The NMEA 0183 Protocol

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The material presented in this document has been compiled from various inofficial sources. It is neither a complete nor error-free description of the NMEA 0183 standard. In particular, it does not cover the new sentences and the high-speed interface defined in version 3.x.

Klaus Betke, May 2000. Revised August 2001.

1. What is the NMEA 0183 Standard?

The National Marine Electronics Association (NMEA) is a non-profit association of manufacturers, distributors, dealers, educational institutions, and others interested in peripheral marine electronics occupations. The NMEA 0183 standard defines an electrical interface and data protocol for communications between marine instrumentation.

NMEA 0183 is a voluntary industry standard, first released in March of 1983. It has been updated from time to time; the latest release, currently (August 2001) Version 3.0, July 2001, is available from the NMEA office (Warning: the price for non-members is 250 US$).

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NMEA has also established a working group to develop a new standard for data communications among shipboard electronic devices. The new standard, NMEA 2000, is a bi-directional, multi-transmitter, multi-receiver serial data network. It is multi-master and self-configuring, and there is no central controller. The NMEA began a beta testing period in January 2000 with eleven manufacturers. A release version of NMEA 2000 is expected in 2001.

2. Electrical Interface

NMEA 0183 devices are designated as either *talkers* or *listeners* (with some devices being both), employing an asynchronous serial interface with the following parameters:

Baud rate:	4800
Number of data bits:	8 (bit 7 is 0)
Stop bits:	1 (or more)
Parity:	none
Handshake:	none

NMEA 0183 allows a single talker and several listeners on one circuit. The recommended interconnect wiring is a shielded twisted pair, with the shield grounded only at the talker. The standard dos not specify the use of a particular connector. Note: The new 0183-HS standard (HS = high speed) introduced in version 3.0 uses a 3-wire interface and a baud rate of 38400. This type of interface is not discussed here.

Its is recommended that the talker output comply with EIA RS-422, a differential system with two signal lines, "A" and "B". Differential drive signals have no reference to ground and are more immune to noise. However, a single-ended line at TTL level is accepted as well. The voltages on the A line correspond to those on the TTL single wire, while the B voltages are inverted (when output A is at +5 V, output B is at 0 V, and vice versa. This is the unipolar RS-422 operation. In bipolar mode ±5 V are used).

In either case, the recommended receive circuit uses an opto-isolator with suitable protection circuitry. The input should be isolated from the receiver's ground. In practice, the single wire, or the RS-422 "A" wire may be directly connected to a computer's RS-232 input. In fact even many of the latest products, like hand-held GPS receivers, do not have a RS-422 differential output, but just a single line with TTL or 5 V CMOS compatible signal level.

3. General Sentence Format

All data is transmitted in the form of *sentences*. Only printable ASCII characters are allowed, plus CR (carriage return) and LF (line feed). Each sentence starts with a "$" sign and ends with <CR><LF>. There are three basic kinds of sentences: *talker sentences*, *proprietary sentences* and *query sentences*.

Talker Sentences. The general format for a talker sentence is:

```
$ttsss,d1,d2,....<CR><LF>
```

The first two letters following the „$" are the *talker identifier*. The next three characters (sss) are the *sentence identifier*, followed by a number of *data fields* separated by commas, followed by an optional *checksum*, and terminated by carriage return/line feed. The data fields are uniquely defined for each sentence type. An example talker sentence is:

```
$HCHDM,238,M<CR><LF>
```

where "HC" specifies the talker as being a magnetic compass, the "HDM" specifies the magnetic heading message follows. The "238" is the heading value, and "M" designates the heading value as magnetic.

A sentence may contain up to 80 characters plus "$" and CR/LF. If data for a field is not available, the field is omitted, but the delimiting commas are still sent, with no space between them. The checksum field consists of a "*" and two hex digits representing the exclusive OR of all characters between, but not including, the "$" and "*".

Proprietary Sentences. The standard allows individual manufacturers to define *proprietary sentence formats*. These sentences start with "$P", then a 3 letter manufacturer ID, followed by whatever data the manufacturer wishes, following the general format of the standard sentences. Some proprietary sentences, mainly from Garmin, Inc., are listed in chapter 6.

Query sentences. A query sentence is a means for a listener to request a particular sentence from a talker. The general format is:

```
$ttllQ,sss,[CR][LF]
```

The first two characters of the address field are the talker identifier of the requester and the next two characters are the talker identifier of the device being queried (listener). The fifth character is always a "Q" defining the message as a query. The next field (sss) contains the three letter mnemonic of the sentence being requested. An example query sentence is:

```
$CCGPQ,GGA<CR><LF>
```

where the "CC" device (computer) is requesting from the "GP" device (a GPS unit) the "GGA" sentence. The GPS will then transmit this sentence once per second until a different query is requested.

4. Talker Identifiers

AG	Autopilot - General
AP	Autopilot - Magnetic
CD	Communications – Digital Selective Calling (DSC)
CR	Communications – Receiver / Beacon Receiver
CS	Communications – Satellite
CT	Communications – Radio-Telephone (MF/HF)
CV	Communications – Radio-Telephone (VHF)
CX	Communications – Scanning Receiver
DF	Direction Finder
EC	Electronic Chart Display & Information System (ECDIS)
EP	Emergency Position Indicating Beacon (EPIRB)
ER	Engine Room Monitoring Systems
GP	Global Positioning System (GPS)
HC	Heading – Magnetic Compass
HE	Heading – North Seeking Gyro
HN	Heading – Non North Seeking Gyro
II	Integrated Instrumentation
IN	Integrated Navigation
LC	Loran C
P	Proprietary Code
RA	RADAR and/or ARPA
SD	Sounder, Depth
SN	Electronic Positioning System, other/general
SS	Sounder, Scanning
TI	Turn Rate Indicator
VD	Velocity Sensor, Doppler, other/general
DM	Velocity Sensor, Speed Log, Water, Magnetic
VW	Velocity Sensor, Speed Log, Water, Mechanical
WI	Weather Instruments
YX	Transducer
ZA	Timekeeper – Atomic Clock
ZC	Timekeeper – Chronometer
ZQ	Timekeeper – Quartz
ZV	Timekeeper – Radio Update, WWV or WWVH

5. Sentence Identifiers and Formats

AAM Waypoint Arrival Alarm

```
       1 2 3   4 5    6
       | | |   | |    |
$--AAM,A,A,x.x,N,c--c*hh
```

1) Status, BOOLEAN, A = Arrival circle entered
2) Status, BOOLEAN, A = perpendicular passed at waypoint
3) Arrival circle radius
4) Units of radius, nautical miles
5) Waypoint ID
6) Checksum

ALM GPS Almanac Data

```
       1   2   3  4   5  6    7  8    9    10     11     12     13     14  15   16
       |   |   |  |   |  |    |  |    |    |      |      |      |      |   |    |
$--ALM,x.x,x.x,xx,x.x,hh,hhhh,hh,hhhh,hhhh,hhhhhh,hhhhhh,hhhhhh,hhhhhh,hhh,hhh,*hh
```

1) Total number of messages
2) Message Number
3) Satellite PRN number (01 to 32)
4) GPS Week Number: Date and time in GPS is computed as number of weeks
   from 6 January 1980 plus number of seconds into the week.
5) SV health, bits 17-24 of each almanac page
6) Eccentricity
7) Almanac Reference Time
8) Inclination Angle
9) Rate of Right Ascension
10) Root of semi-major axis
11) Argument of perigee
12) Longitude of ascension node
13) Mean anomaly
14) F0 Clock Parameter
15) F1 Clock Parameter
16) Checksum

APA Autopilot Sentence "A"

```
       1 2  3   4 5 6 7  8  9 10    11
       | |  |   | | | |  |  | |     |
$--APA,A,A,x.xx,L,N,A,A,xxx,M,c---c*hh
```

1) Status
   V = LORAN-C Blink or SNR warning
   A = general warning flag or other navigation systems when a reliable
       fix is not available
2) Status
   V = Loran-C Cycle Lock warning flag
   A = OK or not used
3) Cross Track Error Magnitude
4) Direction to steer, L or R
5) Cross Track Units (Nautic miles or kilometres)
6) Status
   A = Arrival Circle Entered
7) Status
   A = Perpendicular passed at waypoint
8) Bearing origin to destination
9) M = Magnetic, T = True
10) Destination Waypoint ID
11) checksum

APB Autopilot Sentence "B"

```
                                          13    15
       1 2 3   4 5 6 7 8   9 10   11  12|   14|
       | | |   | | | | |   | |    |   | |   | |
$--APB,A,A,x.x,a,N,A,A,x.x,a,c--c,x.x,a,x.x,a*hh
```

 1) Status
    V = LORAN-C Blink or SNR warning
    A = general warning flag or other navigation systems when a reliable
        fix is not available
 2) Status
    V = Loran-C Cycle Lock warning flag
    A = OK or not used
 3) Cross Track Error Magnitude
 4) Direction to steer, L or R
 5) Cross Track Units, N = Nautical Miles
 6) Status
    A = Arrival Circle Entered
 7) Status
    A = Perpendicular passed at waypoint
 8) Bearing origin to destination
 9) M = Magnetic, T = True
10) Destination Waypoint ID
11) Bearing, present position to Destination
12) M = Magnetic, T = True
13) Heading to steer to destination waypoint
14) M = Magnetic, T = True
15) Checksum

ASD Autopilot System Data

Format unknown

BEC Bearing & Distance to Waypoint – Dead Reckoning

```
                                                      12
       1         2       3 4        5 6   7 8   9 10  11|    13
       |         |       | |        | |   | |   | |   | |    |
$--BEC,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x.x,T,x.x,M,x.x,N,c--c*hh
```

 1) Time (UTC)
 2) Waypoint Latitude
 3) N = North, S = South
 4) Waypoint Longitude
 5) E = East, W = West
 6) Bearing, True
 7) T = True
 8) Bearing, Magnetic
 9) M = Magnetic
10) Nautical Miles
11) N = Nautical Miles
12) Waypoint ID
13) Checksum

BOD Bearing – Waypoint to Waypoint

```
       1   2 3   4 5    6    7
       |   | |   | |    |    |
$--BOD,x.x,T,x.x,M,c--c,c--c*hh
```

1) Bearing Degrees, TRUE
2) T = True
3) Bearing Degrees, Magnetic
4) M = Magnetic
5) TO Waypoint
6) FROM Waypoint
7) Checksum

BWC Bearing and Distance to Waypoint – Latitude, N/S, Longitude, E/W, UTC, Status

```
                                                      11
       1         2       3 4        5 6   7 8   9 10  | 12   13
       |         |       | |        | |   | |   | |   | |    |
$--BWC,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x.x,T,x.x,M,x.x,N,c--c*hh
```

1) Time (UTC)
2) Waypoint Latitude
3) N = North, S = South
4) Waypoint Longitude
5) E = East, W = West
6) Bearing, True
7) T = True
8) Bearing, Magnetic
9) M = Magnetic
10) Nautical Miles
11) N = Nautical Miles
12) Waypoint ID
13) Checksum

BWR Bearing and Distance to Waypoint – Rhumb Line Latitude, N/S, Longitude, E/W, UTC, Status

```
                                                      11
       1         2       3 4        5 6   7 8   9 10  | 12   13
       |         |       | |        | |   | |   | |   | |    |
$--BWR,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x.x,T,x.x,M,x.x,N,c--c*hh
```

1) Time (UTC)
2) Waypoint Latitude
3) N = North, S = South
4) Waypoint Longitude
5) E = East, W = West
6) Bearing, True
7) T = True
8) Bearing, Magnetic
9) M = Magnetic
10) Nautical Miles
11) N = Nautical Miles
12) Waypoint ID
13) Checksum

BWW Bearing – Waypoint to Waypoint

```
       1   2 3   4 5    6    7
       |   | |   | |    |    |
$--BWW,x.x,T,x.x,M,c--c,c--c*hh
```

1) Bearing Degrees, TRUE
2) T = True
3) Bearing Degrees, Magnetic
4) M = Magnetic
5) TO Waypoint
6) FROM Waypoint
7) Checksum

DBK Depth Below Keel

```
       1   2 3   4 5   6 7
       |   | |   | |   | |
$--DBK,x.x,f,x.x,M,x.x,F*hh
```

1) Depth, feet
2) f = feet
3) Depth, meters
4) M = meters
5) Depth, Fathoms
6) F = Fathoms
7) Checksum

DBS Depth Below Surface

```
       1   2 3   4 5   6 7
       |   | |   | |   | |
$--DBS,x.x,f,x.x,M,x.x,F*hh
```

1) Depth, feet
2) f = feet
3) Depth, meters
4) M = meters
5) Depth, Fathoms
6) F = Fathoms
7) Checksum

DBT Depth Below Transducer

```
       1   2 3   4 5   6 7
       |   | |   | |   | |
$--DBT,x.x,f,x.x,M,x.x,F*hh
```

1) Depth, feet
2) f = feet
3) Depth, meters
4) M = meters
5) Depth, Fathoms
6) F = Fathoms
7) Checksum

DCN Decca Position

obsolete

DPT Heading – Deviation & Variation

```
       1   2   3
       |   |   |
$--DPT,x.x,x.x*hh
```

1) Depth, meters
2) Offset from transducer;
   positive means distance from transducer to water line,
   negative means distance from transducer to keel
3) Checksum

DSC Digital Selective Calling Information

Format unknown

DSE Extended DSC

Format unknown

DSI DSC Transponder Initiate

Format unknown

DSR DSC Transponder Response

Format unknown

DTM Datum Reference

Format unknown

FSI Frequency Set Information

```
       1      2      3 4 5
       |      |      | | |
$--FSI,xxxxxx,xxxxxx,c,x*hh
```

1) Transmitting Frequency
2) Receiving Frequency
3) Communications Mode (NMEA Syntax 2)
4) Power Level
5) Checksum

GBS GPS Satellite Fault Detection

Format unknown

GGA Global Positioning System Fix Data. Time, Position and fix related data for a GPS receiver

```
                                                     11
       1         2       3 4        5 6 7  8   9  10 |  12 13  14   15
       |         |       | |        | | |  |   |   | |   | |   |    |
$--GGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,x,M,x.x,M,x.x,xxxx*hh
```

1) Time (UTC)
2) Latitude
3) N or S (North or South)
4) Longitude
5) E or W (East or West)
6) GPS Quality Indicator,
   0 - fix not available,
   1 - GPS fix,
   2 - Differential GPS fix
7) Number of satellites in view, 00 - 12
8) Horizontal Dilution of precision
9) Antenna Altitude above/below mean-sea-level (geoid)
10) Units of antenna altitude, meters
11) Geoidal separation, the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid), "-" means mean-sea-level below ellipsoid
12) Units of geoidal separation, meters
13) Age of differential GPS data, time in seconds since last SC104 type 1 or 9 update, null field when DGPS is not used
14) Differential reference station ID, 0000-1023
15) Checksum

GLC Geographic Position, Loran-C

```
                                          12    14
       1    2   3 4   5 6   7 8   9 10  11|   13|
       |    |   | |   | |   | |   | |   | |   | |
$--GLC,xxxx,x.x,a,x.x,a,x.x,a.x,x,a,x.x,a,x.x,a*hh
```

1) GRI Microseconds/10
2) Master TOA Microseconds
3) Master TOA Signal Status
4) Time Difference 1 Microseconds
5) Time Difference 1 Signal Status
6) Time Difference 2 Microseconds
7) Time Difference 2 Signal Status
8) Time Difference 3 Microseconds
9) Time Difference 3 Signal Status
10) Time Difference 4 Microseconds
11) Time Difference 4 Signal Status
12) Time Difference 5 Microseconds
13) Time Difference 5 Signal Status
14) Checksum

GLL Geographic Position – Latitude/Longitude

```
       1       2 3        4 5         6 7
       |       | |        | |         | |
$--GLL,llll.ll,a,yyyyy.yy,a,hhmmss.ss,A*hh
```

1) Latitude
2) N or S (North or South)
3) Longitude
4) E or W (East or West)
5) Time (UTC)
6) Status A - Data Valid, V - Data Invalid
7) Checksum

GRS GPS Range Residuals

Format unknown

GST GPS Pseudorange Noise Statistics

Format unknown

GSA GPS DOP and active satellites

```
       1 2 3                       14 15  16  17 18
       | | |                       |  |   |   |  |
$--GSA,a,a,x,x,x,x,x,x,x,x,x,x,x,x,x,x.x,x.x,x.x*hh
```

```
 1) Selection mode
 2) Mode
 3) ID of 1st satellite used for fix
 4) ID of 2nd satellite used for fix
 ...
14) ID of 12th satellite used for fix
15) PDOP in meters
16) HDOP in meters
17) VDOP in meters
18) Checksum
```

GSV Satellites in view

```
       1 2 3 4 5 6 7     n
       | | | | | | |     |
$--GSV,x,x,x,x,x,x,x,...*hh
```

```
1) total number of messages
2) message number
3) satellites in view
4) satellite number
5) elevation in degrees
6) azimuth in degrees to true
7) SNR in dB
more satellite infos like 4)-7)
n) Checksum
```

GTD Geographic Location in Time Differences

```
       1   2   3   4   5  6
       |   |   |   |   |  |
$--GTD,x.x,x.x,x.x,x.x,x.x*hh
```

```
1) time difference
2) time difference
3) time difference
4) time difference
5) time difference
n) Checksum
```

GXA TRANSIT Position – Latitude/Longitude, Location and Time of TRANSIT Fix at Waypoint

obsolete

HDG Heading – Deviation & Variation

```
       1   2   3 4   5 6
       |   |   | |   | |
$--HDG,x.x,x.x,a,x.x,a*hh
```

1) Magnetic Sensor heading in degrees
2) Magnetic Deviation, degrees
3) Magnetic Deviation direction, E = Easterly, W = Westerly
4) Magnetic Variation degrees
5) Magnetic Variation direction, E = Easterly, W = Westerly
6) Checksum

HDM Heading – Magnetic

```
       1   2 3
       |   | |
$--HDM,x.x,M*hh
```

1) Heading Degrees, magnetic
2) M = magnetic
3) Checksum

HDT Heading – True

```
       1   2 3
       |   | |
$--HDT,x.x,T*hh
```

1) Heading Degrees, true
2) T = True
3) Checksum

HSC Heading Steering Command

```
       1   2 3   4  5
       |   | |   |  |
$--HSC,x.x,T,x.x,M,*hh
```

1) Heading Degrees, True
2) T = True
3) Heading Degrees, Magnetic
4) M = Magnetic
5) Checksum

LCD Loran-C Signal Data

```
       1    2   3   4   5   6   7   8   9   10  11  12  13  14
       |    |   |   |   |   |   |   |   |   |   |   |   |   |
$--LCD,xxxx,xxx,xxx,xxx,xxx,xxx,xxx,xxx,xxx,xxx,xxx,xxx,xxx*hh
```

1) GRI Microseconds/10
2) Master Relative SNR
3) Master Relative ECD
4) Time Difference 1 Microseconds
5) Time Difference 1 Signal Status
6) Time Difference 2 Microseconds
7) Time Difference 2 Signal Status
8) Time Difference 3 Microseconds
9) Time Difference 3 Signal Status
10) Time Difference 4 Microseconds
11) Time Difference 4 Signal Status
12) Time Difference 5 Microseconds
13) Time Difference 5 Signal Status
14) Checksum

MSK MSK Receiver Interface (for DGPS Beacon Receivers)

```
       1     2  3   4  5 6
       |     |  |   |  | |
$GPMSK,xxx.x,xx,xxx,xx,N*hh
```

1) Frequency in kHz (283.5 to 325.0)
2) Frequency Selection
   M1 = Manual
   A1 = Automatic (field 1 empty)
3) MSK bit rate (100 or 200)
4) Bit Rate Selection
   M2 = Manual
   A2 = Automatic (field 3 empty)
5) Period of output of performance status message, 0 to 100 seconds ($CRMSS)
6) Checksum

MSS MSK Receiver Signal Status

Format unknown

MWD Wind Direction & Speed

Format unknown

MTW Water Temperature

```
       1   2 3
       |   | |
$--MTW,x.x,C*hh
```

1) Degrees
2) Unit of Measurement, Celcius
3) Checksum

MWV Wind Speed and Angle

```
       1   2 3   4 5
       |   | |   | |
$--MWV,x.x,a,x.x,a*hh

1) Wind Angle, 0 to 360 degrees
2) Reference, R = Relative, T = True
3) Wind Speed
4) Wind Speed Units, K/M/N
5) Status, A = Data Valid
6) Checksum
```

OLN Omega Lane Numbers

```
obsolete
```

OSD Own Ship Data

```
       1   2 3   4 5   6 7   8   9 10
       |   | |   | |   | |   |   | |
$--OSD,x.x,A,x.x,a,x.x,a,x.x,x.x,a*hh

 1) Heading, degrees true
 2) Status, A = Data Valid
 3) Vessel Course, degrees True
 4) Course Reference
 5) Vessel Speed
 6) Speed Reference
 7) Vessel Set, degrees True
 8) Vessel drift (speed)
 9) Speed Units
10) Checksum
```

ROO Waypoints in Active Route

```
       1               n
       |               |
$--ROO,c---c,c---c,....*hh

1) waypoint ID
 ...
n) checksum
```

RMA Recommended Minimum Navigation Information

```
                                                      12
       1 2       3 4        5 6   7   8   9   10  11|
       | |       | |        | |   |   |   |   |   | |
$--RMA,A,llll.ll,a,yyyyy.yy,a,x.x,x.x,x.x,x.x,x.x,x.x,a*hh

 1) Blink Warning
 2) Latitude
 3) N or S
 4) Longitude
 5) E or W
 6) Time Difference A, µS
 7) Time Difference B, µS
 8) Speed Over Ground, Knots
 9) Track Made Good, degrees true
10) Magnetic Variation, degrees
11) E or W
12) Checksum
```

RMB Recommended Minimum Navigation Information

```
                                                          14
       1 2   3 4    5    6       7 8        9 10  11  12  13|
       | |   | |    |    |       | |        | |   |   |   | |
$--RMB,A,x.x,a,c--c,c--c,llll.ll,a,yyyyy.yy,a,x.x,x.x,x.x,A*hh
```

1) Status, V = Navigation receiver warning
2) Cross Track error - nautical miles
3) Direction to Steer, Left or Right
4) TO Waypoint ID
5) FROM Waypoint ID
6) Destination Waypoint Latitude
7) N or S
8) Destination Waypoint Longitude
9) E or W
10) Range to destination in nautical miles
11) Bearing to destination in degrees True
12) Destination closing velocity in knots
13) Arrival Status, A = Arrival Circle Entered
14) Checksum

RMC Recommended Minimum Navigation Information

```
                                                       12
       1         2 3       4 5        6 7   8   9    10  11|
       |         | |       | |        | |   |   |    |   | |
$--RMC,hhmmss.ss,A,llll.ll,a,yyyyy.yy,a,x.x,x.x,xxxx,x.x,a*hh
```

1) Time (UTC)
2) Status, V = Navigation receiver warning
3) Latitude
4) N or S
5) Longitude
6) E or W
7) Speed over ground, knots
8) Track made good, degrees true
9) Date, ddmmyy
10) Magnetic Variation, degrees
11) E or W
12) Checksum

ROT Rate Of Turn

```
       1   2 3
       |   | |
$--ROT,x.x,A*hh
```

1) Rate Of Turn, degrees per minute, "-" means bow turns to port
2) Status, A means data is valid
3) Checksum

RPM Revolutions

```
       1 2 3   4   5 6
       | | |   |   | |
$--RPM,a,x,x.x,x.x,A*hh
```

1) Source; S = Shaft, E = Engine
2) Engine or shaft number
3) Speed, Revolutions per minute
4) Propeller pitch, % of maximum, "-" means astern
5) Status, A means data is valid
6) Checksum

RSA Rudder Sensor Angle

```
       1   2 3   4 5
       |   | |   | |
$--RSA,x.x,A,x.x,A*hh
```

1) Starboard (or single) rudder sensor, "-" means Turn To Port
2) Status, A means data is valid
3) Port rudder sensor
4) Status, A means data is valid
5) Checksum

RSD RADAR System Data

```
                                                      14
       1   2   3   4   5   6   7   8   9   10  11 12 13|
       |   |   |   |   |   |   |   |   |   |   |  | | |
$--RSD,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,a,a*hh
```

 9) Cursor Range From Own Ship
10) Cursor Bearing Degrees Clockwise From Zero
11) Range Scale
12) Range Units
14) Checksum

RTE Routes

```
       1   2   3 4    5           x    n
       |   |   | |    |           |    |
$--RTE,x.x,x.x,a,c--c,c--c, ..... c--c*hh
```

1) Total number of messages being transmitted
2) Message Number
3) Message mode
   c = complete route, all waypoints
   w = working route, the waypoint you just left, the waypoint you're heading to, then all the rest
4) Waypoint ID
x) More Waypoints
n) Checksum

SFI Scanning Frequency Information

```
       1   2   3      4                    n
       |   |   |      |                    |
$--SFI,x.x,x.x,xxxxxx,c ..........  xxxxxx,c*hh
```

1) Total Number Of Messages
2) Message Number
3) Frequency 1
4) Mode 1
n) Checksum

STN Multiple Data ID

```
       1   2
       |   |
$--STN,x.x,*hh
```

1) Talker ID Number
2) Checksum

TLL Target Latitude and Longitude

Format unknown

TRF TRANSIT Fix Data

obsolete

TTM Tracked Target Message

```
                                        11     13
       1  2   3   4 5   6   7 8   9   10|    12| 14
       |  |   |   | |   |   | |   |   | |    | | |
$--TTM,xx,x.x,x.x,a,x.x,x.x,a,x.x,x.x,a,c--c,a,a*hh
```

1) Target Number
2) Target Distance
3) Bearing from own ship
4) Bearing Units
5) Target speed
6) Target Course
7) Course Units
8) Distance of closest-point-of-approach
9) Time until closest-point-of-approach "-" means increasing
10) "-" means increasing
11) Target name
12) Target Status
13) Reference Target
14) Checksum

VBW Dual Ground/Water Speed

```
       1   2   3 4   5   6 7
       |   |   | |   |   | |
$--VBW,x.x,x.x,A,x.x,x.x,A*hh
```

1) Longitudinal water speed, "-" means astern
2) Transverse water speed, "-" means port
3) Status, A = data valid
4) Longitudinal ground speed, "-" means astern
5) Transverse ground speed, "-" means port
6) Status, A = data valid
7) Checksum

VDR Set and Drift

```
       1   2 3   4 5   6 7
       |   | |   | |   | |
$--VDR,x.x,T,x.x,M,x.x,N*hh
```

1) Degress True
2) T = True
3) Degrees Magnetic
4) M = Magnetic
5) Knots (speed of current)
6) N = Knots
7) Checksum

VHW Water Speed and Heading

```
       1   2 3   4 5   6 7   8 9
       |   | |   | |   | |   | |
$--VHW,x.x,T,x.x,M,x.x,N,x.x,K*hh
```

1) Degress True
2) T = True
3) Degrees Magnetic
4) M = Magnetic
5) Knots (speed of vessel relative to the water)
6) N = Knots
7) Kilometers (speed of vessel relative to the water)
8) K = Kilometres
9) Checksum

VLW Distance Traveled through Water

```
       1   2 3   4 5
       |   | |   | |
$--VLW,x.x,N,x.x,N*hh
```

1) Total cumulative distance
2) N = Nautical Miles
3) Distance since Reset
4) N = Nautical Miles
5) Checksum

VPW Speed – Measured Parallel to Wind

```
       1   2 3   4 5
       |   | |   | |
$--VPW,x.x,N,x.x,M*hh
```

1) Speed, "-" means downwind
2) N = Knots
3) Speed, "-" means downwind
4) M = Meters per second
5) Checksum

VTG Track Made Good and Ground Speed

```
       1   2 3   4 5  6 7   8 9
       |   | |   | |  | |   | |
$--VTG,x.x,T,x.x,M,x.x,N,x.x,K*hh
```

1) Track Degrees
2) T = True
3) Track Degrees
4) M = Magnetic
5) Speed Knots
6) N = Knots
7) Speed Kilometers Per Hour
8) K = Kilometres Per Hour
9) Checksum

VWR Relative Wind Speed and Angle

```
        1  2  3  4  5  6  7  8 9
        |  |  |  |  |  |  |  | |
$--VWR,x.x,a,x.x,N,x.x,M,x.x,K*hh
```

1) Wind direction magnitude in degrees
2) Wind direction Left/Right of bow
3) Speed
4) N = Knots
5) Speed
6) M = Meters Per Second
7) Speed
8) K = Kilometers Per Hour
9) Checksum

WCV Waypoint Closure Velocity

```
       1   2 3    4
       |   | |    |
$--WCV,x.x,N,c--c*hh
```

1) Velocity
2) N = knots
3) Waypoint ID
4) Checksum

WDC Distance to Waypoint – Great Circle

Format unknown

WDR Distance to Waypoint – Rhumb Line

Format unknown

WNC Distance – Waypoint to Waypoint

```
       1   2 3   4 5    6    7
       |   | |   | |    |    |
$--WNC,x.x,N,x.x,K,c--c,c--c*hh
```

1) Distance, Nautical Miles
2) N = Nautical Miles
3) Distance, Kilometers
4) K = Kilometers
5) TO Waypoint
6) FROM Waypoint
7) Checksum

WPL Waypoint Location

```
       1       2 3        4 5    6
       |       | |        | |    |
$--WPL,llll.ll,a,yyyyy.yy,a,c--c*hh
```

1) Latitude
2) N or S (North or South)
3) Longitude
4) E or W (East or West)
5) Waypoint Name
6) Checksum

XDR Cross Track Error – Dead Reckoning

```
       1 2   3 4           n
       | |   | |           |
$--XDR,a,x.x,a,c--c, ..... *hh
```

1) Transducer type
2) Measurement data
3) Units of measurement
4) Name of transducer
x) More of the same
n) Checksum

XTE Cross-Track Error – Measured

```
       1 2 3   4 5  6
       | | |   | |  |
$--XTE,A,A,x.x,a,N,*hh
```

1) Status
   V = LORAN-C blink or SNR warning
   A = general warning flag or other navigation systems when a reliable
       fix is not available
2) Status
   V = Loran-C cycle lock warning flag
   A = OK or not used
3) Cross track error magnitude
4) Direction to steer, L or R
5) Cross track units. N = Nautical Miles
6) Checksum

XTR Cross Track Error – Dead Reckoning

```
       1   2 3 4
       |   | | |
$--XTR,x.x,a,N*hh
```

1) Magnitude of cross track error
2) Direction to steer, L or R
3) Units, N = Nautical Miles
4) Checksum

ZDA Time & Date – UTC, Day, Month, Year and Local Time Zone

```
       1         2  3  4    5  6  7
       |         |  |  |    |  |  |
$--ZDA,hhmmss.ss,xx,xx,xxxx,xx,xx*hh
```

1) Local zone minutes description, same sign as local hours
2) Local zone description, 00 to +/- 13 hours
3) Year
4) Month, 01 to 12
5) Day, 01 to 31
6) Time (UTC)
7) Checksum

ZDL Time and Distance to Variable Point

Format unknown

ZFO UTC & Time from Origin Waypoint

```
       1         2         3    4
       |         |         |    |
$--ZFO,hhmmss.ss,hhmmss.ss,c--c*hh
```

1) Time (UTC)
2) Elapsed Time
3) Origin Waypoint ID
4) Checksum

ZTG UTC & Time to Destination Waypoint

```
       1         2         3    4
       |         |         |    |
$--ZTG,hhmmss.ss,hhmmss.ss,c--c*hh
```

1) Time (UTC)
2) Time Remaining
3) Destination Waypoint ID
4) Checksum

6. Some Proprietary Sentences

$PGRMC Sensor Configuration Information

Garmin proprietary sentence

```
                                      13  14
       1 2   3  4   5   6   7   8   9 10| 12|
       | |   |  |   |   |   |   |   | | | | |
$PGRMC,A,x.x,hh,x.x,x.x,x.x,x.x,x.x,x.x,c,c,2,c*hh
```

1) Fix mode, A=automatic (only option)
2) Altitude above/below mean sea level, -1500.0 to 18000.0 meters
3) Earth datum index. If the user datum index (96) is specified, fields 5-8 must contain valid values. Otherwise, fields 4-8 must be null.
4) User earth datum semi-major axis, 6360000.0 to 6380000.0 meters (.001 meters resolution)
5) User earth datum inverse flattening factor, 285.0 to 310.0 (10-9 resolution)
6) User earth datum delta x earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
7) User earth datum delta y earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
8) User earth datum delta z earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
9) Differential mode, A = automatic (output DGPS data when available, non-DGPs otherwise), D = differential exclusively (output only differential fixes)
10) NMEA Baud rate, 1 = 1200, 2 = 2400, 3 = 4800, 4 = 9600
11) Filter mode, 2 = no filtering (only option)
12) PPS mode, 1 = No PPS, 2 = 1 Hz
13) Checksum

$PGRME Estimated Position Error

Garmin proprietary sentence

```
       1   2 3   4 5   6 7
       |   | |   | |   | |
$PGRME,x.x,M,x.x,M,x.x,M*hh
```

1) Estimated horizontal position error (HPE)
2) Unit, metres
3) Estimated vertical error (VPE)
4) Unit, metres
5) Overall spherical equivalent position error
6) Unit, metres
7) Checksum

$PGRMF Position Fix Sentence

Garmin proprietary sentence

```
                                                      10  12        15
       1   2   3      4      5   6         7 8          9 | 11|   13  14| 16
       |   |   |      |      |   |         | |          | | | |   |   | | |
$PGRMF,x.x,x.x,ddmmyy,hhmmss,x.x,ddmm.mmmm,c,dddmm.mmmm,c,c,c,x.x,x.x,x.x,c,c*hh
```

```
 1) GPS week number (0 - 1023)
 2) GPS seconds (0 - 604799)
 3) UTC date of position fix
 4) UTC time of position fix
 5) GPS leap second count
 6) Latitude
 7) N or S
 8) Longitude
 9) E or W
10) Mode
    M = manual
    A = automatic
11) Fix type
    0 = no fix
    1 = 2D fix
    2 = 3D fix
12) Speed over ground, 0 to 999 kilometers/hour
13) Course over ground, 0 to 359 degrees, true
14) Position dilution of precision, 0 to 9 (rounded to nearest integer value)
15) Time dilution of precision, 0 to 9 (rounded to nearest integer value)
16) Checksum
```

$PGRMI Sensor Initialisation Information

Garmin proprietary sentence

```
       1        2 3        4 5      6      7
       |        | |        | |      |      |
$PGRMI,ddmm.mmm,N,ddmm.mmm,E,ddmmyy,hhmmss*hh
```

```
1) Latitude
2) N or S
3) Longitude
4) E or W
5) Current UTC date
6) Current UTC time
7) Checksum
```

$PGRMM Map Datum

Garmin proprietary sentence

```
       1     2
       |     |
$PGRMM,c---c*hh
```

```
1) Currently active horizontal datum (WGS-84, NAD27 Canada, ED50, a.s.o)
2) Checksum
```

$PGRMO Output Sentence Enable/Disable

```
Garmin proprietary sentence

       1     2 3
       |     | |
$PGRMO,ccccc,c*hh

1) Target sentence description (e.g., PGRMT, GPGSV, etc.)
2) Target sentence mode
   0 = disable specified sentence
   1 = enable specified sentence
   2 = disable all
   3 = enable all output sentences (except GPALM)
3) Checksum
```

$PGRMT Sensor Status Information

```
Garmin proprietary sentence

       1     2 3 4 5 6 7 8   9 10
       |     | | | | | | |   | |
$PGRMT,c...c,c,c,c,c,c,c,x.x,c*hh

 1) Product, model and software version
    e.g. "GPS25VEE] 1.10"
 2) Rom checksum test
    P = pass
    F = fail
 3) Receiver failure discrete
    P = pass
     F = fail
 4) Stored data lost
    R = retained
    L = lost
 5) Real time clock lost
    R = retained
    L = lost
 6) 0scillator drift discrete
    P = pass
    F = excessive drift detected
 7) Data collection discrete
    C = collecting
    null if not collecting
 8) Board temperature in degrees C
 9) Board configuration data
    R = retained
    L = lost
10) Checksum
```

$PGRMV 3D Velocity

```
Garmin proprietary sentence

       1   2   3   4
       |   |   |   |
$PGRMV,x.x,x.x,x.x*hh

1) True east velocity, -999.9 to 9999.9 meters/second
2) True north velocity, -999.9 to 9999.9 meters/second
3) Up velocity, -999.9 to 9999.9 meters/second
4) Checksum
```

$PGRMZ Altitude Information

```
Garmin proprietary sentence

       1   2 3 4
       |   | | |
$PGRMZ,x.x,f,h*hh

1) Altitude
2) Unit, feets
3) Position fix dimensions
   2 user altitude
   3 GPS altitude
4) Checksum
```

$PSLIB Differental GPS Beacon Receiver Control

```
Starlink, Inc. proprietary sentence, used by Garmin and others

       1   2   3 4
       |   |   | |
$PSLIB,x.x,x.x,c*hh

1) Frequency
2) Bit rate
3) Request type
   J = status request
   K = configuration request
   blank = tuning message
4) Checksum
```

7. Manufacturer Codes

Note: This list is out-of-date, but perhaps still useful.

AAR Asian American Resources
ACE Auto-Comm Engineering Corporation
ACR ACR Electronics, Inc.
ACS Arco Solar, Inc.
ACT Advanced Control Technology
AGI Airguide Instrument Company
AHA Autohelm of America
AIP Aiphone Corporation
ALD Alden Electronics, Inc.
AMR AMR Systems
AMT Airmar Technology
ANS Antenna Specialists
ANX Analytyx 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 Company
ASP American Solar Power
ATE Aetna Engineering
ATM Atlantic Marketing Company, Inc.
ATR Airtron
ATV Activation, Inc.
AVN Advanced Navigation, Inc.
AWA Awa New Zealand, Limited
BBL BBL Industries, Inc.
BBR BBR and Associates
BDV Brisson Development, Inc.
BEC Boat Electric Company
BGS Barringer Geoservice
BGT Brookes and Gatehouse, Inc.
BHE BH Electronics
BHR Bahr Technologies, Inc.
BLB Bay Laboratories
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 Corporation
BTS Boat Sentry, Inc.
BXA Bendix-Avalex, Inc.
CAT Catel
CBN Cybernet Marine Products
CCA Copal Corporation of America
CCC Coastal Communications Company
CCL Coastal Climate Company
CCM Coastal Communications
CDC Cordic Company
CEC Ceco Communications, Inc.
CHI Charles Industries, Limited
CKM Cinkel Marine Electronics Industries
CMA Societe Nouvelle D'Equiment du Calvados
CMC Coe Manufacturing Company
CME Cushman Electronics, Inc.
CMP C-Map, s.r.l.
CMS Coastal Marine Sales Company
CMV CourseMaster USA, Inc.
CNV Coastal Navigator
CNX Cynex Manufactoring Company
CPL Computrol, Inc.
CPN Compunav
CPS Columbus Positioning, Inc.
CPT CPT, Inc.
CRE Crystal Electronics, Limited
CRO The Caro Group
CRY Crystek Crystals Corporation
CSI Communication Systems International, Inc.
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, Limited
CNI Continental Instruments
CWD Cubic Western Data
CWV Celwave R.F., Inc.
CYZ cYz, Inc.
DCC Dolphin Components Corporation
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 Corporation
DYN Dynamote Corporation
DYT Dytek Laboratories, Inc.
EBC Emergency Beacon Corporation
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 Company
FMM First Mate Marine Autopilots
FNT Franklin Net and Twine, Limited
FRC The Fredericks Company
FTG T.G. Faria Corporation
FUJ Fujitsu Ten Corporation of America
FEC Furuno Electric Company (??)

FUR	Furuno USA, Inc.
GAM	GRE America, Inc.
GCA	Gulf Cellular Associates
GES	Geostar Corporation
GFC	Graphic Controls Corporation
GIS	Galax Integrated Systems
GPI	Global Positioning Instrument Corporation
GRM	Garmin Corporation
GSC	Gold Star Company, Limited
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, Limited
JAN	Jan Crystals
JFR	Ray Jefferson
JMT	Japan Marine Telecommunications
JRC	Japan Radio Company, Inc.
JRI	J-R Industries, Inc.
JTC	J-Tech Associates, Inc.
JTR	Jotron Radiosearch, Ltd.
KBE	KB Electronics, Ld.
KBM	Kennebec Marine Company
KLA	Klein Associates, Inc.
KMR	King Marine Radio Corporation
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 Corporation
LMM	Lamarche Manufacturing Company
LRD	Lorad
LSE	Littlemore Scientific Engineering
LSP	Laser Plot, Inc.
LTF	Littlefuse, Inc.
LWR	Lowrance Electronics Corportation
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
MGN	Magellan Corporation
MGS	MG Electronic Sales Corporation
MIE	Mieco, Inc.
MIM	Marconi International Marine Company
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
MPN	Memphis Net and Twine Company, Inc.
MQS	Marquis Industries, Inc.
MRC	Marinecomp, Inc.
MRE	Morad Electronics Corporation
MRP	Mooring Products of New England
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	Narine Technical Assistance Group
MTK	Martech, Inc.
MTR	Mitre Corporation, Inc.
MTS	Mets, Inc.
MUR	Murata Erie North America
MVX	Magnavox Advanced Products and Systems Company
MXX	Maxxima Marine
MES	Marine Electronics Service, Inc.
NAT	Nautech, Limited
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 Corporation
ODN	Odin Electronics, Inc.
OIN	Ocean instruments, Inc.
OKI	Oki Electronic Industry Company
OLY	Navstar Limited (Polytechnic Electronics)
OMN	Omnetics
ORE	Ocean Research

OTK	Ocean Technology
PCE	Pace
PDM	Prodelco Marine Systems
PLA	Plath, C. Division of Litton
PLI	Pilot Instruments
PMI	Pernicka Marine Products
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 Company
RFP	Rolfite Products, Inc.
RGC	RCS 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	SAIT, Inc.
SBR	Sea-Bird electronics, Inc.
SCR	Signalcrafters, Inc.
SEA	SEA
SEC	Sercel Electronics of Canada
SEP	Steel and Engine Products, Inc.
SFN	Seafarer Navigation International
SGC	SGC, Inc.
SIG	Signet, Inc.
SIM	Simrad,Inc
SKA	Skantek Corporation
SKP	Skipper Electronics A/S
SLI	Starlink, Inc.
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 Corporation
STM	Si-Tex Marine Electronics
SVY	Savoy Electronics
SWI	Swoffer Marine Instruments, Inc.
SRS	Shipmate, Rauff & Sorensen, A/S
TBB	Thompson Brothers Boat Manufacturing Company
TCN	Trade Commission of Norway (THE)
TDL	Tideland Signal
THR	Thrane and Thrane A/A
TLS	Telesystems
TMT	Tamtech, Ltd.
TNL	Trimble Navigation
TRC	Tracor, 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	Vexillar
VIS	Vessel Information Systems, Inc.
VMR	Vast Marketing Corporation
WAL	Walport USA
WBG	Westberg Manufacturing, Inc.
WEC	Westinghouse Electric Corporation
WHA	W-H Autopilots
WMM	Wait Manufacturing and Marine Sales Company
WMR	Wesmar Electronics
WNG	Winegard Company
WSE	Wilson Electronics Corporation
WTC	Watercom
WST	West Electronics Ltd.
YAS	Yaesu Electronics

8. References

[1] National Marine Electronics Association: http://www.nmea.org

[2] Torsten Baumbach's web site: http://pandora.inf.uni-jena.de/ttbb/

[3] Peter Bennett's GPS and NMEA site: http://vancouver-webpages.com/pub/peter/index.html

[4] Data Transmission Protocol Specification for Magellan Products. Revision 1.0. Magellan Corporation, Santa Clara 1999. Available at: http://magellangps.com

This document describes the protocol used by Magellan's consumer GPS units, including a number of NMEA 0183 proprietary sentences.

[5] SBA-1 Interfacing Manual. Revision 0.0. Communications Systems International, Inc, Calgary, 1999. Available at: www.csi-dgps.com.

This manual explains the interfacing of the SBA-1 DGPS beacon receiver to numerous GPS units as well as the CSI proprietary sentences used.