx,...
       |  |  | |  |  |
       |  |  | |  |   +------\
       |  |  | |   +----------|
       |  |  |  +--------------/pair 2
       |  |   +-----------------\
       |   +---------------------|
       +-------------------------/pair 1


      aa,xxx,xxx*hh<CR><LF>
      |  |  |
      |  |   +---------------------\Centilane number
      |   +-------------------------|Lane number
      +-----------------------------/pair 3, AB-GH
```


*OSD - Own Ship Data

I.M.O. Ref. A477 (XII). Heading, course, speed, set and drift summary. Useful for, but not limited to RADAR/ARPA applications.



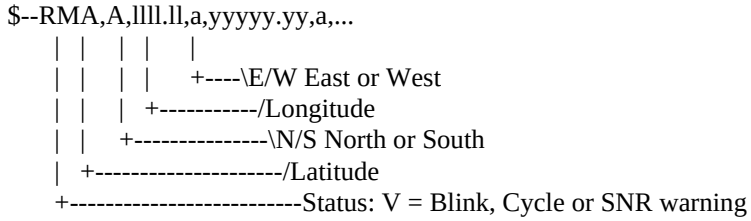


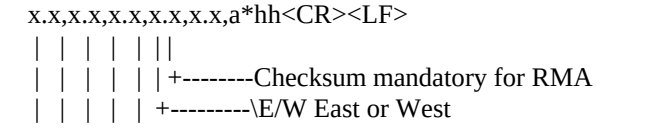
Notes:

[1] Reference system: B = Bottom tracking log
M = Manually entered
W = Water referenced
R = RADAR tracking (of fixed target)
P = Positioning system ground reference

RMA - Recommended Minimum Specific Loran-C Data

Position, course and dpeed data provided by a Loran-C receiver. Time differences A and B are those used in computing latitude/longitude. Checksum is madatory in this entence. This sentence is transmitted at intervals not exceeding 2-seconds and is always accompanied by RMB when a destination waypoint is active. RMA and RMB are the recommended minimum data to be provided by a loran receiver. All data fields must be provided, null fields used only when data is temporarily unavailable.





```
| | | | +------------/Magnetic variation [1], degrees
| | | +-----------------Track Made Good, degrees True
| | +---------------------Speed over ground, knots
| +-------------------------Time difference B, uS
+----------------------------Time difference A, uS
```

Notes:

[1] Easterly variation (E) subtracts from True course
Westerly variation (W) adds to True course

RMB - Recommended Minimum Navigation Information

Navigation data from present position to a destination waypoint provided ba a Loran-C, TRANSIT, OMEGA, GPS, DECCA, navigation computer or other integrated navigation system. Checksum is mandatory in this sentence. This semtemce always accompanies RMA or RMC sentences when a destination is active when provided by a Loran-C, TRANSIT or GPS receiver, other systems may transmit $--RMB without $--RMA or $--RMC.

```
$--RMB,A,x.x,a,c--c,c--c,...
   | | | |   |
   | | | |   +------------Destination waypoint ID
   | | | +-----------------Origin      waypoint ID
   | | +--------------------\Direction to steer - L/R Left or Right
   | +----------------------/Cross track error  - nautical miles [2]
   +--------------------------Data status: V = Navigation receiver warning


llll.ll,a,yyyyy.yy,a,...
 |    | |     |
 |    | |     +----------\E/W East or West
 |    | +-----------------/Destination wpt. longitude
 |    +----------------------\N/S North or South
 +---------------------------/Destination wpt. latitude


x.x,x.x,x.x,A*hh<CR><LF>
| | | ||
| | | | +----------------Checksum, mandatory for RMB
| | | +------------------Arrival status: A = arrivalcircle entered or perpendicular passed
| | +---------------------Destination closing velocity, knots
| +-------------------------Bearing to destination, degrees True
+----------------------------Range   to destination, nautical miles [1]
```

Notes:

[1] If range to destination exceeds 999.9 NM, display 999.9

[2] if cross track error exceeds 9.99 NM, display 9.99

RMC - Recommended Minimum Specific GPS/TRANSIT Data

Time, date, position, course and speed data provided by a GPS or TRANSIT navigation receiver. Checksum is mandatory in this sentence. This sentence is transmitted at intervals not exceeding 2-secondes and is always accompanied by RMB when a destination waypoint is active. RMC and RMB are recommended minimum data to be provided by a GPS or TRANSIT receiver. All data fields must be provided, null fields used only when data is temporarily unavailable.

```
$--RMC,hhmmss.ss,A,llll.ll,a,...
       |     | |    |
       |     | |    +-----\N/S North or South
       |     | +----------/Latitude
       |     +----------------Status: V = Nav. receiver warning
       +------------------------UTC of position fix


yyyyy.yy,a,x.x,x.x,xxxxxx,...
 |    | |  |   |
 |    | |  |   +---------Date: dd|mm|yy
 |    | |  +-------------Track made good, degrees True
 |    | +-----------------Speed over ground, knots
 |    +--------------------\E/W East or West
 +-------------------------/Longitude


x.x,a*hh<CR><LF>
| ||
| |+-------------------------Checksum, mandatory for RMC
| +-------------------------\E/W East or West [1]
+--------------------------/Magnetic variation, degrees
```

Notes:

[1] Easterly variation (E) subtract from True course
Westerly variation (W) adds to True course

*ROT - Rate of Turn

I.M.O. Ref. A526 (XIII). Rate of turn and direction of turn.

```
$--ROT,x.x,A*hh<CR><LF>
       | |
       | +----------------------Status: A = Data valid
       +------------------------Rate of turn, degrees/minute, "-" = bow turns to port
```

*RPM - Revolutions

I.M.O. Ref. (none). Shaft or engine revolution rate and propeller pitch.

```
$--RPM,a,x,x.x,x.x,A*hh<CR><LF>
      | | |  | |
      | | |  | +--------------Status: A = Data valid
      | | |  +----------------Propeller pitch, % of max., "-" = astern
      | |  +--------------------Speed, rev/min, "-" = counter-clockwise
      | +-------------------------Engine or shaft number, numbered from center-
      |                        line, odd = starboard, even = port, 0 = single
      |                        or on center-line
      +--------------------------Source: Shaft/Engine - S/E
```

*RSA - Rudder Sensor Angle

I.M.O. Ref. (none). Relative rudder angle, from rudder angle sensor.

```
$--RSA,x.x,A,x.x,A*hh<CR><LF>
      | | | |
      | | |  +---------------\Status A = Valid
      | |  +------------------/Port                rudder sensor [1]
      |  +---------------------\Status A = Valid
      +-------------------------/Starboard (or single) rudder sensor [1]
```

*RSD - RADAR System Data

I.M.O. Ref. A477 (XII). RADAR screen setting data.

```
$--RSD,x.x,x.x,x.x,x.x,x.x,x.x,...
      |  |  |  |  |  |
      |  |  |  |  |  +-----Origin2 bearing
      |  |  |  |  +---------Origin2 range
      |  |  |  +------------Bearing Line 1 (EBL1), degrees from 0 deg
      |  |  +---------------Variable Range Marker 1 (VRM1), range
      |  +--------------------Origin1 bearing, degrees from 0 deg
      +-------------------------Origin1 range  , from own ship


     x.x,x.x,x.x,x.x,x.x,a,a*hh<CR><LF>
     |  |  |  |  | ||
     |  |  |  |  | |+--------Display rotation [1]
     |  |  |  |  | +----------Range units, K/N/S
     |  |  |  |  +------------Range scale (maximum)
     |  |  |  +---------------Cursor bearing, degrees CW from 0 deg.
     |  |  +------------------Cursor range, from own ship
     |  +-------------------------EBL2, degrees
     +----------------------------VRM2, range
```

Notes:

[1] Display rotation: C = Course-up, course-over-ground up, degrees True
H = Head -up, ship's heading (center-line) 0 deg up
N = North -up, True north is 0 deg up

RTE - Routes

Waypoint identifiers, listed in order with starting waypoint first, for the identified route. Two mode of transmission are provided: 'c' indicates that the complete list of waypoints in the route are being transmitted; 'w' indicates a working route where the first listed waypoint is always the last waypoint that had been reached (FROM), while the second listed waypoint is always the waypoint that the vessel is currently heading for (TO), the remaining list of waypoints represents the remainder of the route.

```
$--RTE,x.x,x.x,a,c--c,c--c,...
       |  | | |   |
       |  | | |   +----------Waypoint identifier
       |  | | +---------------Route identifier
       |  | +------------------Message mode: c = complete route, all waypoints
       |  |                                w = working route, 1st listed waypoint
       |  |                                   is 'FROM', 2nd is 'TO' and remain-
       |  |                                   ing are rest of route
       |  +----------------------Message number [2]
       +-------------------------Total   number of messages being transmitted [2]


______ c--c*hh<CR><LF>
 |    |
 |    +----------------------Waypoint 'n' identifier        [1]
 +-----------------------------Additional waypoint identifiers [1]
```

Notes:

[1] A variable number of waypoint identifiers, up to 'n', may be in included within the limits of allowed sentence length. As there is no specified number of waypoints, null fields are not required for Waypoint Identifier fields.

[2] A single route may require the transmission of multipe messages. The first field specifies the total number of messages, minimum value = 1. The second field identifies the order of this message (message number), minimum value = 1.

*SFI - Scanning Frequency Information

This sentence is used to set frequencies and mode of operation for scanning purposes and to acknowledge setting commands. Scanning frequencies are listed in order of scanning.

Note:
For DSC distress and safety watchkeeping only 6 channels shall be scanned in the same scanning sequence.
To indicate a frequency set at the scanning receiver use FSI sentence.

```
$--SFI,x.x,x.x,xxxxxx,c _______ ...
      |  |   |   |  |
      |  |   |   |  +-------2nd - 5th frequency, mode [3]
      |  |   |   +----------\Mode of operation [1]
      |  |   +--------------/1st       frequency or ITU channel [2]
      |  +----------------------Message number [4]
      +-------------------------Total number of messages being transmitted [4]


xxxxxx,c*hh<CR><LF>
 |   |
 |   +----------------------\mode [3]
 +--------------------------/6th       frequency
```


Notes:

[1] Mode of operation:
d = F3E/G3E simplex, telephone w = F1B/J2B, teleprinter/DSC
e = F3E/G3E duplex, telephone x = A1A Morse, tape recorder
m = J3E , telephone { = A1A Morse, morse key/head set
o = H3E , telephone | = F1C/F2C/F3C, FAX-machine
q = F1B/J2B FEC NBDP, TELEX/teleprinter null for no information
s = F1B/J2B ARQ NBDP, TELEX/teleprinter
t = F1B/J2B receive only, teleprinter/DSC

[2] Frequencies to be in 100 Hz increments.
MF/HF telephone channels to have first digit 3 followed by ITU channel numbers with leading zeros as required.
MF/HF teletype channels to have first digit 4; the second and third digit frequency bands; and the fourth to sixth digits ITU channel numbers; each with leading zeros as required.
VHF channels to have first digit 9 followed by channel number with leading zeros as required.

[3] A variable number of frequency-mode pair fields are allowed up to a maximum of six pairs. Null fields are not required for unused pairs when less than six pairs are transmitted.

[4] Scanning frequency information may require the transmision of multiple messages. The first field specifies the total number of messages, minimum value = 1. The second field identifies the order of this message (message number), minimum value = 1.

STN - Multiple Data ID

This sentence is transmitted before each individual sentence where there is a need for the Listener to determine the exact source of data in a system. Examples might include dual-frequency depthsounding equipment or equipment that integrates data from a number of sources and produces a single output.

```
$--STN,xx*hh<CR><LF>
      |
      +--------------------------Talker ID number, 00 to 99
```

TRF - TRANSIT Fix Data

Time, date, position and information related to a TRANSIT fix.

```
$--TRF,hhmmss.ss,xxxxxx,llll.ll,a,...
       |       |     |    |
       |       |     |    +\N/S North or South
       |       |     +------/Latitude
       |       +--------------Date: dd|mm|yy
       +------------------------UTC of position fix


yyyyy.yy,a,x.x,x.x,x.x,x.x,...
 |     | |  |  |  |
 |     | |  |  |  +------Update distance, nautical miles
 |     | |  |  +----------Number of Doppler intervals
 |     | |  +--------------Number of iterations
 |     | +------------------Elevation angle
 |     +--------------------\E/W East or West
 +--------------------------/Longitude


xxx,A*hh<CR><LF>
| |
| +--------------------------Data status: warning flag
+----------------------------Satellite ID
```


*TTM - Tracked Target Message

I.M.O. Ref. A477 (XII). Data associated with a tracked target relative to own ship's position.

```
$--TTM,xx,x.x,x.x,a,x.x,x.x,a,...
       |  |  | | |  | |
       |  |  | | |  | +----\true/relative - T/R
       |  |  | | |  +-------/Target course, degrees
```

```
      |  |  | |  +------------Target speed
      |  |  | +--------------\true/relative - T/R
      |  |  +-----------------/Bearing from own ship, degrees
      |  +---------------------Target distance, from own ship
      +--------------------------Target number, 00 to 99


    x.x,x.x,a,c--c,a,a*hh<CR><LF>
    |  | | | | ||
    |  | | | | |+-------------Reference target = R, null otherwise
    |  | | |  +---------------Target status [1]
    |  | | +-------------------User data (eg. target name)
    |  | +---------------------Minutes
    |  +-------------------------Time to CPA, "-" increasing
    +----------------------------Distance of closest-point-of-approach
```

Notes:

[1] Target status: L = Lost, tracked target has been lost
Q = Query, target in the process of acquisition
T = Tracking

*VBW - Dual Ground/Water Speed

Water referenced and ground referenced speed data.

```
  $--VBW,x.x,x.x,A,x.x,x.x,A*hh<CR><LF>
       |  | | |  | |
       |  | | |  | +--------Status: Ground speed, A = Data valid
       |  | | |  +-----------Transverse   ground speed [1], knots
       |  | | +---------------Longitudinal ground speed [1], knots
       |  | +------------------Status: Water  speed, A = Data valid
       |  +--------------------Transverse   water  speed [1], knots
       +-------------------------Longitudinal water  speed [1], knots
```

Notes:

[1] Transverse speed: "-" = port, Longitudinal speed: "-" = astern

VDR - Set and Drift

The direction towards which a current flows (Set) and speed (Drift) of a current.

```
  $--VDR,x.x,T,x.x,M,x.x,N*hh<CR><LF>
       | | | | | |
       | | | | | +---------\Knots
       | | | | +------------/Current speed
       | | | +---------------\Magnetic
```

```
      | | +------------------/Direction, degrees
      | +----------------------\True
      +------------------------/Direction, degrees
```

VHW - Water Speed and Heading

The compass heading to which the vessel points and the speed of the vessel relative to the water.

```
$--VHW,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
      | | | | | | | |
      | | | | | | | +---\km/hr
      | | | | | | +------/Speed
      | | | | | +---------\knots
      | | | | +------------/Speed
      | | | +---------------\Magnetic
      | | +------------------/Heading, degrees
      | +----------------------\True
      +------------------------/Heading, degrees
```


VLW - Distance Traveld through the Water

The distance traveled, relative to the water.

```
$--VLW,x.x,N,x.x,N*hh<CR><LF>
      | | | |
      | | | +---------------\nautical miles
      | | +------------------/Distance since reset
      | +----------------------\nautical miles
      +------------------------/Total cumulative distance
```

VPW - Speed Measured Parallel to Wind

The component of the vessel's velocity vector parallel to the direction of the true wind direction. Sometimes called "speed made good to windward" or "velocity made good to windward".

```
$--VPW,x.x,N,x.x,M*hh<CR><LF>
      | | | |
      | | | +---------------\meters/second
      | | +------------------/Speed, "-" = downwind
      | +----------------------\knots
      +------------------------/Speed, "-" = downwind
```

VTG - Track Made Good and Ground Speed

The actual track made good and speed relative to the ground.

```
$--VTG,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
      | | | | | | | |
      | | | | | | |  +---\km/hr
      | | | | | |  +------/Speed
      | | | | |  +---------\knots
      | | | |  +------------/Speed
      | | |  +---------------\Magnetic
      | |  +------------------/Track, degrees
      |  +---------------------\True
      +-------------------------/Track, degrees
```

WCV - Waypoint Closure Velocity

The component of the velocity vector in the direction of the waypoint, from present position. Sometimes called "speed made made good" or "velocity made good".

```
$--WCV,x.x,N,c--c*hh<CR><LF>
      | | |
      | |  +-------------------Waypoint identifier
      |  +---------------------\knots
      +-------------------------/Velocity component
```

WNC - Distance - Waypoint to Waypoint

Distance between two specified waypoints.

```
$--WNC,x.x,N,x.x,K,c--c,c--c*hh
      | | | | |   |
      | | | | |    +--------'FROM' Waypoint identifier
      | | | |  +-------------'TO'   Waypoint identifier
      | | |  +---------------\km
      | |  +------------------/Distance
      |  +---------------------\nautical miles
      +-------------------------/Distance
```

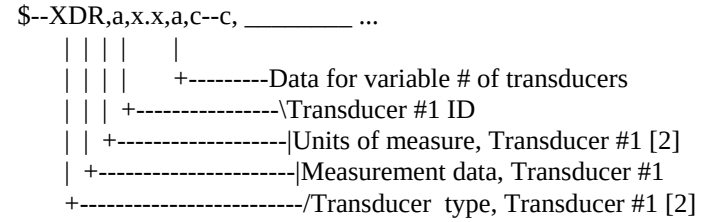
WPL - Waypoint Location

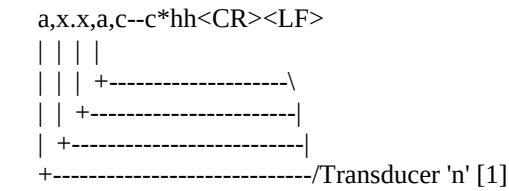
Latitude and longitude of specified waypoint.

```
$--WPL,llll.ll,a,yyyyy.yy,a,c--c*hh<CR><LF>
       |    |  |     | |
       |    |  |     |  +----Waypoint identifier
       |    |  |     +------\E/W East  or West
       |    |  +-------------/Waypoint longitude
       |    +----------------\N/S North or South
       +-------------------------/Waypoint latitude
```

XDR - Transducer Measurements

Measurement data from transducers that measure physical quantities such as temperature, force, pressure, frequency, angular or linear displacement, etc. Data from a variable number transducers measuring the same or different quantities can be mixed in the same sentence. This sentence is designed for use by integrated systems as well as transducers that may be connected in a 'chain' where each transducer receives the sentence as an input and adds its own data fields on before retransmitting the sentence.





Notes:

[1] Sets of the four fields 'Type-Data-Units-ID' are allowed for an undefined number of transducers. Up to 'n' transducers may be included within the limits of allowed sentence length, null fields are not required except where portions of the 'Type-Data-Units-ID' combination are not available.

[2] Allowed transducer types and their units of measure are:

Transducer	Type Field	Units Field	Comments
temperature	C	C = degrees Celsius	
angular displacement	A	D = degrees	"-" = anticlockwise
linear displacement	D	M = meters	"-" = compression
frequency	F	H = Hertz	
force	N	N = Newtons	"-" = compression
pressure	P	B = Bars	"-" = vacuum
flow rate	R	l = liters/second	
tachometer	T	R = RPM	
humidity	H	P = Percent	

volume V M = cubic meters

XTE - Cross-Track Error - Measured

Magnitude of the position error perpendicular to the intended track line and the direction to steer to reduce the error.

```
$--XTE,A,A,x.x,a,N*hh<CR><LF>
      | | | ||
      | | | +---------------\Units, nautical miles
      | | |  +----------------|Direction to steer, L/R Left or right
      | |  +-------------------/Magnitude of Cross-Track-Error
      | +------------------------Status: V = Loran-C Cycle Lock warning flag
      |                           A = OK or not used
      +--------------------------Status: V = Loran-C Blink or SNR warning
                                  V = general warning flag for other navigation
                                     system when a reliable fix is not available
```


XTR - Cross-Track Error - Dead Reckoning

Magnitude of the dead reckoned position error perpendicular to the intended track line and the direction to steer to reduce the error.

```
$--XTR,x.x,a,N**hh<CR><LF>
      | ||
      | +------------------\Units, nautical miles
      |  +-------------------|Direction to steer, L/R Left or right
      +-----------------------/Magnitude of Cross-Track-Error
```

ZDA - Time & Date

UTC, day, month, year and local time zone.

```
$--ZDA,hhmmss.ss,xx,xx,xxxx,xx,xx*hh<CR><LF>
      |     | |  |  | |
      |     | |  |  | +--Local zone minutes description, same sign as local hours
      |     | |  |  +-----Local zone description [1], 00 to +-13 hrs
      |     | |  +---------Year
      |     | +-------------Month, 01 to 12
      |     +---------------Day  , 01 to 31
      +-----------------------UTC
```

Notes:

[1] Zone description is the number of whole hours added to local time to obtain GMT, Zone description is negative for East

longitudes.

ZFO - UTC & Time from Origin Waypoint

UTC and elapsed time from origin waypoint.

```
$--ZFO,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
      |       |      |
      |       |      +-----Origin waypoint ID
      |       +--------------Elapsed time
      +------------------------UTC of observation
```

ZTG - UTC & Time to Destination Waypoint

UTC and predicted time-to-go to destination waypoint.

```
$--ZTG,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
      |       |      |
      |       |      +-----Destination waypoint ID
      |       +--------------Time-to-go
      +------------------------UTC of observation
```


7. Applications

7.1 Example Sentences

These examples are intended as samples of correct constructed sentences. They are representative samples only and show part of the wide range of legal variations possible with sentences. They should not necessarily be used as templates for sentences.

7.1.1 Example #1, Loran-C LAT/LONG

This example gives present position in Lat-Long, as determined by LoranC. The 3 character mnemonic in the address, GLL, indicates that the data is present position in Lat.-Long. The time (UTC) of the position fix is 09 hours, 13 minutes and 42 seconds. Decimal seconds are not available and the decimal point is optionally omitted. There are no warning flags set in the navigation receiver as indicated by Status = 'A'.

```
$LCGLL,4728.31,N,12254.25,W,091342,A*21<CR><LF>
| |    |    | |    |  |   ||   |
| |    |    | |    |  |   ||   +--Sentence Terminator
| |    |    | |    |  |   |+-------Checksum 21HEX
| |    |    | |    |  |   +---------Receiver status: no warnings
| |    |    | |    |  +--------------Time of position fix
| |    |    | |    +-----------------\Units Designator (West)
```

```
| |   |   |  +-----------------------/Long. 122 Degrees, 54.25 Minutes
| |   |   +---------------------------\Units Designator (North)
| |   +-----------------------------------/Lat.   47 Degrees, 28.31 Minutes
| +-------------------------------------------Address: LC  = Loran-C
|                                          GLL = Present Position
+-------------------------------------------Start of sentence
```

7.1.2 Example #2, Loran-C Arrival Alarm

This example illustrates Arrival Alarm data. The mnemonic code for Arrival Alarm is AAM. In this case the address Field is "LCAAM" for Loran-C Arrival Alarm. The first data field shows "V" indicating the radius of the arrival circle HAS NOT been entered, the second data field is "A" showing that the perpendicular to the course line, at the destination, HAS been crossed. The third and fourth fields show the radius and units of the destination waypoint arrival circle ".15,N" for 0.15 nautical miles. Data field five is the Waypoint Identifier field of valid characters.

```
$LCAAM,V,A,.15,N,CHAT-N6*56<CR><LF>
| |  || | |   |   |   |
| |  || | |   |   |   +--------------Sentence Terminator
| |  || | |   |   +------------------Checksum 56HEX
| |  || | |   +----------------------Identifier for waypoint "CHAT-N6"
| |  || | +--------------------------\Units  of arrival circle, nautical miles
| |  ||  +-------------------------------/Radius of arrival circle, 0.15
| |  | +-----------------------------------Status: perpendicular has been crossed
| |   +------------------------------------Status: arrival circle has not been entered
| +-------------------------------------------Address: LC  = Loran-C
+-------------------------------------------          AAM = Start of Sentence
```


7.1.3 Example #3 - Proprietary Sentence

A proprietary sentence has the following general format:

```
|<--- 80 character Sentence or less --->|
v                                       v

$Paaa-------------------------------------<CR><LF>
|| | |                                |  |
|| | +--> data, 75 character maximum <--+   +--> End of sentence
|| |
|| +-----> 3 character manufacturer's mnemonic code
||
|+-------> Proprietary sentence identifier
|
+--------> Start of sentence
```

A specific example will have little meaning to someone other than the particular manufacturer that designed the sentence:

```
$PSRDA003[470738][1224523]???RST47,3809,A004*47<CR><LF>
|| | |                          | |    |
|| | +> any serie of valid (non-reserved) <+ |     +--> End of Sentence
|| | +> characters of manufacturers choice<+ +---------> Checksum  47HEX
|| |
|| +--> Unique manufacturer's assigned code
||
|+----> Proprietary sentence identifier
|
+-----> Start of sentence
```

7.1.4 Example #4 - RMA Examples

The following group of sentences show a typical progression of output data as a Loran-C receiver acquires stations:

a) $LCRMA,V,,,,,14162.8,,,,,*0D<CR><LF>
Data invalid, only one TD acquired. Fields where data is not yet available are null fields.

b) $LCRMA,V,,,,,14172.3,26026.7,,,,*2E<CR><LF>
Two TDs acquired but not settled, data invalid.

c) $LCRMA,A,,,,,14182.3,26026.7,,,,*36<CR><LF>
Data valid, two TDs cycled but Lat/Lon not yet calculated.

d) $LCRMA,A,4226.26,N,07125.89,W,14182.3,26026.7,8.5,275.,14.0,W*68<CR><LF>
Normal operation

e) $LCRMA,V,4226.26,N,07125.89,W,14182.3,26026.7,8.5,275.,14.0,W*7F<CR><LF>
Data invalid, potential Loran problem.

f) $LCRMA,A,4226.265,N,07125.890,W,14182.33,26026.71,8.53,275.,14.0,W*53<CR><LF>
Loran operating in high resolution mode.

7.1.5 Example #5 - FSI Examples

The following sentences show typical applications for remote control of radiotelephones:

a) $--FSI,020230,026140,m,0*hh<CR><LF>
Set transmitter 2023 kHz, receiver 2614 kHz, mode J3E, telephone, standby.

b) $CTFSI,020230,026140,m,5*11<CR><LF>
MF/HF radiotelephone set transmit 2023 kHz, receive 2614 kHz, mode J3E, telephone, medium power.

c) $--FSI,,021820,o,*hh<CR><LF>
Set receiver 2182 kHz, mode H3E, telephone.

d) $CDFSI,900016,,d,9*08<CR><LF>

Set VHF transmit and receive channel 16, F3E/G3E simplex, telephone, high power.

e) $--FSI,300821,,m,9*hh<CR><LF>
Set MF/HF radiotelephone to telephone channel 821 e.g. transmit 8 255 kHz, receive 8 779 kHz, mode J3E, telephone, high power.

f) $--FSI,404001,,w,5*hh<CR><LF>
Set MF/HF radiotelephone to telephone channel 1 in 4 MHz band e.g. transmit 4 172.5 kHz, receive 4 210.5 kHz, mode F1B/J2B, teleprinter, medium power.

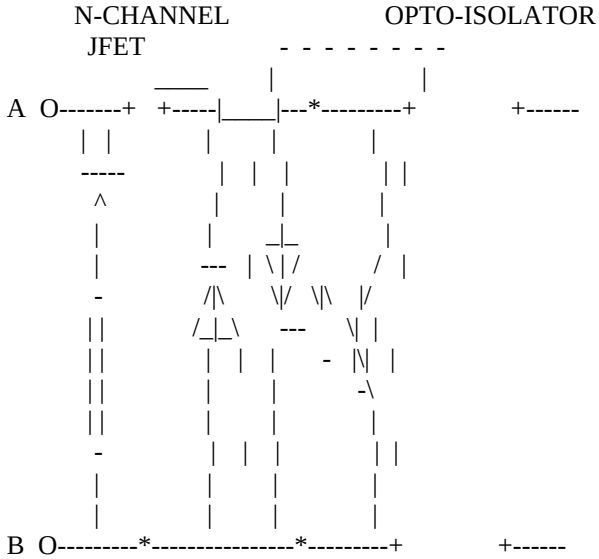
g) $CTFSI,416193,,s,0*00<CR><LF>
MF/HF radiotelephone tuned to teletype channel 193 in 16 MHz band e.g. transmitter 16 784.5 kHz, receiver 16 902.5kHz, mode F1B/J2E ARQ, TELEX/teleprinter, standby.

h) $--FSI,041620,043020,|,9*hh<CR><LF>
Set MF/HF radiotelephone transmit 4 162 kHz, receive 4 302 kHz, mode F1C/F2C/F3C, FAX-machine, high power.

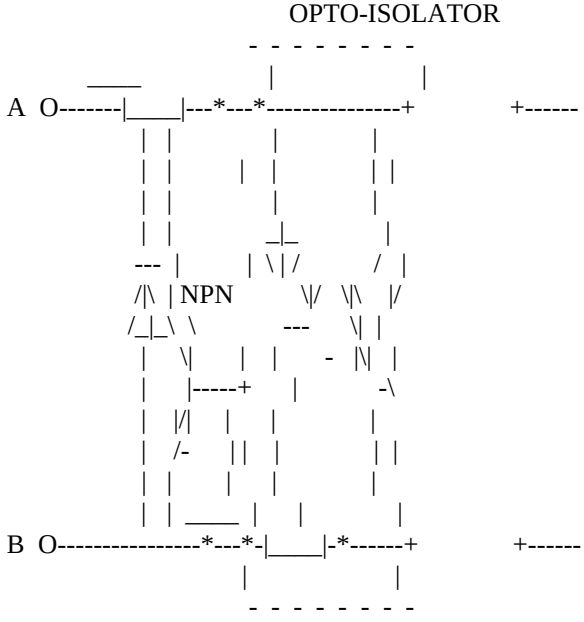
i) $CXFSI,,021875,t,*3A<CR><LF>
Scanning receiver set 2 187.5 kHz, mode F1B/J2B receive only, teleprinter/DSC.

7.2 Receiver Diagrams

The illustrative diagrams in Figure 3 and Figure 4 show the structure of two optoisolator based LISTENER circuits that offer overvoltage, reverse voltage and power dissipation protection for the optoisolator and serve-limit the current drawn from the line.



(Figure 3)



(Figure 4)

End of NMEA 0183 Version 2.00

NMEA 0183 APPENDIX I

Version 2.00

Januar 1, 1992

Sentences Not Recommended for New Designs

The following identifiers and senteces are scheduled to be phased out
of use and are no longer recommended for sole use in new or revised

designs. The senteces are valid sentences, but due to changing circumstances it is desirable to delete or replace these sentences as indicated below.

Generally in each of the sentence descriptions below reference is made to a sentence in the current Version of the standard, manufacturers are urged to use the currently recommended sentence in new or revised designs. It is desirable that manufacturers provide both new and old sentences whenever possible for a period of time that will serve as a phase-in period for the new sentences.

TABLE I-1 - TALKER IDENTIFIER MNEMONICS

TALKER DEVICE	IDENTIFIER
COMPUTER	
Programmed Calc.	CC
Memory data	CM
Microwave Positioning System	MP
Distress Alarm System	OS
TRANSDUCERS	
Temperature	YC
Displacement, Angular or Linear	YD
Frequency	YF
Level	YL
Pressure	YP
Flow Rate	YR
Tachometer	YT
Volume	YV

TABLE I-2 - SENTENCE FORMATTERS NOT RECOMMENDED FOR NEW DESIGNS

APA - Autopilot Sentence "A"

Commonly used by autopilots this sentence contains navigation receiver warning flag status, cross-track-error, waypoint arrival status and initial bearing from origin waypoint to the destination waypoint for the active navigation leg of journy.

Use of $--APB with additional data fields of heading-to-steer and bearing from present position to destination is recommended.

```
$--APA,A,A,x.x,a,N,A,A,x.x,M,c--c*hh<CR><LF>
      | | | |||| | | |
      | | | |||| | | +---Destination waypoint ID
      | | | |||| | +-----\Magnetic
      | | | |||| +--------/Bearing origin to destination
      | | | ||| +------------Status: perpendicular passed at waypoint
      | | | || +--------------Status: arrival circle entered
      | | | +---------------\XTE units, Nautical miles
      | | +-----------------|Direction to steer, L/R
      | +-------------------/Magnitude of XTE (cross-track-error)
      |+------------------------Data status: Loran-C Cycle Lock warning flag
      +-------------------------Data status: "OR" of Loran-C Blink and SNR warning flags
```

BER - Bearing & Distance to Waypoint, Dead Reckoning, Rhumb Line
BPI - Bearing & Distance to Point of Interest

Time (UTC) and distance & bearing to, and locationof, a specified waypoint from present position:

BER: Calculated along the rhumb line from dead reckoned present position. The use of $--BEC using great circle calculations is recommended.

BPI: Calculated along a great circle path from measured present position. Redundant with BWC, the use of $--BWC is recommended.

```
$--BER,hhmmss.ss,llll.ll,a,...
$--BPI,... |     |     |
         |     |     +-------\N/S North or South
         |     +-------------/Waypoint latitude
         +---------------------UTC of observation


yyyyy.yy,a,x.x,T,x.x,M,x.x,N,...
  |     | | | | | | |
  |     | | | | | | +--\nautical miles
  |     | | | | | +-----/Distance
  |     | | | | +--------\degrees Magnetic
  |     | | | +-----------/Bearing
  |     | | +--------------\degrees True
  |     | +-----------------/Bearing
  |     +-------------------\E/W East  or West
   +---------------------------/Waypoint longitude


c--c*hh<CR><LF>
 |
 +----------------------------Waypoint ID
```

DBK - Depth Below Keel
DBS - Depth Below Surface

Water depth referenced to the vessel's keel (DBK) or to the water surface (DBS).

The use of $--DPT is recommended in place of either of these.

$--DBK,x.x,f,x.x,M,x.x,F*hh<CR><LF>
$--DBS,x.x,f,x.x,M,x.x,F*hh<CR><LF>

```
      | | | | | |
      | | | | | +---------\Fathoms
      | | | | +-------------/Water depth
      | | | +---------------\Meters
      | | +-------------------/Water depth
      | +---------------------\feet
      +-----------------------/Water depth
```


DRU - DUAL DOPPLER AUXILIARY DATA

Depth, turn rate and % RPM in support of Doppler velocity systems.

The use of $--DPT is recommended for depth data, $--RPM for shaft rotation and $--ROT for rate of turn.

$--DRU,x.x,A,x.x,A,x.x*hh<CR><LF>

```
      | | | | |
      | | | | +-------------Propeller shaft rotation, % of maximum
      | | | +---------------\Status: Rate of turn
      | | +-------------------/Rate of turn, degrees per minute, "-" = port
      | +---------------------\Status: Depth
      +-----------------------/Depth
```

GDa - Dead Reckoning Positions
GLa - Loran-C Positions
GOa - OMEGA Positions
GXa - TRANSIT Positions

Location and time at waypoint "c--c":
$--aaF: predicted or estimated time
$--aaP: present position and time
$--aaA: past position and time

The use of waypoint location $--WPL (for past positions) or $--GLL (for present position) followed by time tag $--ZDA is recommended for reporting past or present waypoint times; $--WPL followed by $--ZTG is recommended for estimated time.

Dead reckoned positions:

```
$--GDF,hhmmss.ss,llll.ll,a,...
$--GDP,...|       |    |
$--GDA,...|       |    +--------\N/S North or South
          |       +--------------/Latitude
          +------------------------UTC of position fix


   yyyyy.yy,a,c--c*hh<CR><LF>
    |     | |
    |     | +-------------------Waypoint ID
    |     +---------------------\E/W East  or West
    +-----------------------------/Longitude



Loran-C determined positions:
$--GLF,...
$--GLP,...
$--GLA,...



Omega determined positions:
$--GOF,...
$--GOP,...
$--GOA,...



TRANSIT determined positions:
$--GXF,hhmmss.ss,llll.ll,a,...
$--GXP,...|       |    |
          |       |    +--------\N/S North or South
          |       +--------------/Latitude
          +------------------------UTC of position fix


   yyyyy.yy,a,c--c,x*hh<CR><LF>
    |     | |  |
    |     | |  +---------------Satellite number
    |     | +-------------------Waypoint ID
    |     +---------------------\E/W East  or West
    +-----------------------------/Longitude
```


Loran-C Time Difference (TD) lines of position for present vessel position.

The use of $--GLC is recommended.

```
$--GTD,x.x,x.x,x.x,x.x,x.x*hh<CR><LF>
```

```
| | | | |
| | | |  +---------TD 5, micro-seconds
| | |  +-------------TD 4, micro-seconds
| |  +-----------------TD 3, micro-seconds
|  +---------------------TD 2, micro-seconds
+-------------------------TD 1, micro-seconds
```

HCC - Compass Heading

Vessel compass heading, which differs from magnetic heading by the amount of uncorrected magnetic variation.

The use of $--HDG is recommended.

```
$--HCC,x.x*hh<CR><LF>
       |
       +-------------------------Compass heading, degrees
```

HCD - Heading and Deviation

Actual Vessel magnetic heading, indicated compass heading and the difference (deviation) between them.

The use of $--HDG is recommended.

```
$--HCD,x.x,M,x.x,H,x.x,a*hh<CR><LF>
       | | | | | |
       | | | | |  +---------\degrees E/W [1]
       | | | |  +------------/Magnetic deviation
       | | |  +---------------\Compass,  degrees
       | |  +------------------/Heading
       |  +---------------------\Magnetic, degrees
       +-------------------------/Heading
```

Note:

[1] Easterly deviation (E) subtracts from Compass Heading
Westerly deviation (W) adds to Compass Heading

HDM - Heading, Magnetic

Actual vessel heading in degrees Magnetic.

The use of $--HDG is recommended.

```
$--HDM,x.x,M*hh<CR><LF>
       | |
       |  +----------------------\degrees Magnetic
```

```
        +------------------------/Heading
```


HVD - Magnet Variation, Automatic
HVM - Magnet Variation, Manually Set

Magnetic Variation, automatically derived (calculated or taken from a data base) (HDV), or manually entered (HVM).

The use of $--HDG is recommended.

```
$--HVD,x.x,a*hh<CR><LF>
$--HVM,x.x,a*hh<CR><LF>
       | |
       | +----------------------\degrees E/W [1]
       +------------------------/Magnetic variation
```

Note:

[1] Easterly variation (E) subtracts from True Heading
Westerly variation (W) adds to True Heading

IMA - Vessel Identification

Limited utility, no recommended replacement.

```
$--IMA,aaaaaaaaaaaa,aaaxxxx,...
         |         |
         |         +-----------Radio call sign
         +---------------------12 character vessel name


llll.ll,a,yyyyy.yy,a,x.x,T,...
 |    |  |     | | |
 |    |  |     | |  +----\degrees True
 |    |  |     |  +-------/Heading
 |    |  |     +----------\E/W East  or West
 |    |  +----------------/Longitude
 |    +-------------------\N/S North or South
  +--------------------------/Latitude


x.x,M,x.x,N*hh<CR><LF>
| | | |
| | |  +-------------------\knots
| |  +----------------------/Speed
|  +-------------------------\degrees Magnetic
 +---------------------------/Heading
```

MDA - Meteorological Composite

Barometric pressure, air and water temperature, humidity, dew point and wind speed and direction relative to the surface of the earth.

The use of $--MTW, $--MWV and $--XDR is recommended.

```
$--MDA,x.x,I,x.x,B,x.x,C,x.x,C,...
       | | | | | | | |
       | | | | | | | +---\degrees C
       | | | | | | +------/Water temperature
       | | | | | +---------\degrees C
       | | | | +------------/Air   temperature
       | | | +---------------\bars
       | | +------------------/Barometric pressure
       | +---------------------\inches of mercury
       +-----------------------/Barometric pressure


     x.x,x.x,x.x,C,x.x,T,x.x,M,...
     |  |  | | | | | |
     |  |  | | | | | +-----\degrees Magnetic
     |  |  | | | | +--------/Wind direction
     |  |  | | | +-----------\degrees True
     |  |  | | +--------------/Wind direction
     |  |  | +-----------------\degrees C
     |  |  +--------------------/Dew point
     |  +-------------------------Absolute humidity, percent
     +----------------------------Relative humidity, percent


     x.x,N,x.x,M*hh<CR><LF>
     | | | |
     | | | +------------------\meters/second
     | | +--------------------/Wind speed
     | +-------------------------\knots
     +---------------------------/Wind speed
```


MHU - Humidity

The use of $--XDR is recommended.

```
$--MHU,x.x,x.x,x.x,C*hh<CR><LF>
       |  |  | |
       |  |  | +-------------\degrees C
       |  |  +----------------/Dew point
       |  +--------------------Absolute humidity, percent
       +-----------------------Relative humidity, percent
```

MMB - Barometer

The use of $--XDR is recommended.

```
$--MMB,x.x,I,x.x,B*hh<CR><LF>
      | | | |
      | | |  +---------------\bars
      | |  +------------------/Barometric pressure
      |  +---------------------\inches of mercury
      +-------------------------/Barometric pressure
```

MTA - Air Temperature
MTW - Water Temperature

The use of $--XDR is recommended.

```
$--MTA,x.x,C*hh<CR><LF>
$--MTW,x.x,C*hh<CR><LF>
      | |
      |  +-----------\degrees C
      +--------------/Temperature
```

MWD - Wind Direction and Velocity, Surface

The use of $--MWV is recommended.

```
$--MWD,x.x,T,x.x,M,x.x,N,x.x,M*hh<CR><LF>
      | | | | | | | |
      | | | | | | |  +---\meters/second
      | | | | | |  +------/Wind speed
      | | | | |  +---------\knots
      | | | |  +------------/Wind speed
      | | |  +---------------\degrees Magnetic
      | |  +------------------/Wind direction
      |  +---------------------\degrees True
      +-------------------------/Wind direction
```

MWH - Wave Height

Limited utility, no recommended replacement.

```
$--MWH,x.x,f,x.x,M*hh<CR><LF>
      | | | |
      | | |  +---------------\meters
      | |  +------------------/Wave height
      |  +---------------------\feet
      +-------------------------/Wave height
```

MWS - Wind & Sea State

Limited utility, no recommended replacement.

```
$--MWS,xx,xx*hh<CR><LF>
      | |
      | +-----------------------Beaufort Sea  State Code
      +-------------------------Beaufort Wind Force Code
```

OLW - Omega Lane Width

Limited utility, no recommended replacement.

```
$--OLW,x.x,N,xxxx,M*hh<CR><LF>
      | | |  |
      | | |  +--------------\meters
      | | +------------------/Lane width
      | +--------------------\nautical miles
      +----------------------/Lane width
```


OMP - OMEGA Pairs

Limited utility, no recommended replacement.

```
$--OMP,1,aa,2,aa,3,aa*hh<CR><LF>
      || || ||
      || || |+-------------\AB-GH
      || ||  +--------------/Pair 3
      || |+-----------------\AB-GH
      ||  +-------------------/Pair 2
      |+-----------------------\AB-GH
      +-------------------------/Pair 1,
```

ONZ - Omega Zone Number

Limited utility, no recommended replacement.

```
$--ONZ,a*hh<CR><LF>
      |
      +-------------------------Station identifier, A-H
```

Rnn - Routes

Waypoint identifiers, listed in order with starting waypoint first

for route number "nn".

```
$--Rnn,c--c,c--c----,c--c*hh<CR><LF>
  | |          |
  | |    ...   +-----------\
  |  +------------------------/14 field sequence of route waypoint IDs
   +-----------------------------nn = Route number
```

SBK - Loran-C Blink Status
SCY - Loran-C Cycle Lock Status

Loran-C warning flags for Blink (SBK) and Cycle Lock (SCY) indicating that one or more Loran-C stations being used to produce Lat/Lon and other navigation data are unreliable.

The use of $--GLC is recommended.

```
$--SBK,A*hh<CR><LF>
$--SCY,A*hh<CR><LF>
     |
     +--------------------------Warning Flag
```

SCD - Loran-C ECDs

The use of $--LCD is recommeded.

```
$--SCD,0,xxx,1,xxx,2,xxx,3,xxx,...
     | | | | | | | |
     | | | | | | |  +----\
     | | | | | |  +-------/Secondary 3
     | | | | |  +----------\ECD
     | | | |  +-------------/Secondary 2
     | | |  +----------------\ECD
     | |  +--------------------/Secondary 1
     |  +----------------------\ECD
     +-------------------------/Master signal


  4,xxx,5,xxx*hh<CR><LF>
  | | | |
  | | |  +--------------------\ECD
  | |  +-----------------------/Secondary 5
  |  +--------------------------\ECD
  +-----------------------------/Secondary 4
```

SDB - Loran-C Signal Strength

Limited utility, no recommended replacement.

```
$--SDB,x.x*hh<CR><LF>
      |
      +-------------------------Signal strength, dB
```


SGD - Position Accuracy Estimate

Estimate of position accuracy based on geometric of precision (GDOP) and system noise, in feet and nauticl miles.

Limited utility, no recommended replacement.

```
$--SGD,x.x,N,x.x,f*hh<CR><LF>
      | | | |
      | | | +---------------\feet
      | | +-----------------/Accuracy
      | +---------------------\nautical miles
      +-------------------------/Accuracy
```

SGR - Loran-C Chain Identifier

The unique Loran-C Chain identifier, representing Group Repetition Interval (GRI) in tens of microseconds (Group Repetition Interval = [Chain ID]*10, microseconds).

The use of $--GLC is recommended.

```
$--SGR,xxxx*hh<CR><LF>
      |
      +-------------------------GRI, tens of microseconds
```

SIU - Loran-C Stations in Use

The use of $--GLC is recommended.

```
$--SIU,1,2,3,4,5,6,7,8*hh<CR><LF>
      |           |
      |    ...    +-----------\
      +-------------------------/Stations in use, null fields for stations not in use
```

SLC - Loran-C Status

Blink, Cycle and SNR warning status and SNR value for all stations. Stations used in Lat/Lon conversion are identified.

The use of $--GLC and/or $--LCD is recommended.

```
$--SLC,A,A,A,xxx,A,A,A,A,xxx,...
      | | | | | | | |
      | | | | | | | +------\SNR value, 000 to 999          , Secondary #1
      | | | | | | +---------|Status: SNR        Warning Flag, Secondary #1
      | | | | | +-----------|Status: Cycle Lock Warning Flag, Secondary #1
      | | | | +-------------|Status: Blink      Warning Flag, Secondary #1
      | | | +---------------/Status: Secondary #1 used in Lat/lon calculation
      | | +-------------------SNR value, 000 to 999          , Master
      | +----------------------Status: SNR        Warning Flag, Master
      +------------------------Status: Cycle Lock Warning Flag, Master
                               Status: Blink      Warning Flag, Master


   A,A,A,A,xxx,A,A,A,A,xxx,...
   | | | | | | | | |
   | | | | | | | | +--------\
   | | | | | | | +-----------|
   | | | | | | +-------------|Secondary #3
   | | | | | +---------------|
   | | | | +-----------------/
   | | | +--------------------\
   | | +----------------------|
   | +------------------------|Secondary #2
   +--------------------------/


   A,A,A,A,xxx,A,A,A,A,xxx*hh<CR><LF>
   | | | | | | | | |
   | | | | | | | | +--------\
   | | | | | | | +-----------|
   | | | | | | +-------------|Secondary #5
   | | | | | +---------------|
   | | | | +-----------------/
   | | | +--------------------\
   | | +----------------------|
   | +------------------------|Secondary #4
   +--------------------------/
```

SNC - Navigation Calculation Basis

Basis for navigation calculations, Great Circle or Rhumb Line.

Limited utility, no recommended replacement.

```
$--SNC,a*hh<CR><LF>
      |
      +--------------------------Great Circle or Rhumb Line, G/R
```

SNU - Loran-C SNR Status

Loran-C warning flag for Signal-To-Noise-Ratio indicating that one or more Loran-C stations being used to produce Lat/Lon and other navigation data are unreliable.

The use of $--GLC is recommended.

```
$--SNU,A*hh<CR><LF>
      |
      +-------------------------Warning Flag
```

SPS - Loran-C Predicted Signal Strength

Limited utility, no recommended replacement.

```
$--SPS,xx*hh<CR><LF>
      |
      +-------------------------Signal strength, dB
```

SSF - Position Correction Offset

Amount of offset, and direction of offset, applied to measured position Lat/Lon to produce a displayed position Lat/Lon.

Limited utility, no recommended replacement.

```
$--SSF,x.x,a,x.x,a*hh<CR><LF>
      | | | |
      | | | +---------------\E/W East  or West
      | | +-----------------/Longitude offset, minutes
      | +---------------------\N/S North or South
      +-----------------------/Latitude  offset, minutes
```

STC - Time Constant

Time constant specified manually for use in navigation calculations.

Limited utility, no recommended replacement.

```
$--STC,xxx*hh<CR><LF>
      |
      +-------------------------Time constant, 000 to 999 seconds
```

STR - Tracking Reference

Transmitted prior to a sentence containing velocity-based data to indicate when velocity is measured over-the-ground or relative to the water.

The use of appropriate ground or water-referenced approved sentences such as $--VBW, $--VHW or $--VTG is recommended.

```
$--STR,a*hh<CR><LF>
      |
      +-------------------------A = Ground reference, V = Water reference
```

SYS - Hybrid System Configuration

Limited utility, no recommended replacement.

```
$--SYS,L,O,T,G,D*hh<CR><LF>
      | | | | |
      | | | | +-----------------DECCA     \
      | | | +-------------------GPS       \
      | | +---------------------TRANSIT      Null fields for systems not in use
      | +-----------------------OMEGA      /
      +-------------------------LORAN-C   /
```


TEC - TRANSIT Satellite Error & Doppler Count

The use of $--TRF is recommended.

```
$--TEC,A,A,A*hh<CR><LF>
      | | |
      | | +---------------------Status: Iteration number
      | +-----------------------Status: Doppler count
      +-------------------------Status: Maximum angle
```

TEP - TRANSIT Satellite Predicted Elevation

Limited utility, no recommended replacement.

```
$--TEP,x.x,D*hh<CR><LF>
       | |
       |  +--------------------\degrees
       +-----------------------/Elevation
```

TGA - TRANSIT Satellite Antenna & Geoidal Heigths

Limited utility, no recommended replacement.

```
$--TGA,x.x,M,x.x,M,x.x,M*hh<CR><LF>
       | | | | | |
       | | | | | +---------\meters
       | | | | +-------------/Antenna + geoidal height
       | | | +---------------\meters
       | | +-----------------/Geoidal height
       | +---------------------\meters
       +------------------------/Antenna height
```

TIF - TRANSIT Satellite Initial Flag

Limited utility, no recommended replacement.

```
$--TIF,a*hh<CR><LF>
      |
      +--------------------------Normal operation            = A
                        Set initialization data      = V
                        Initialization data complete = J
```

TRP - TRANSIT Satellite Predicted Direction of Rise

Limited utility, no recommended replacement.

```
$--TRP,aa*hh<CR><LF>
      |
      +--------------------------Southeasterly = SE, southwesterly = SW
```

TRS - TRANSIT Satellite Operating Status

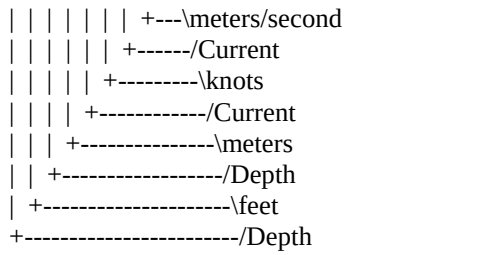
Limited utility, no recommended replacement.

```
$--TRS,a*hh<CR><LF>
      |
      +--------------------------Acquiring      = A
                        Calculating    = c
                        Error          = e
                        Message        = m
                        Test           = T
                        Dead reckoning = U
```


VCD - Current at Selected Depth

Limited utility, no recommended replacement.

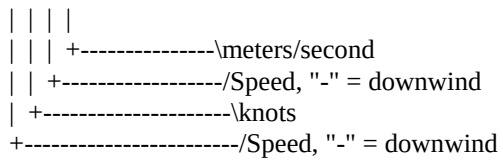
```
$--VCD,x.x,f,x.x,M,x.x,N,x.x,M*hh<CR><LF>
      | | | | | | | |
```



VPE - Speed, Dead Reckoned Parallel to True Wind

Limited utility, no recommended replacement.

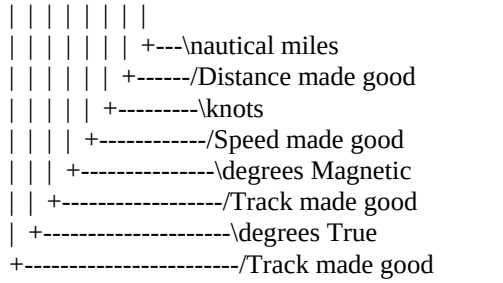
$--VPE,x.x,N,x.x,M*hh<CR><LF>



VTA - Actual Track

Limited utility, possible use of $--VTG for a portion of the data.

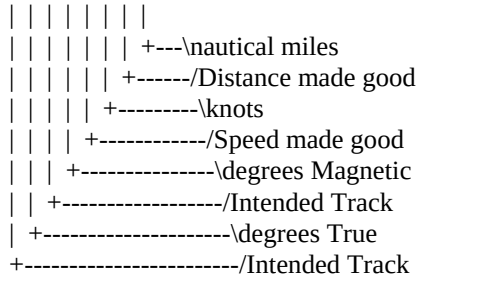
$--VTA,x.x,T,x.x,M,x.x,N,x.x,N*hh<CR><LF>



VTI - Intended Track

Limited utility, no recommended replacement.

$--VTI,x.x,T,x.x,M,x.x,N,x.x,N*hh<CR><LF>



VWE - Wind Track Efficiency

Limited utility, no recommended replacement.

```
$--VWE,x.x*hh<CR><LF>
      |
      +-------------------------Efficiency, percent
```

VWR - Relative (Apparent) Wind Speed and Angle

Wind angle in relation to the vessel's heading and wind speed measured relative to the moving vessel.

The use of $--MWV is recommended.

```
$--VWR,x.x,a,x.x,N,x.x,M,x.x,K*hh<CR><LF>
      | | | | | | | |
      | | | | | | | +---\Km/Hr
      | | | | | | +------/Wind speed
      | | | | | +---------\meters/second
      | | | | +------------/Wind speed
      | | | +---------------\knots
      | | +------------------/Measured wind Speed
      | +----------------------\L/R Left or Right of vessel heading
      +-------------------------/Measured wind angle relative to the vessel, 0 to 180 deg
```


VWT - True Wind Speed and Angle

True wind angle in relation to the vessel's heading and true wind speed referenced to the water. True wind is the vector sum of the Relative (Apparent) wind vector and the vessel's velocity vector relative to the water along the heading line of the vessel. It represents the wind at the vessel if it were stationary relative to the water and heading in the same direction.

The use of $--MWV is recommended.

```
$--VWT,x.x,a,x.x,N,x.x,M,x.x,K*hh<CR><LF>
      | | | | | | | |
      | | | | | | | +---\Km/Hr
      | | | | | | +------/Wind speed
      | | | | | +---------\meters/second
      | | | | +------------/Wind speed
      | | | +---------------\knots
      | | +------------------/Calculated wind Speed
      | +----------------------\L/R Left or Right of vessel heading
      +-------------------------/Calculated wind angle relative to the vessel, 0 to 180 deg
```

WDC - Distance & Waypoint

Distance from present position to the specified waypoint.

The use of $--BWC is recommended.

```
$--WDC,x.x,N,c--c*hh<CR><LF>
      | | |
      | | +--------------------Waypoint identifier
      | +----------------------\nautical miles
      +------------------------/Distance
```

WDR - Waypoint Distance, Rhumb Line

The use of $--WDC using great circle calculations is recommended.

```
$--WDR,x.x,N,c--c*hh<CR><LF>
      | | |
      | | +--------------------Waypoint identifier
      | +----------------------\nautical miles
      +------------------------/Distance
```

WFM - Route Following Mode

Limited utility, no recommended replacement.

```
$--WFM,a*hh<CR><LF>
      |
      +--------------------------Mode: "A" = automatic, "V" = manual
```

WNR - Waypoint-to-Waypoint Distance, Rhumb Line

The use of $--WNC using great circle calculations is recommended.

```
$--WNR,x.x,N,x.x,K,c--c,c--c*hh<CR><LF>
      | | | | |   |
      | | | | |   +--------
      | | | | +-------------
      | | | +---------------\
      | | +-----------------/
      | +---------------------\
      +------------------------/
```

YWP - Water Propagation Speed

Limited utility, no recommended replacement.

```
$--YWP,x.x,f,x.x,M*hh<CR><LF>
       | | | |
       | | |  +---------------\meters/second
       | |  +------------------/Speed
       |  +---------------------\feet/second
       +-------------------------/Speed
```

YWS - Water Profile

Limited utility, no recommended replacement.

```
$--YWS,x.x,x.x,x.x,C,x.x,f,x.x,M*hh<CR><LF>
       |  |  | | | | | |
       |  |  | | | | |  +-\meters
       |  |  | | | |  +----/Depth
       |  |  | | |  +-------\feet
       |  |  | |  +----------/Depth
       |  |  |  +-------------\degrees C
       |  |   +----------------/Temperature at depth
       |   +---------------------Chlorinity, parts/thousand
       +-------------------------Salinity,   parts/thousand
```

Zaa - Time, Elapsed/Estimated

Elapsed time from point-of-interest.
The use of $--ZFO is recommended.

```
$--ZFI,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
       |       |      |
       |       |      +-----Waypoint ID
       |       +--------------Elapsed time from waypoint
       +------------------------UTC
```

Arrival time at point-of-interest.
The use of $--ZTG is recommended.

```
$--ZPI,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
       |       |      |
       |       |      +-----Waypoint ID
       |       +--------------Arrival time at waypoint
       +------------------------UTC
```

Estimated time of arrival at waypoint.

The use of $--ZTG is recommended.

```
$--ZTA,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
       |       |      |
       |       |      +-----Waypoint ID
       |       +--------------Estimated time at waypoint
       +------------------------UTC
```

Estimated time to event/point-of-interest.
The use of $--ZTG is recommended.

```
$--ZTE,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
$--ZTI,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
       |       |      |
       |       |      +-----Waypoint ID
       |       +--------------Estimated time-to-go to waypoint
       +------------------------UTC
```

Arrival time at waypoint.
The use of $--ZTG is recommended.

```
$--ZWP,hhmmss.ss,hhmmss.ss,c--c*hh<CR><LF>
       |       |      |
       |       |      +-----Waypoint ID
       |       +--------------Arrival time at waypoint
       +------------------------UTC
```


ZCD - Timer

Limited utility, no recommended replacement.

```
$--ZCD,xxxxxx,a*hh<CR><LF>
       |   |
       |   +--------------------Control: "+" = count up
       |                            "-" = count down
       |                            "V" = stop  count
       +------------------------Timer initial value, seconds
```

ZEV - Event Timer

Limited utility, no recommended replacement.

```
$--ZEV,hhmmss.ss,hhmmss.ss,a,c--c*hh<CR><LF>
       |       |      | |
       |       |      | +---Waypoint ID
       |       |      +------Control: "+" = count up
       |       |                     "-" = count down
       |       |                     "V" = stop  count
```

```
|       +--------------Timer initial value, seconds
+------------------------UTC
```

ZLZ - Time of Day

Time of day in hours-minutes-seconds, both with respect to (UTC) and the local time zone.

The use of $--ZDA is recommended.

```
$--ZEV,hhmmss.ss,hhmmss.ss,xx*hh<CR><LF>
       |       |     |
       |       |     +------Local zone description [1], -12 to +12
       |       +--------------Local time
       +------------------------UTC
```

Notes:

[1] Zone description is the number of whole hours added to local time to obtain GMT, Zone description is negative for East longitudes.

ZZU - Time, UTC

The use of $--ZDA is recommended.

```
$--ZZU,hhmmss.ss*hh<CR><LF>
       |
       +------------------------UTC
```

End of Appendix I

(To Be Determined)

Version 2.00

January 1, 1992

Manufacturer's Mnemonic Codes

AAR ASIAN AMERICAN RESOURCES
ACE AUTO-COMM ENGINEERING CORP.
ACR ACR ELECTRONICS, INC.
ACS ARCO SOLAR, INC.
ACT ADVANCED CONTROL TECHNOLOGY
AGI AIRGUIDE INSTRUMENT CO.
AHA AUTOHELM OF AMERICA
AIP AIPHONE CORP.
ALD ALDEN ELECTRONICS, INC.
AMR AMR SYSTEMS
AMT AIRMAR TECHNOLOGY
ANS ANTENNA SPECIALISTS
ANX ANALYTYXS ELECTRONIC SYSTEMS
ANZ ANSCHUTZ OF AMERICA
APC APELCO
APN AMERICAN PIONEER, INC.
APX AMPEREX, INC.
AQC AQUA-CHEM, INC.
AQD AQUADYNAMICS, INC.
AQM AQUA METER INSTRUMENT CO.
ASP AMERICAN SOLAR POWER
ATE AETNA ENGENEERING
ATM ATLANTIC MARKETING COMPANY, INC.
ATR AIRTRON
ATV ACTIVATION, INC.
AVN ADVANCED NAVIGATION, INC.
AWA AWA NEW ZEALAND, LTD.

BBL BBL INDUSTRIES, INC.
BBR BBR AND ASSOCIATES
BDV BRISSON DEVELOPMENT, INC.
BEC BOAT ELECTRIC CO.
BGS BARRINGER GEOSERVICE
BGT BROOKES AND GATEHOUSE, INC.
BHE BH ELECTRONICS
BHR BAHR TECHNOLOGIES, INC.

BLB BAY LABORATORIES
BMC BMC
BME BARTEL MARINE ELECTRONICS

BNI NEIL BROWN INSTRUMENT SYSTEMS
BNS BOWDITCH NAVIGATION SYSTEMS
BRM MEL BARR COMPANY
BRY BYRD INDUSTRIES
BTH BENTHOS, INC.
BTK BALTEK CORP.
BTS BOAT SENTRY, INC.
BXA BENDIX-AVALEX, INC.

CAT CATEL
CBN CYBERNET MARINE PRODUCTS
CCA COPAL CORPORATION OF AMERICA
CCC COASTEL COMMUNICATIONS COMPANY
CCL COASTAL CLIMATE COMPANY
CCM COASTAL COMMUNICATIONS
CDC CORDIC COMPANY
CEC CECO COMMUNICATIONS, INC.
CHI CHARLES INDUSTRIES, LTD.
CKM CINKEL MARINE ELECTRONICS INDUSTRIES
CMA SOCIETE NOUVELLE D'EQUIPEMENT DU CALVADOS
CMC COE MANUFACTURING CO.
CME CUSHMAN ELECTRONICS, INC.
CMP C-MAP, s.r.l.
CMS COASTAL MARINE SALES COMPANY
CMV COURSEMASTER USA, INC.
CNV COASTAL NAVIGATOR
CNX CYNEX MANUFACTURING COMPANY
CPL COMPUTROL, INC.
CPN COMPUNAV
CPS COLUMBUS POSITIONING, LTD.
CPT CPT, INC.
CRE CRYSTAL ELECTRONICS, LTD.
CRO THE CARO GROUP
CRY CRYSTEK CRYSTALS CORP.
CSM COMSAT MARITIME SERVICES
CST CAST, INC.
CSV COMBINED SERVICES
CTA CURRENT ALTERNATIVES
CTB CETEC BENMAR
CTC CELL-TECH COMMUNICATIONS
CTE CASTLE ELECTRONICS
CTL C-TECH, LTD.
CNI CONTINENTAL INSTRUMENTS
CWD CUBIC WESTERN DATA
CWV CELWACE R.F., INC.
CYZ CYZ, INC.

DCC DOLPHIN COMPONENTS CORP.
DEB DEBEG GMBH

DFI DEFENDER INDUSTRIES, INC.
DGC DIGICOURSE, INC.
DME DIGITAL MARINE ELECTRONICS CORP.
DMI DATAMARINE INTERNATIONAL, INC.

DNS DORNIER SYSTEM GMBH
DNT DEL NORTE TECHNOLOGY, INC.
DPS DANAPLUS, INC.
DRL R.L.DRAKE COMPANY
DSC DYNASCAN CORP.
DYN DYNAMOTE CORPORATION
DYT DYTEK LABORATORIES, INC.

EBC EMERGENCY BEACON CORP.
ECT ECHOTEC, INC.
EEV EEV, INC.
EFC EFCOM COMMUNICATION SYSTEMS
ELD ELECTRONIC DEVICES, INC.
EMC ELECTRIC MOTION COMPANY
EMS ELECTRO MARINE SYSTEMS, INC.
ENA ENERGY ANALYSTS, INC.
ENC ENCRON, INC.
EPM EPSCO MARINE
EPT EASTPRINT, INC.
ERC THE ERICSSON CORPORATION
ESA EUROPEAN SPACE AGENCY

FDN FLUIDDYNE
FHE FISH HAWK ELECTRONICS
FJN JON FLUKE CO.
FMM FIRST MATE MARINE AUTOPILOTS
FNT FRANKLIN NET AND TWINE, LTD.
FRC THE FREDERICKS COMPANY
FTG T.G.FARIA CORPORATION
FUJ FUJITSU TEN CORPORATION OF AMERICA
FEC FURUNO ELECTRIC CO.
FUR FURUNO, USA. INC.

GAM GRE AMERICA, INC.
GCA GULF CELLULAR ASSOCIATES
GES GEOSTAR CORPORATION
GFC GRAPHIC CONTROLS, CORP.
GIS GALAX INTEGRATED SYSTEMS
GPI GLOBAL POSITIONING INSTRUMENT CORP.
GRM GARMIN CORPORATION
GSC GOLD STAR COMPANY, LTD.
GTO GRO ELECTRONICS
GVE GUEST CORPORATION
GVT GREAT VALLEY TECHNOLOGY

HAL HAL COMMUNICATIONS CORPORATION
HAR HARRIS CORPORATION
HIG HY-GAIN

HIT HI-TEC
HPK HEWLETT-PACKARD
HRC HARCO MANUFACTURING COMPANY
HRT HART SYSTEMS, INC.
HTI HEART INTERFACE, INC.

HUL HULL ELECTRONICS COMPANY
HWM HONEYWELL MARINE SYSTEMS

ICO ICOM OF AMERICA, INC.
IFD INTERNATIONAL FISHING DEVICES
IFI INSTRUMENTS FOR INDUSTRY
IME IMPERIAL MARINE EQUIPMENT
IMI I.M.I.
IMM ITT MACKAY MARINE
IMP IMPULSE MANUFACTURING, INC.
IMT INTERNATIONAL MARKETING AND TRADING, INC.
INM INMAR ELECTRONIC AND SALES, INC.
INT INTECH, INC.
IRT INTERA TECHNOLOGIES, LTD.
IST INNERSPACE TECHNOLOGY, INC.
ITM INTERMARINE ELECTRONICS, INC.
ITR ITERA, LTD.

JAN JAN CRYSTALS
JFR RAY JEFFERSON
JMT JAPAN MARINE TELECOMMUNICATIONS
JRC JAPAN RADIO COMPANY, LTD.
JRI J-R INDUSTRIES, INC.
JTC J-TECH ASSOCIATES, INC.
JTR JOTRON RADIOSEARCH, LTD.

KBE KB ELECTRONICS, LTD.
KBM KENNEBEC MARINE COMPANY
KLA KLEIN ASSOCIATES, INC.
KMR KING MARINE RADIO CORP.
KNG KING RADIO CORPORATION
KOD KODEN ELECTRONICS COMPANY, LTD.
KRP KRUPP INTERNATIONAL, INC.
KVH KVH COMPANY
KYI KYOCERA INTERNATIONAL, INC.

LAT LATITUDE CORPORATION
LEC LORAIN ELECTRONICS CORP.
LMM LAMARCHE MANUFACTURING CO.
LRD LORAD
LSE LITTLEMORE SCIENTIFIC ENGINEERING
LSP LASER PLOT, INC.
LTF LITTLEFUSE, INC.
LWR LOWRANCE ELECTRONICS CORP.

MCL MICROLOGIC, INC.
MDL MEDALLION INSTRUMENTS, INC.

MEC MARINE ENGINE CENTER, INC.
MEG MARITEC ENGINEERING GMBH
MFR MODERN PRODUCTS, LTD.
MFW FRANK W. MURPHY MANUFACTURING
MGS MG ELECTRONIC SALES CORP.
MIE MIECO, INC.

MIM MARCONI INTERNATIONAL MARINE CO.
MLE MARTHA LAKE ELECTRONICS
MLN MATLIN COMPANY
MLP MARLIN PRODUCTS
MLT MILLER TECHNOLOGIES
MMB MARSH-MCBIRNEY, INC.
MME MARKS MARINE ENGINEERING
MMP METAL MARINE PILOT, INC.
MMS MARS MARINE SYSTEMS
MNI MICRO-NOW INSTRUMENT COMPANY
MNT MARINE TECHNOLOGY
MNX MARINEX
MOT MOTOROLA COMMUNICATIONS AND ELECTRONICS
MPN MEMPHIS NET AND TWINE COMPANY, INC.
MQS MARQUIS INDUSTRIES, INC.
MRC MARINECOMP, INC.
MRE MORAD ELECTRONICS CORP.
MRP MOORING PRODUCTS OF NEW ZEALAND
MRR II MORROW, INC.
MRS MARINE RADIO SERVICE
MSB MITSUBISHI ELECTRIC COMPANY, LTD.
MSE MASTER ELECTRONICS
MSM MASTER MARINER, INC.
MST MESOTECH SYSTEMS, LTD.
MTA MARINE TECHNICAL ASSOCIATES
MTG MARINE TECHNICAL ASSISTANCE GROUP
MTK MARTECH, INC.
MTR MITRE CORPORATION, THE
MTS METS, INC.
MUR MURATA ERIE NORTH AMERICA
MVX MAGNAVOX ADVANCED PRODUCTS AND SYSTEMS CO.
MXX MAXXIMA MARINE
MES MARINE ELECTRONICS SERV. INC.

NAT NAUTECH, LTD.
NEF NEW ENGLAND FISHING GEAR, INC.
NMR NEWMAR
NGS NAVIGATION SCIENCES, INC.
NOM NAV-COM, INC.
NOV NOVATEL COMMUNICATIONS, LTD.
NSM NORTHSTAR MARINE
NTK NOVATECH DESIGNS, LTD.
NVC NAVICO
NVS NAVSTAR
NVO NAVIONICS, S.P.A.

OAR O.A.R. CORPORATION
ODE OCEAN DATA EQUIPMENT CORP.
ODN ODIN ELECTRONICS, INC.
OIN OCEAN INSTRUMENTS, INC.
OKI OKI ELECTRIC INDUSTRY COMPANY
OLY NAVSTAR LTD. (POLYTECHNIC ELECTRONICS)
OMN OMNETICS

ORE OCEAN RESEARCH
OTK OCEAN TECHNOLOGY

PCE PACE
PDM PRODELCO MARINE SYSTEMS
PLA PLATH, C. DIV OF LITTON
PLI PILOT INSTRUMENTS
PMI PERNICKA MARINE INSTRUMENTS
PMP PACIFIC MARINE PRODUCTS
PRK PERKO, INC.
PSM PEARCE-SIMPSON
PTC PETRO-COM
PTG P.T.I./GUEST
PTH PATHCOM, INC.

RAC RACAL MARINE, INC.
RAE RCA ASTRO-ELECTRONICS
RAY RAYTHEON MARINE COMPANY
RCA RCA SERVICE COMPANY
RCH ROACH ENGINEERING
RCI ROCHESTER INSTRUMENTS, INC.
RDI RADAR DEVICES
RDM RAY-DAR MANUFACTURING COMPANY
REC ROSS ENGINEERING CO.
RFP ROLFITE PRODUCTS, INC.
RGC RCA GLOBAL COMMUNICATIONS, INC.
RGY REGENCY ELECTRONICS, INC.
RMR RCA MISSILE AND SURFACE RADAR
RSL ROSS LABORATORIES, INC.
RSM ROBERTSON-SHIPMATE, USA.
RWI ROCKWELL INTERNATIONAL
RME RACAL MARINE ELECTRONICS
RTN ROBERTSON TRITECH NYASKAIEN A/S

SAI SAI, INC.
SBR SEA-BIRD ELECTRONICS, INC.
SCR SIGNALCRAFTERS, INC.
SEA SEA
SEC SERCEL ELECTRONICS OF CANADA
SEP STEEL AND ENGINE PRODUCTS, LTD.
SFN SEAFARER NAVIGATION INTERNATIONAL, LTD.
SGC SGC, INC.
SIG SIGNET, INC.
SIM SIMRAD, INC.
SKA SKANTEK CORPORATION

SKP SKIPPER ELECTRONICS A/S
SME SHAKESPEARE MARINE ELECTRONICS
SMF SEATTLE MARINE AND FISHING SUPPLY CO.
SML SIMERL INSTRUMENTS
SMI SPERRY MARINE, INC.
SNV STARNAV CORPORATION
SOM SOUND MARINE ELECTRONICS, INC.
SOV SELL OVERSEAS AMERICA

SPL SPELMAR
SPT SOUND POWERED TELEPHONE
SRD SRD LABS
SRS SCIENTIFIC RADIO SYSTEMS, INC.
SRT STANDARD RADIO AND TELEFON AB
SSI SEA SCOUT INDUSTRIES
STC STANDARD COMMUNICATIONS
STI SEA-TEMP INSTRUMENT CORP.
STM SI-TEX MARINE ELECTRONICS
SVY SAVOY ELECTRONICS
SWI SWOFFER MARINE INSTRUMENTS, INC.
SRS SHIPMATE, RAUFF & SORENSEN, A/S

TBB THOMPSON BROTHERS BOAT MANUFACTURING CO.
TCN TRADE COMMISSION OF NORWAY, THE
TDL TIDELAND SIGNAL
THR THRANE AND THRANE A/A
TLS TELESYSTEMS
TMT TAMTECH, LTD.
TNL TRIMBLE NAVIGATION
TRC TRACTOR, INC.
TSI TECHSONIC INDUSTRIES, INC.
TTK TALON TECHNOLOGY CORPORATION
TTS TRANSTECTOR SYSTEMS
TWC TRANSWORLD COMMUNICATIONS, INC.
TXI TEXAS INSTRUMENTS, INC.

UME UMEC
UNI UNIDEN CORPORATION OF AMERICA
UNP UNIPAS, INC.
UNF UNIFORCE ELECTRONICS COMPANY

VAN VANNER, INC.
VAR VARIAN EIMAC ASSOCIATES
VCM VIDEOCOM
VEX VEXILAR
VIS VESSEL INFORMATION SYSTEMS, INC.
VMR VAST MARKETING CORP.

WAL WALPORT U.S.A.
WBG WESTBERG MANUFACTURING, INC.
WBR WESBAR CORPORATION
WEC WESTINGHOUSE ELECTRIC CORP.
WHA W-H AUTOPILOTS

WMM WAIT MANUFACTURING AND MARINE SALES CO.
WMR WESMAR ELECTRONICS
WNG WINEGARD COMPANY
WSE WILSON ELECTRONICS CORPORATION
WTC WATERCOM
WST WEST ELECTRONICS LIMITED

YAS YAESU ELECTRONICS

GLOSSARY

accuracy - in navigation, a measure of the error between the point desired and the point achieved, or between the position indicated by measurement and the true position [compare with precision].

address field - for sentences in this standard, the fixed length field following the beginning sentence delimiter "$" (HEX 24). For approved sentences, composed of a two character talker identifier and a three character sentence formatter. For proprietary sentences, composed of the charcter "P" (HEX 50) followed by a three character manufacturer identification code.

additional secondary factor - in Loran-C, a correction in addition to the secondary phase factor correction for the additional time (or phase delay) for transmission of a low frequency signal over a composite land-seawater path when the signal transit time is based on the free-space velocity.

apparent wind - (see 'relative wind').

approved sentence - a sentence which has been approved for general use by the NMEA general assembly and is listed in this standard and attached Appendices.

arrival alarm - an alarm signal issued by a voyage tracking unit which indicates arrival at or at a pre-determined distance from a waypoint. - (see 'arrival circle')

arrival circle - an artificial boundary placed around the desti-

nation waypoint of the present navigation leg, the entering of which will signal an arrival alarm.

arrival perpendicular - crossing of the line which is perpendicular to the course line and which passes through the destination waypoint.

azimuth - the horizontal direction of a celestial point from a terrestrial point, expressed as the angular distance from a reference direction, usually measured from 000deg at the reference direction clockwise through 360deg.

ASCII - American Standard Code for Information Interchange. A 7 bit wide serial code describing numbers, upper and lower case alpha, characters, special and non-printing charcters. See American National Standards Institute documents ANSI X 3.15, ANSI X 3.16 and ANSI X 3.4.

atomic time - time obtained by counting the cycles of a signal in resonance with certain kinds of atoms.

autopilot - an automatic device for steering a vessel so as to maintain its heading in an intended direction. Mechanical means are used to steer the rudder. A radio navigation system is often connected to correct for track errors, or to select new destinations.

bearing - the horizontal direction of one terrestrial point from another, expressed as the angular distance from a reference direction, usually measured from 000deg at the reference direction clockwise through 360deg.

Beaufort wind scale - a numerical scale for indicating wind speed. Beaufort numbers (or forces) range from force 0 (calm) to force 12 (hurricane).

blink - in Loran-C, a signal used to indicate that a station is malfunctioning. Intended to prevent use of that signal for navigation.

checksum - for this standard, a validity check performed on the data contained in the sentence, calculated by the talker, appended to the message, when recalculated by the listener for comparison to determine if the message was received correctly. Required for some sentences, optional for all others.

communication protocoll - a method established for message transfer between a talker and a listener which includes the message format and the sequence in which the message are to be transferred. Also includes the signaling requirements such as baud rate, stop bits, parity, and bits per character.

course - the horizontal direction in which a vessel is steered or

intended to be steered, expressed as angular distance from north, usually from 000deg at north, clockwise through 360deg. Strictly, the term applies to direction through the water, not the direction intended to be made good over the ground (see 'track'). Differs from heading.

course over ground (COG) - term used to refer to the direction of the path over ground actually followed by a vessel [a misnomer in that courses are directions steered or intended to be steered through the water with respect to a reference meridian].

cross track error (XTE) - the distance from the vessel's present position to the closest point on a line between the origin and destination waypoints of the navigation leg being travelled.

cycle lock - in Loran-C, the comparison, in time difference, between corresponding carrier cycles contained in the rise times of a master and slave station pulse is called cycle match. This value when refined to a determination of the phase difference between these two cycles results in cycle lock. (See also 'envelope-to-cycle distortion').

data field - in an NMEA 0183 sentence, a field which contains a data value.

dead reckoning - the process of determining the position of a vessel at any instant by applying to the last well-determined position (point of departure or subsequent fix) the run that has since been made, usually based on the recent history of speed and heading measurements.

Decca chain - a group of associated stations of the Decca Navigator System. A Decca chain normally consists of a master and three slave stations. Each slave station is called by the color of associated pattern of hyperbolic lines as printed on the chart, i.e., red slave, green slave, purple slave.

Decca Navigator System - a short to medium range low frequency (70-130 kHz) radionavigation system by which a hyperbolic line of position of high accuracy is obtained. The system is an arrangement of fixed, phase locked, continuous wave transmitters operating on harmonically related frequencies and special receiving equipment located on a vessel.

delimiter - in this standard, a character or characters used to separate fields or sentences. The following delimiters are used in this standard:

field delimiters - ASCII "$" (HEX 24) for address fields
- ASCII "," (HEX 2C) for data fields
- ASCII "*" (HEX 2A) for checksum field

sentence delimiters - carriage return <CR> and line feed

<LF> (HEX 0D0A)
[note: a <CR><LF> is not required preceding the first sentence transmitted]

depth sounder - an instrument which determines the depth of water by measuring the time interval between the emissions of a sound and the return of its echo from the bottom.

destination - the immediate geographic point of interest to which a vessel is navigating. It may be the next waypoint along a route of waypoints or the final destination of a voyage.

deviation - the angle between the magnetic meridian and the axis of a compass card, expressed in degrees east or west to indicate direction in which the northern end of the compass card is offset from magnetic north.

Doppler speed log - an instrument which measures the relative motion between a vessel and the reflective sea bottom (for bottom return mode) or suspended particulate matter in the seawater itself (for water return mode) by measuring the frequency shifts between a transmitted and subsequently echoed acoustic or electromagnetic signal.

drift - the speed of a current.

echo sounder - (see 'depth sounder').

envelope-to-cycle distortion (ECD) - the time relationship between the phase of the Loran-C carrier and the time origin of the envelope waveform.

field - in this standard, a character or string of characters immediately preceded by a field delimiter (see 'delimiters').

fixed field - in this standard, a field in which the number of characters is fixed. For data fields, such fields are shown in the sentence definitions with no decimal point. Other fields which fall into this category are the address field and the checksum field (if present).

geoid - a surface along whith the gravity potential is everywhere equal (equipotential surface) and to which the direction of gravity is always perpendicular.

geometric dilution of precision (GDOP) - a value representing all geometric factors that degrade the accuracy of a position fix which has been derived from a navigation system.

Global Positioning System (GPS) - (full name NAVSTAR Global Positioning System) an all-weather, continuous satellite navigation system being developed by the Department of Defense under Air Force management. The fully deployed operational system is in-

tended to provide highly accurate position and velocity information in three dimensions and precise time and time interval on a global basis, to an unlimited number of authorized users. Although developed primarily for military missions, current policy calls for civil availability with a degradation in system accuracy in order to protect U.S. national security interests.

great circle - the intersection of the surface of a sphere and a plane through its center.

great circle chart - a chart on which a great circle appears as a straight line or approximately so.

great circle direction - horizontal direction of a great circle, expressed as angular distance from a reference direction.

group repetition interval (GRI) - of a particular Loran-C chain, the specified time interval for all stations of the chain to transmit their pulse groups. For each chain a minimum group

repetition interval is selected of sufficient duration to provide time for each station to transmit its pulse group and additional time between each pulse group so that signals from two or more stations cannot overlap in time anywhere within the coverage area.

gyrocompass - a compass having one or more gyroscopes as the directive element, and which is north-seeking. Its operation depends upon four natural phenomena: gyroscopic inertia, gyroscopic precession, the earth's rotation, and gravity.

gyropilot - an automatic device for steering a vessel by means of control signals received from gyrocompass (see 'autopilot').

gyroscope - a rapidly rotating mass free to move about one or both axes perpendicular to the axis of rotation and to each other.

heading - the horizontal direction in which a ship actually points or heads at any instant, expressed in angular units from a reference direction, usually from 000deg at the reference direction clockwise through 360deg. (See 'true heading' and 'magnetic heading')

heading-to-steer - the difference between the bearing to destination (from present position) and track-made-good, applied to the bearing to the destination to produce a heading that will guide the vessel to the destination.

horizontal dilution of precision (HDOP) - similar to GDOP, except elevation factors are ignored.

keel - a longitudinal timber or plate extending along the center of the bottom of a ship and often projecting from the bottom.

line of position (LOP) - in Loran or Decca navigation systems, a vector obtained by measurement of the time difference between the receipt of the master and slave signals which is then used to selected a corresponding LOP from a chart or table, Two or more intersecting LOP's are required to obtain a position fix.

listener - in this standard, the recipient of message across the interconnecting link.

log - an instrument for measuring the speed or distance or both traveled by a vessel.

Loran - the general designation of one group of radionavigation systems by which a hyperbolic line of position is determined through measuring the difference in the times of reception of synchronized pulse signals from two fixed transmitters.

magnetic bearing - bearing relative to magnetic north; compass bearing corrected for deviation.

magnetic heading - heading relative to magnetic north.

manufacturer identification code - in this standard, a three character manufacturer identifier, usually an acronym derived from the company name, which has been approved and is listed in Appendix III, for use by a manufacturer as part of the address field in formulation of proprietary sentences.

Mercator map projection - a conformal cylindrical map projection in which the surface of a sphere or spheroid, such as earth, is conceived as developed on a cylinder tangent along the equator. Meridias appear as equally spaced vertical lines and parallels as horizontal lines drawn farther apart as the latitude and longitude scales at any point is maintained. Also known as Mercator map projection.

Navigation Leg - the portion of a voyage upon which the vessel currently travels. Each leg consists of two waypoints, an ORIGIN, a DESTINATION, and a line between between them, upon which the vessel travels.

Navy Navigation Satellite System (TRANSIT) - an operational satellite navigation system of the united States conceived and developed by the Applied Physics Laboratory of John Hopkins University for the U.S. Navy. It is an all-weather, worldwide, and passive system used primarily for the navigation of surface ships and submarines. Also known by the acronyms NAVSAT or TRANSIT, it consists of a constellation of orbiting satellites, a ground system of tracking stations, and any number of user stations (navigators). The user stations are radionavigation devices composed of a receiver, a frequency cycle-counter, and a

computer. The minimum constellation for system operation is four satellites (five satellites in orbit provide redundancy). The satellite orbits are controlled by the tracking stations. Satellites broadcast current known positions while orbiting the earth. The NAVSAT system utilizes the Doppler shift of radio signals transmitted from the satellite to measure the relative velocity between the satellite and the navigator. Knowing the satellite orbit precisely, the navigator's absolute position can be accurately determined from this time rate of change of range to the satellite.

null field - in this standard, indicates that data is not available for the field. Indicated by two ASCII commas, i.e., ",," (HEX 2C2C), or, for the last data field in a sentence, one comma followed by either the checksum delimiter "*" (HEX 2A) or the sentce delimiters <CR><LF> (HEX 0D0A). [Note: the ASCII Null character (HEX 00) is not to be used for null fields!]

Omega Navigation System - a worldwide, continuous, radionavigation system of medium accuracy which provides hyperbolic lines of position through phase comparisons of VLF (10-14kHz) continuous wave signals transmitted on a common frequency on a time-shared basis. The fully implemented system is comprised of only eight transmitting stations.

one-way communication protocol - a protocol established between a talker and a listener in which only the talker may send messages [compare to 'two-way communication protocol'].

origin waypoint - the starting point of the present navigation leg.

precision - a measure of how close the outcome of a series of observations or measurements cluster about some estimated value of a desired quantity, such as the average value of a series of observations of a quantity. Precision implies repeatability of the observations within some specified limit and depends upon the random errors encountered due to the quality of the observing equipment, the skill of the observer and randomly fluctuating conditions such as temperature, pressure, refraction, ect. [compare with 'accuracy'].

proprietary sentence - a sentence to be sent across the interconnecting link which is not included in the List of Approved Sentences of this standard. All proprietary sentences sent over the interconnecting link shall contain a unique talker identifier which bwgins with a "P" (HEX 50) followed by a three character manufacturer identification code.

relative bearing - bearing relative to heading or to vessel.

relative wind - the speed and relative direction from which the wind appears to blow with reference to a moving point (also

called apparent wind).

rhumb line - a line on the surface of the earth making the same oblique angle with allmeridians. A rhumb line is a straight line on a rhumb (or Mercator) projection.

rhumb direction - the horizontal direction of a rhumb line, expressed as angular distance from a refernce direction. Also known as Mercator direction. (See Mercator map projection).

RMa sentence - Recommended Minimum Acceptable sentence, a composite sentence recommended by this standard to insure interoperability between talkers and listeners and to insure that all data considered necessary for navigation is sent by a particular navigation unit.

route - a planned course of travel, usually composed of more than one navigation leg.

route system - any system of one or more routes and/or routing measures aimed at reducing the risk of casualties schemes, recommended tracks, restricted areas, inshore traffic zones, etc.

semi-fixed field - data fields having a base other than 10, but use base 10 to express precision of the final term (such as minutes expressed as units with a decimal trailer instead of sec-

onds in a base 60 field, or seconds expressed with a decimal trailer).

selected waypoint - the waypoint currently selected to be the point toward which the vessel is travelling. Also called "TO" Waypoint, destination or destination waypoint.

sentence formatter - in this standard, a three charcter sentence identifier which follows the talker identifier ans is included as part of the address field. The sentence formatters are an integral part of the sentence definitions provided by this standard and attached appendices.

set - the direction towards which a current flows.

speed log - an instrument for measuring a vessel's speed through water and/or speed over ground. Asingle axis speed log normally measures speed along the longitudinal (fore/aft) axis of the vessel, while a dual axis speed log measures speed along the transverse (port/starboeard) axis as well. (Also see 'Doppler speed log').

speed made good - the adjusted speed which takes into account factors such as drift and wind speed. Can be estimated or computed ny a navigation receiver.

speed over ground (SOG) - the speed of a vessel along the actual path of travel over the ground.

signal-to-noise ratio (SNR) - the ratio of the magnitude of a signal to that of the noise (interference), often expressed in decibels.

talker - in the NMEA 0183 Standard, the originator of messages across an NMEA 0183 link.

talker identifier - the first two characters following the "$" (HEX 24) in an NMEA 0183 sentence (address character 1 and 2); selected from Table - Talker Identifier, Mnemonics of the NMEA 0183 Standard.

time difference (TD) - in Loran-C, the time difference measured from the time of reception of the master station signal to the time of reception of the slave station signal.

track - the intended or desired horizontal direction of travel with respect to the earth. The track expressed in degrees of the compass may differ from the course due to allowence made in the course for such factors as sea and weather conditions in order to resume the desired track (see 'track made good').

track made good - the single resultant direction from a point of departure to a point of arrival at any given time.

transducer - a device that converts one type of energy to another, as a loudspeaker that changes electrical energy into acoustical energy.

true bearing - bearing relative to true north; compass bearing corrected for compass error.

true heading - heading relative to true north.

to-way-communication protocol - a protocol established between a talker and a listener in which the listener may also issue requests to the talker when required [compare to 'one-way communication protocol].

UART - Universal Asynchronous Receiver/Transmitter which produces an electrical signal and timing for transmission of data over a communication path, and circuitry for detection and capture of such data transmitted from another UART.

Iniversal Time Coordinated (UTC) - a time scale based on the rotation of the earth which is disseminated by most broadcast time services [compare with 'atomic time'].

variable field - in NMEA 0183 sentences, a data field which may

or may not contain a decimal point depending on the requirements and the accuracy of the measuring device (talker).

variation - the angle between the magnetic and geographic meridians at any place, expressed in degrees and minutes east or west to indicate the direction of magnetic north from true north.

waypoint - a reference point on a track.

End of Appendix IV

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