6 DIGITAL FORMATS

This chapter provides detailed descriptions of each of the data output formats available from the Orion and the aiding data input formats required to achieve the best performance from the unit.

6.1 INTRODUCTION

If you select the default configuration, the Orion uses the communication settings outlined in Table 6-22.

Table 6-22: Orion default communication settings

Channel	Settings
PORT A	Control I/O, TSS1, 9600, 8, N, 1, RS232, 25Hz
PORT B	Control I/P, NMEA 0183 HDT, 4800, 8, N, 1, RS232, 1Hz
PORT C	GPS I/P, NMEA 0183 ALR, 4800, 8, N, 1, RS232, 1Hz

6.2 OUTPUT FORMATS

The Orion can supply motion, attitude, heading and inertial position information using any of the available digital data formats listed below.

Data latency for all output formats is zero to the specific packet start character.

NOTE

If you select Load Default Configuration, the Orion will use the communication settings outlined in Table 6-22.

Each digital output string contains a series of data fields. The content of each data field depends upon the selected digital output format.

The available proprietary sentence formats are:

- TSS1 - refer to sub-section 6.2.1.
- TSS1 supplying remote heave - refer to sub-section 6.2.1.1.
- TSS1 + NMEA HDT - refer to sub-section 6.2.2.
- TSS HHRP2 - refer to sub-section 6.2.3.
- TSS3 - refer to sub-section 6.2.4.
- Two Simrad formats supplying local heave for use with the Simrad EM1000 and EM3000 multibeam sounders - refer to sub-sections 6.2.5 and 6.2.6.
- Two Simrad formats supplying remote heave for use with the Simrad EM1000 and EM3000 multibeam sounders - refer to sub-sections 6.2.5.1 and 6.2.6.1.
- BMT2 - refer to sub-section 6.2.7.
- Honeywell HMR3000 - refer to sub-section 6.2.8.
- TSS binary - refer to sub-section 6.2.9.
- TSS Euler binary - refer to sub-section 6.2.10.
- TSS HiRes binary - refer to sub-section 6.2.11.

- TSS HiRes (Euler) binary - refer to sub-section 6.2.12.
- A user-configurable output format - refer to sub-section 6.2.13.
- TSS IMU raw data - refer to sub-section 6.2.14.

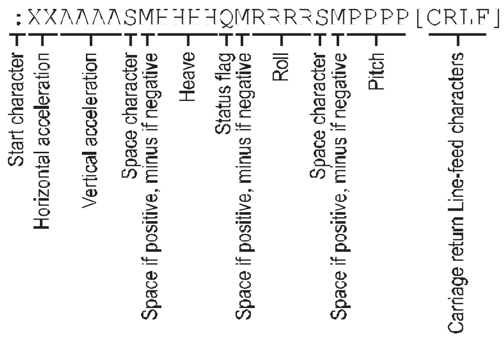
The available NMEA 0183/IEC 61162 approved sentence formats are:

- NMEA 0183 PRDID format - refer to sub-section 6.2.15.
- NMEA 0183 PSXN data format - refer to sub-section 6.2.16.
- IEC 61162 HDT format - refer to sub-section 6.2.17.
- IEC 61162 ROT format -refer to sub-section 6.2.18.
- IEC 61162 GGA format - refer to sub-section 6.2.19.
- IEC 61162 VTG format - refer to sub-section 6.2.20.
- IEC 61162 ZDA format - refer to sub-section 6.2.20.
- IEC 61162 THS format - refer to sub-section 6.2.20.

Refer to section 5.5 "Configuring Orion Communication Parameters" for instructions to select and change the digital output format and the communication parameters used.

6.2.1 TSS1

Figure 6-26: TSS1 Format



- The TSS1 data string contains 27 characters in five data fields.
- A data status flag is included in the packet. This status flag can be modified by the user to allow compatibility with other Teledyne TSS products. Refer to Table 6-23 for flag details.
- A heading status flag is also included in the packet identifying the compass status. This status flag can also be modified by the user to allow compatibility with other Teledyne TSS products. Refer to Table 6-24 below for flag details.
- The acceleration fields contain ASCII-coded hexadecimal values:
  - Horizontal acceleration uses units of 3.83cm/s² in the range zero to 9.81m/s².
  - Vertical acceleration uses units of 0.0625cm/s² in the range –20.48 to +20.48m/s².
- Motion measurements contained in the data string are in real time, valid from the instant when the system transmits the packet start character (':').
- Motion measurements include ASCII-coded decimal values.

- Heave measurements are in cm in the range –99.99 to +99.99 metres.
  - Positive heave is above datum.
- Roll and pitch measurements are in degrees in the range –90.00° to +90.00°.
  - Positive roll is port-side up, starboard down.
  - Positive pitch is bow up, stern down.

Table 6-23: Orion data status flag definitions

Default Status Flag	Description	MAHRS Compatible Status Flag	Marinus Compatible Status Flag
u	Buffer data	u	i
h	GPS/EM Log aided Coarse Heading	f	g
m	Manually aided Course Heading/Fine Alignment	h	g
M	Manually aided Aligned (Ready)	H	H
g	GPS aided Fine Alignment	f	g
G	GPS aided Aligned (Ready)	F	G
l	EM Log aided Course Heading/Fine Alignment	f	h
L	EM Log aided Aligned (Ready)	F	H
f	GPS drop-out, invalid or rejected during GPS Aided Fine Alignment mode.	h	n
F	GPS drop-out, invalid or rejected during GPS Aligned (Ready) mode.	H	N

Table 6-24: Heading status flag definitions

Default Status Flag	Description	MAHRS Compatible Status Flag	Marinus Compatible Status Flag
A	Buffer data	A	A
f	Manually aided Course Heading/Fine Alignment	A	A
f	GPS/EM Log aided Course Heading/Fine Alignment	f	f
F	Aligned (Ready)	F	F

The output data rate will depend upon the baud and output rate selected for the serial data communications. For example, with the output data rate set to continuous:

Baud rate	Maximum update rate
9600	25 updates per second
19200	50 updates per second

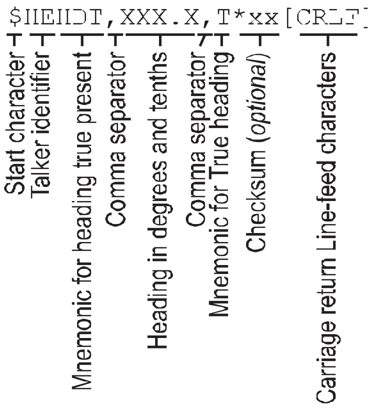
6.2.1.1 TSS1 with Remote Heave

This format is identical to format TSS1 described in sub-section 6.2.1 "TSS1" except the heave field contains the remote heave measurement in units of 1cm.

NOTE
This format does not supply local heave information.

6.2.2 TSS1 + HDT

Figure 6-27: NMEA 0183 HDT Format

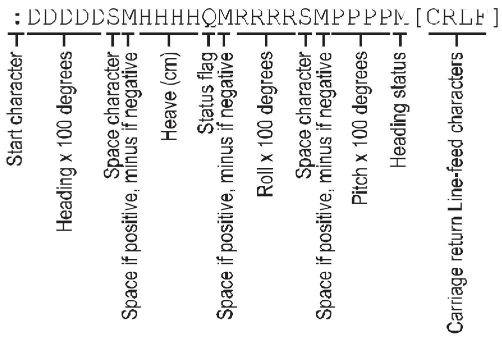


This format supplies alternate packets that include the TSS1 format described in sub-section 6.2.1 and the NMEA 0183 HDT format detailed in Figure 6-27.

- This output is a standard NMEA 0183 data format.
- The packet is variable length dependent upon the heading measurement.
- The talker indentifier mnemonic is ‘HE’ (gyro, north-seeking), as specified in IEC 61162-1 Table 8.2.
- Heading measurements are not output while the Orion is in idle mode (refer to Table 6-23 for status character information). The field will be NULL until the Orion enters course alignment mode.
- A checksum will always be output before the carriage return line feed characters as specified by the NMEA 0183 standard. It is calculated by exclusive-ORing each valid character proceeding the ‘$’ start character and formatted as the HEX value of the checksum in ASCII characters.

6.2.3 TSS HHRP2

Figure 6-28: TSS HHRP2 Format



- The TSS HHRP2 data string contains 27 characters in six data fields.
- Heading measurements are in 0.01° in the range 0° - 359.99°.

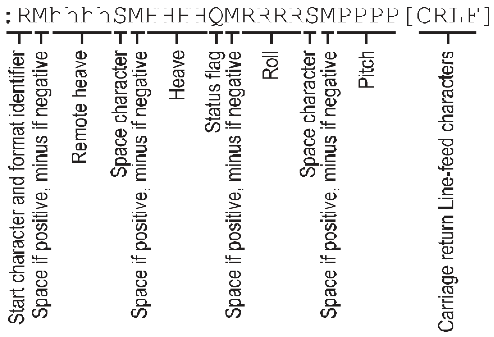
- Heave measurements are in cm in the range –99.99 to +99.99 metres.
  - Positive heave is above datum.
- A data status flag is included in the packet. This status flag can be modified by the user to allow compatibility with other Teledyne TSS products. Refer to Table 6-23 for flag details.
- Roll and pitch measurements are in degrees in the range –99.99° to +99.99°.
  - Positive roll is port-side up, starboard down.
  - Positive pitch is bow up, stern down.
- A heading status flag is included in the packet identifying the compass status. This status flag can also be modified by the user to allow compatibility with other Teledyne TSS products. Refer to Table 6-24 below for flag details.

The output data rate will depend upon the baud and output rate selected for the serial data communications. For example, with the output data rate set to continuous:

Baud rate	Approximate maximum update rate
9600	25 updates per second
19200	50 updates per second

6.2.4 TSS3

Figure 6-29: TSS3 Format



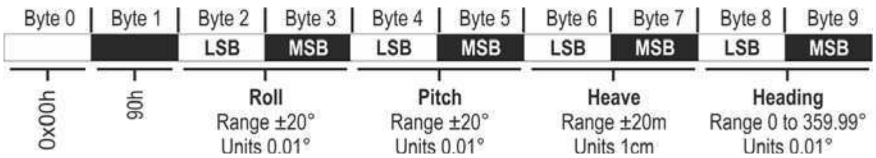
- The TSS3 data string contains 27 characters in five data fields.
- After the start character (a colon, ASCII 3Ah), the TSS3 data string includes an upper case ‘R’ to identify the string as using the TSS3 remote heave format.
- The motion measurements contained in the string will be in real time, valid for the instant when the system begins to transmit the string.
- Motion measurements include ASCII-coded decimal values.
- Local and remote heave measurements are in cm in the range –99.99 to +99.99 metres.
  - Positive heave is above datum.
- Roll and pitch measurements are in degrees in the range –99.99° to +99.99°.
  - Positive roll is port-side up, starboard down.
  - Positive pitch is bow up, stern down.

The output data rate will depend upon the baud and output rate selected for the serial data communications. For example, with the output data rate set to continuous:

Baud rate	Approximate update rate
9600	25 updates per second
19200	50 updates per second

6.2.5 Simrad EM1000

Figure 6-30: SIMRAD EM1000 Format



MSB = Most significant byte. LSB = Least significant byte.

- This format is suitable for use with Simrad EM1000 multibeam sounders.
- The data string is a 10-byte message of 16-bit 2's complement numbers, each expressed as two binary-coded digits.
- Positive heave is above datum. Positive roll is port-side up, starboard down. Positive pitch is bow up, stern down.
- The motion measurements contained in the data string will be in real time, valid for the instant when the system begins to transmit the string.
- The data string does not include a status flag. The system will take three minutes to settle after power-on or a change of mode or heave bandwidth.
- The gyro heading information is NOT a 2's complement number.

The output data rate will depend upon the baud and output rate selected for the serial data communications. For example, with the output data rate set to continuous:

Baud rate	Approximate update rate
9600	50 updates per second
19200	100 updates per second

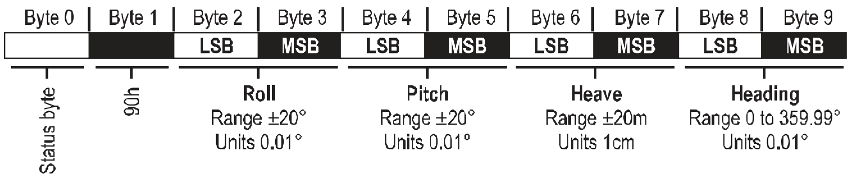
6.2.5.1 Simrad EM1000 with Remote Heave

This format is identical to the Simrad EM1000 format described in sub-section 6.2.5 "Simrad EM1000", except the heave field contains the remote heave measurement in units of 1cm.

NOTE
This format does not supply local heave information.

6.2.6 Simrad EM3000

Figure 6-31: SIMRAD EM3000 Format



MSB = Most significant byte. LSB = Least significant byte.

- This format is suitable for use with Simrad EM3000 multibeam sounders.
- The data string is a 10-byte message of 16-bit 2's complement numbers, each expressed as two binary-coded digits.
- Positive heave is above datum. Positive roll is port-side up, starboard down. Positive pitch is bow up, stern down.
- The motion measurements contained in the data string will be in real time, valid for the instant when the system begins to transmit the string.
- The Status byte = 0x91h for an unsettled unit or 0x90h for a settled unit. The system will take three minutes to settle after power-on or a change of mode or heave bandwidth.
- The gyro heading is NOT a 2's complement number.

The output data rate will depend upon the baud and output rate selected for the serial data communications. For example, with the output data rate set to continuous:

Baud rate	Approximate update rate
9600	50 updates per second
19200	100 updates per second

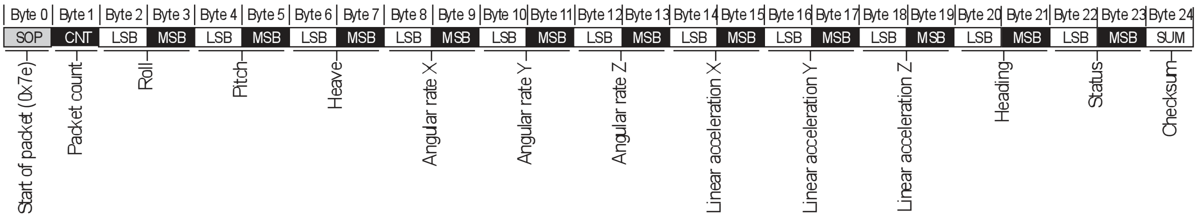
6.2.6.1 Simrad EM3000 with Remote Heave

This format is identical to the Simrad EM3000 format described in sub-section 6.2.6 "Simrad EM3000" above, except the heave field contains the remote heave measurement in units of 1cm.

NOTE
This format does not supply local heave information.

6.2.7 BMT2

Figure 6-32: BMT2 Format



MSB = Most significant byte
LSB = Least significant byte

SOP = Start of packet

The BMT2 data format provides heading, system status, attitude, angular rates and linear acceleration measurements in six axes to an external data processor. The external data processor can use the supplied information to compute the linear accelerations for a large number of points on the vessel. A suitable application for this format may be, for example, to calculate the loads on the securing straps for the various deck-mounted containers on a container vessel.

Inevitably, errors will exist in the calculations made by the external processor caused primarily by flexing of the vessel. Typically, such errors will result from high frequency vibrations that affect the system directly, but not the vessel.

To reduce the effect of such vibrations, you will need to filter the outputs from the system. The Orion system does not apply such filtration because the specific characteristics of the vessel, its loading condition, and the system's installation location will all have a significant influence on the filter design parameters. Therefore, you must exercise control over the filtering function through the software of the external data processor.

- By default the system uses 38400 baud to transmit this string. You will reduce the update rate if you set a lower baud rate. To achieve an update rate of 100Hz, the channel baud rate must be 38400 or higher.
- The start of packet character (SOP) is always 0x7e.
- The packet count field increments each time a packet is output. When the count reaches 255, it resets to zero and restarts the count.
- The heading and attitude measurements contained in the data string will be in real time, valid for the instant when the system begins to transmit the SOP byte.
- The six angular rate and linear acceleration measurements are averaged over the time difference between the IMU internal data rate and the user selected output rate. For example,

  internal update rate (100Hz) / user specified output rate (5Hz) = average of 20 samples
- Refer to sub-section 6.2.7.1 "Filtering" for a suggested method to extract the acceleration and angular rate data from these fields.
- Angular rates and linear accelerations are all in the vessel body reference frame.
- Positive heave is above datum. Positive roll is port-side up, starboard down. Positive pitch is bow up, stern down.
- Roll and pitch measurements (±90°) use units 180÷65536 (°).
- Heave measurements (±50m) use units 100÷65536 (m).
- Angular rate measurements (±15°/s) use units 30÷65536 (°/s).

- Linear acceleration measurements (±12.5m/s²) use units 25÷65536 (m/s²).
- Heading measurements (0 - 359.99°) use units 360÷65536 (°).
- The status field contains the Orion alignment state or, if present, an error condition. This status flag can be modified by the user to allow compatibility with other Teledyne TSS products. Refer to Table 6-23 for flag details. Note, the status MSB will always equal zero.
- The MSB and LSB form 16-bit 2's complement signed values in the range –32767 to +32768 to represent the relevant measurement.
- You may recover the floating point value for each word by using
  $= ((\text{<Value MSB>} \times 256) \text{ OR } \text{<Value LSB>}) \times (\mathit{MeasurementRange}) \div 65536$.

  In this expression, the OR function is an arithmetic OR performed in integer arithmetic.
- The system computes the checksum value by summing all the bytes, excluding the checksum itself: $\text{CKSUM} = \sum_{i=1}^{23} \mathit{byte}(i)$ where $\text{SOP} = \mathit{byte}(0)$

6.2.7.1 Filtering

The following suggestion helps you to compute the average of each measurement during the system's previous calculation cycle. This will reduce the problems caused by vibration, but not eliminate them. Note that the averaged value will be valid for an instant in time half way between the start and the end of the averaged period.

You will also need to compute the angular accelerations. To do this, divide the measurements in half (time-wise) and compute the average of each half. Take the difference between the two and then divide this by half the time interval. This is the process of differentiation.

For example, on a set of 50 samples (lasting one second) you should compute the angular accelerations from the angular rates by using the following method:

$ArX_{am} = \text{mean}(ArX[1]..ArX[25])$

$ArX_{pm} = \text{mean}(ArX[26]..ArX[50])$

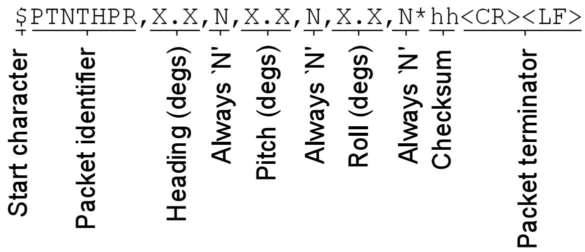
$AaX = (ArX_{pm} - ArX_{am}) \div 0.5$

AaX is the angular acceleration in the X-axis.

0.5 is the time interval (half a second).

6.2.8 Honeywell HMR3000

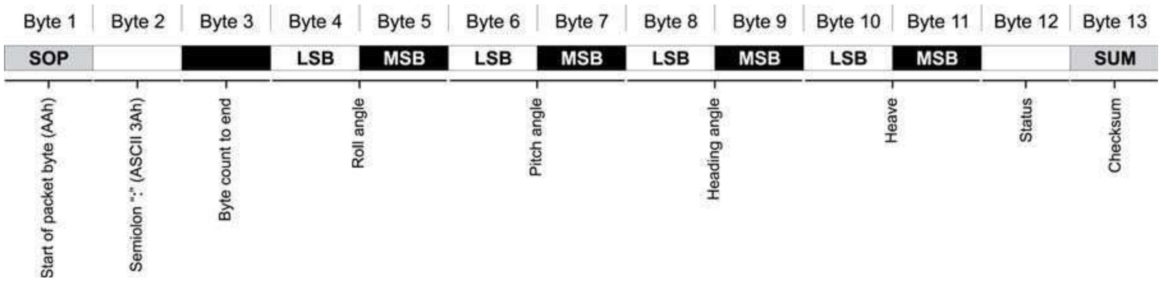
Figure 6-33: Honeywell HMR3000 data format



- The Honeywell HMR3000 data string is a proprietary NMEA output.
- Packet is variable length including heading, roll and pitch measurements.
- Heading measurents are in the range 0° - 359.99°.
- Roll and pitch measurements are in the range ±99.99°.
    - Positive roll is port-side up, starboard down.
    - Positive pitch is bow up, stern down.
- No status information is available.
- The system computes the checksum value by summing all the bytes, excluding the SOP and checksum itself.

6.2.9 TSS Binary

Figure 6-34: TSS Binary data format



MSB = Most significant byte. LSB = Least significant byte

- The data string is a 13-byte message of 16-bit 2's complement numbers, each expressed as two binary-coded digits.
- Heading measurements (0.0° to 359.9°) use units 180 / 32768 (°).
- Roll and Pitch measurements (±180°) use units 180 / 32768 (°).
    - Positive roll is port side up, starboard side down.
    - Positive pitch is bow up, stern down.
- Heave measurements (±50m) use units 1/1000(mm).
    - Positive heave is above datum.
- Refer to Table 6-25 for the status codes.

- The system computes the checksum value by summing all the bytes, excluding the SOP and checksum itself: $\mathrm{CKSUM} = \sum_{i=2}^{12} byte(i)$ where SOP = $byte(1)$

Table 6-25: TSS Binary status codes

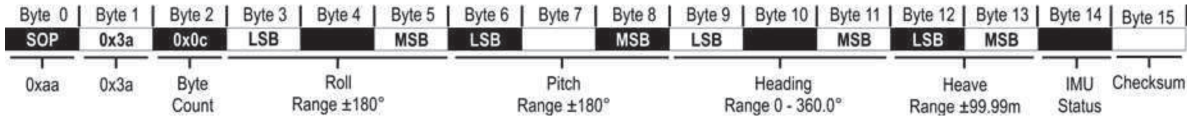
Byte Value	Definition	Ready	OK
n/a	No packet received.	No	No
0x00	Coarse levelling.	No	Yes
0x01	Coarse heading.	No	Yes
0x02	Fine alignment.	No	Yes
0x03	Fine alignment complete (not applicable to Orion).	N/A	N/A
0x04	Coarse alignment. Bad GPS (not applicable to Orion).	N/A	N/A
0x05	Fine alignment. Bad GPS.	No	Yes
0x06	Ready (GPS aided). Bad GPS.	Yes	Yes
0x07	Doppler alignment in progress (not applicable to Orion).	N/A	N/A
0x08	Doppler alignment complete (not applicable to Orion).	N/A	N/A
0x09	Ready (manually aided).	Yes	Yes
0x0A	System failure.	No	No
0x0B	Fine alignment (manually aided).	No	Yes
0x0C	Ready (manually aided).	Yes	Yes
0x0D	Fine alignment (log aided).	No	Yes
0x0E	Ready (log aided).	Yes	Yes
0x14	Coarse alignment. Dropped GPS (not applicable to Orion).	N/A	N/A
0x15	Fine alignment. Dropped GPS.	No	Yes
0x16	Ready (GPS). Dropped GPS.	No	Yes
0x24	Coarse alignment (not applicable to Orion)	N/A	N/A
0x25	Fine alignment (GPS aided).	No	Yes
0x26	Ready (GPS aided).	Yes	Yes

6.2.10 TSS Euler Binary

TSS Euler Binary is formatted identically to TSS Binary (see sub-section 6.2.9 "TSS Binary" for details) with the exception of the roll field being replaced with Euler roll.

6.2.11 TSS HiRes Binary

Figure 6-35: TSS HiRes Binary data format



- The data string is a 16-byte message of 16-bit 2's complement numbers. The roll, pitch and heading measurements are expressed as three binary-coded digits to facilitate the high-resolution outputs. Heave measurements are expressed as two binary-coded digits and do not provide a high resolution output.
- You may recover the floating point value for each high resolution field by using :

  ((MSB << 16) OR (BYTE[MSB+1] << 8) OR (LSB) * units)

- Heading measurements (0.000° to 359.99°) use units 360 / 16777216 (°).
- Roll and Pitch measurements (±180.000°) use units 180 / 8388608.
- Heave measurements are output (±99.99m) use units 1/1000 (mm).
- Refer to Table 6-25 for the status codes.
- The system computes the checksum value by summing all the bytes, excluding the SOP and

  checksum itself: $\text{CKSUM} = \sum_{i=1}^{14} byte(i)$ where SOP = $byte(0)$

6.2.12 TSS HiRes Euler binary

Refer to sub-section 6.2.11 "TSS HiRes Binary" for TSS HiRes Euler Binary data format information. The only difference being the roll field is replaced with Euler roll.

6.2.13 User Configurable Format

The Orion system allows you to configure a special output packet to meet the particular needs of your application. The user configurable packet can have any length and can include the available data fields in any convenient order. If necessary, you may set the format to repeat data fields within any single string (although both occurrences will always include the same values).

Figure 6-36: Setting the User Configurable output

```
----------------------------------

Orion Version x.x Terminal Mode

----------------------------------

Configure Digital Output

Digital Output Format : User Configurable

Baud rate: 9600

Data Bits: 8

Stop Bits: 2

Parity: None
```


User fields 1 to 3 inclusive will be set to roll, and pitch and heave already when you select this output format. You may change these if necessary.

To establish your special output format:

1. Select the User Configurable format from the Configure Digital Output screen.
2. Establish appropriate settings for the baud rate, data bits, stop bits and parity. Set RS232 or RS422 communications as required.
3. Set the content of User Field 1. When you first select this data format, User Field 1 will contain Roll. Press the space bar to cycle through the available options listed in Table 6-26 "User configurable data fields". Press [ENTER] to set the displayed User Field and progress to the next.
4. Continue setting the contents of the User Fields as required. You may change the contents of those fields that already contain a default.
5. To complete your selection, choose the User Field called 'None' and then press [ENTER]. The system will then restore the Configure I/O menu.

Table 6-26: User configurable data fields

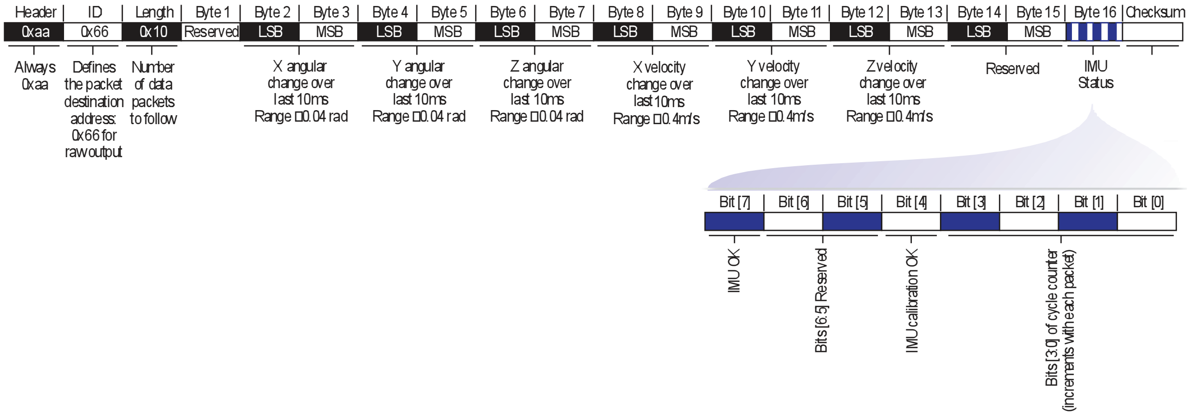
Field No	User field name	Contents	Range and (units)
1	Heading	Heading measurement from IMU	0° to 359.99° (0.01°)
2	Roll	Angle of roll	–90° to +90° (0.01°)
3	Pitch	Angle of pitch	–90° to +90° (0.01°)
4	Heave	Heave displacement	–99 to +99m (1cm)
5	Remote Heave	Remote heave displacement	–99 to +99m (1cm)
6	Euler Roll	Angle of Euler roll	–90° to +90° (0.01°)
7	Status	Status flag as defined in Table 6-23 "Orion data status flag definitions".	N/A
8	Compass Status	Status flag as defined in Table 6-24 "Heading status flag definitions".	N/A
9	Surge	Teledyne TSS specific field	–99 to +99m (1cm)
10	Sway	Teledyne TSS specific field	–99 to +99m (1cm)
11	Acceleration X	Linear acceleration in the X direction using the body frame of reference of the Sensor	–20000 to +20000 mm/s^2
12	Acceleration Y	Linear acceleration in the Y direction using the body frame of reference of the Sensor	–20000 to +20000 mm/s^2
13	Acceleration Z	Linear acceleration in the Z direction using the body frame of reference of the Sensor	–20000 to +20000 mm/s^2
14	Acceleration North	Linear acceleration in the geographical north direction. Northerly acceleration is positive.	–20000 to +20000 mm/s^2
15	Acceleration East	Linear acceleration in the geographical east/west direction. Easterly acceleration is positive.	–20000 to +20000 mm/s^2

Table 6-26: User configurable data fields (Continued)

Field No	User field name	Contents	Range and (units)
16	Acceleration Down	Linear acceleration in the geographical south direction. Southern acceleration is negative.	−20000 to +20000 mm/s^2
17	Angular Rate X	Angular rate of rotation in the X direction using the body frame of reference of the Sensor.	−9999 to +9999 (0.01°/s)
18	Angular Rate Y	Angular rate of rotation in the Y direction using the body frame of reference of the Sensor.	−9999 to +9999 (0.01°/s)
19	Angular Rate Z	Angular rate of rotation in the Z direction using the body frame of reference of the Sensor.	−9999 to +9999 (0.01°/s)
20	Angular Rate North	Angular rate of rotation about the geographical north/south axis.	−9999 to +9999 (0.01°/s)
21	Angular Rate East	Angular rate of rotation about the geographical east/west axis.	−9999 to +9999 (0.01°/s)
22	Angular Rate Down	Angular rate of rotation about the geographical north/south axis.	−9999 to +9999 (0.01°/s)
23	None	Indicator during configuration that no further data fields are to be included	N/A

6.2.14 TSS IMU Raw Data Format

Figure 6-37: IMU raw data format



The raw data format provides inertial angular and velocity increments at an update rate of 100 Hz. It has been designed to drive a navigation solution. The baud rate is 115200 with odd parity, and the format uses RS422 or RS232 voltage levels set within the Configure IO menu. Refer to sub-section B.2.2.2 "Raw IMU O/P Interface" for details.

NOTE

The raw output is only available on the dedicated ‘Raw Data’ port.

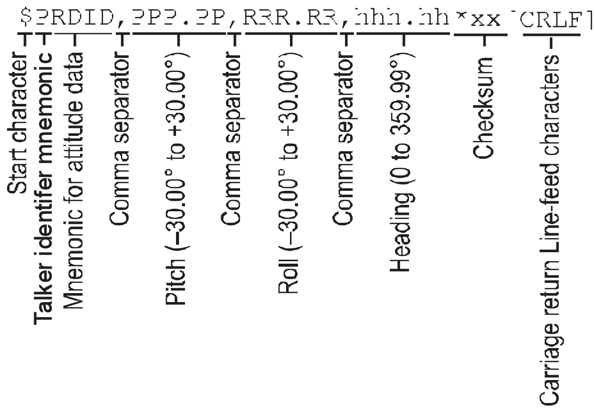
The raw output uses a binary format, shown in Figure 6-37. The full raw output includes two types of data packets, sent alternately.

- The first data packet is used for timing purposes and contains no information. Its Length byte contains 0x00.
- The second data packet, shown in detail above, includes 16 information bytes as indicated by the value 0x10 in the Length byte. This packet contains the angular rates and acceleration information, and an IMU Status byte.

The time of validity for the IMU raw data packets is when the header byte (0xaa) arrives. Latency is less than 1 ms.

6.2.15 NMEA 0183 PRDID

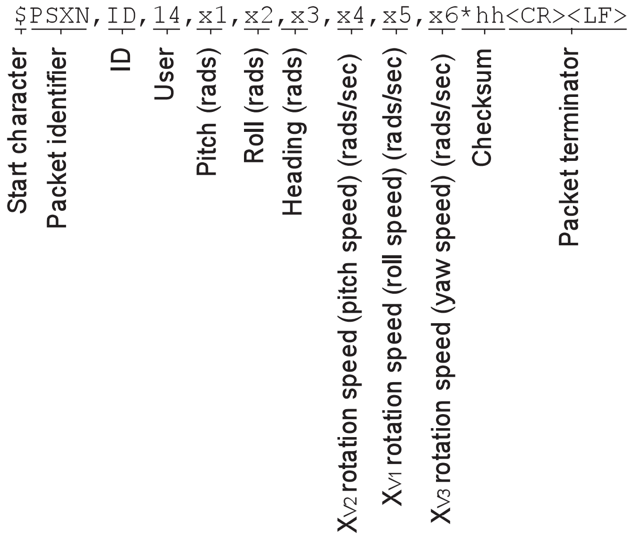
Figure 6-38: NMEA 0183 PRDID data format



- This output is a proprietary NMEA 0183 data format.
- The packet start character is ‘$’ and has variable length with leading zeros and minus signs added where necessary.
- The talker ID mnemonic is ‘P’ for proprietary sentence.
- The format specifier is ‘RDID’.
- Positive roll is port-side up, starboard down. Positive pitch is bow up, stern down.
- The attitude measurements contained in the data string will be in real time, valid for the instant when the system begins to transmit the string.
- Heading measurements are not output while the Orion is in idle mode. The heading field will be NULL until the Orion enters course alignment mode.
- A checksum will always be output before the carriage return line feed characters as specified by the NMEA 0183 standard. It is calculated by exclusive-ORing each valid character proceeding the ‘$’ start character and formatted as the HEX value of the checksum in ASCII characters.

6.2.16 NMEA 0183 PSXN

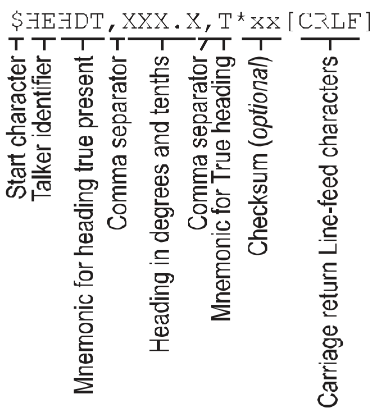
Figure 6-39: NMEA 0183 PSXN data format



- Standard NMEA 0183 output compatible with Seatex MRU system.
- Packet includes heading, roll, pitch and rotation rates.
- ID is 10 when no error occurs, 11 if one or more errors occur.
- User is always 14.
- x1, x2, x3, x4, x5 and x6 are output as floating point values in scientific format, i.e -2.5648e1.
- Includes checksum before the carriage return line feed characters as specified by the NMEA 0183 standard. Calculated by exclusive-ORing each valid character proceeding the ‘$’ start character and formatted as the HEX value of the checksum in ASCII characters.

6.2.17 IEC 61162 HDT

Figure 6-40: IEC 61162 HDT data format

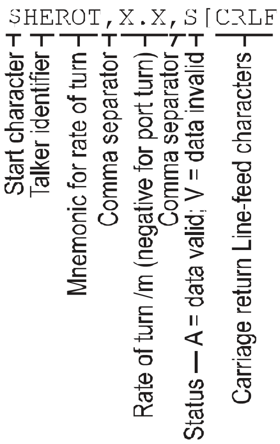


- This output is a standard IEC 61162 data format.
- The start character is ‘$’ and packet is variable length dependent upon the heading measurement.
- The talker indentifier mnemonic is ‘HE’ (gyro, north-seeking), as specified in IEC 61162-1 Table 8.2.
- Format specifier for heading (degrees) is ‘HDT’.

- Heading measurements are not output while the Orion is in idle mode. The field will be NULL until the Orion enters course alignment mode.
- The mnemonic for true heading is ‘T’.
- A checksum will always be output before the carriage return line feed characters as specified by the IEC 61162 standard. It is calculated by exclusive-ORing each valid character proceeding the ‘$’ start character and formatted as the HEX value of the checksum in ASCII characters.

6.2.18 IEC 61162 ROT

Figure 6-41: IEC 61162 ROT data format



- This output is a standard IEC 61162 data format.
- The start character is ‘$’ and packet is variable length dependent upon the rate of turn measurement.
- The talker indentifier mnemonic is ‘HE’ (gyro, north-seeking), as specified in IEC 61162-1 Table 8.2.
- The format specifier for rate of turn (°/min) is ‘ROT’.
- Negative values indicate bow turns to port, positive values indicate bow turns to starboard.
- The packet includes a status indicator identifying data validity. A = data valid, V = data invalid.
- A checksum will always be output before the carriage return line feed characters as specified by the IEC 61162 standard. It is calculated by exclusive-ORing each valid character proceeding the ‘$’ start character and formatted as the HEX value of the checksum in ASCII characters.

6.2.19 IEC 61162 GGA Format

Figure 6-42: IEC 61162 GGA data format

```
$INGGA,HHMMSS.sss,DDMM.mmmmmm,x,DDDDMM.mmmmmm,x,Q,SS,?.?,?.?,?,?.?,?,?.?,????*hh[CRLF]
```

Start character
Talker identifier (any characters)
Mnemonic for GPS fix data
UTC of position (see Note 1)
Latitude (see Note 2)
Mnemonic for North or South
Longitude (see Note 3)
Mnemonic for East or West
GPS quality indicator
Number of satellites in use (00 - 12)
Horizontal dilution of precision
Antenna altitude relative to mean sea level (+ve = above seabed) (see Note 4)
Mnemonic for metres
Geoidal separation
Mnemonic for metres
Age of differential GPS data
Differential reference station (0000 - 1023)
Checksum
Carriage return Line-feed characters

- This output is a standard IEC 61162 data format.
- The start character is '$' and packet is variable length dependent upon field lengths.
- The talker indentifier mnemonic is 'IN' (integrated navigation), as specified in IEC 61162-1 Table 8.2.
- The format specifier for GPS fix data is 'GGA'.
- The GPS quality indicator flags are outlined in Table 6-27.
- If the Orion is not operating in GPS aided mode, all fields will be output as NULL. When the Orion receives valid GGA and VTG GPS data and is operating in Ready (Aligned) mode, the fields will be formatted as shown in Figure 6-42.

Notes:

1. The time field is derived from the UTC input from the GPS source. A system timestamp is taken on arrival of the GPS GGA sentence. Before output, a system timestamp is taken and the difference between the two timestamps added to the GPS UTC time. Hence, the UTC of the output GGA sentence should be within the system time resolution (10ms * 2 = 20ms).
2. The latitude is the calculated latitude obtained from the Kalman filter calculations.
3. The longitude is the calculated longitude obtained from the Kalman filter calculations.
4. The antenna altitude above sea level is derived from the GPS lever arm offsets entered into the Orion.
5. All remaining fields are obtained directly from the IEC 61162 GGA input sentence.

- A checksum will always be output before the carriage return line feed characters as specified by the IEC 61162 standard. It is calculated by exclusive-ORing each valid character proceeding the ‘$’ start character and formatted as the HEX value of the checksum in ASCII characters.

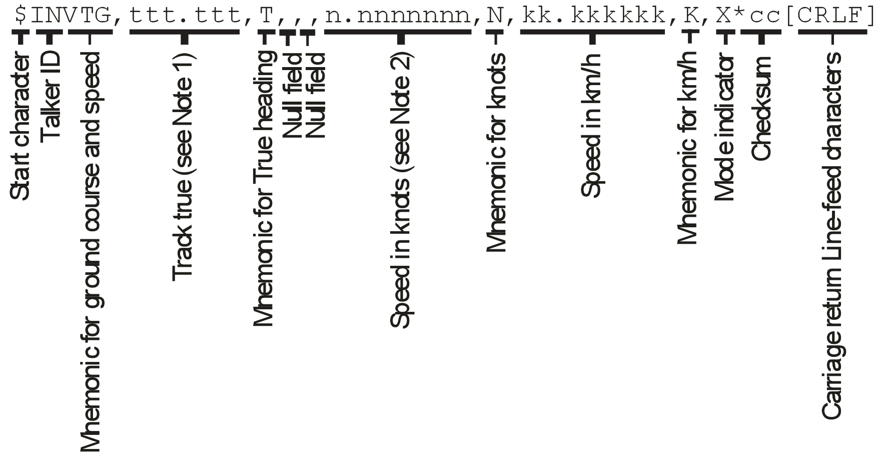
Table 6-27: GGA GPS quality indicator flags

Flag ID	Description
0	Fix not available or invalid
1	GPS SPS mode, fix valid
2	Differential GPS, SPS mode, fix valid
3	GPS PPS mode, fix valid
4	Real time kinematic, satellite system used in RTK mode with fixed integers
5	Float RTK, satellite system used in RTK mode with floating integers
6	Estimated (dead reckoning) data
7	Manual input mode
8	Simulator mode

6.2.20 IEC 61162 VTG Format

Figure 6-43: IEC 61162 VTG data format

```
$INVTG,ttt.ttt,T,,,n.nnnnnnn,N,kk.kkkkkk,K,X*cc[CRLF]
```



- This output is a standard IEC 61162 data format.
- The start character is ‘$’ and packet is variable length dependent upon field lengths.
- The talker indentifier mnemonic is ‘IN’ (integrated navigation), as specified in IEC 61162-1 Table 8.2.
- The format specifier for course over ground and ground speed is ‘VTG’.
- The mode indicator flags are outlined in Table 6-28.
- If the Orion is not operating in GPS aided mode, all fields will be output as NULL. When the Orion receives valid GGA and VTG GPS data and is operating in Ready (Aligned) mode, the fields will be formatted as shown in Figure 6-43.

Notes:

1. True track is calculated from the measured vessel frame velocities, as follows:

*track = atan2(VelocityV.v2, VelocityV.1) * R2D*

2. Speed (Knots) is obtained from the calculated vessel frame velocities, as follows:

   *speed = sqrt((vN * vN) + (vE * vE))*

   speedN = speed / K2MS

   *speedK = speed * 3.6*

3. Speed (km/h) is the calculated vessel frame velocities in km/h.

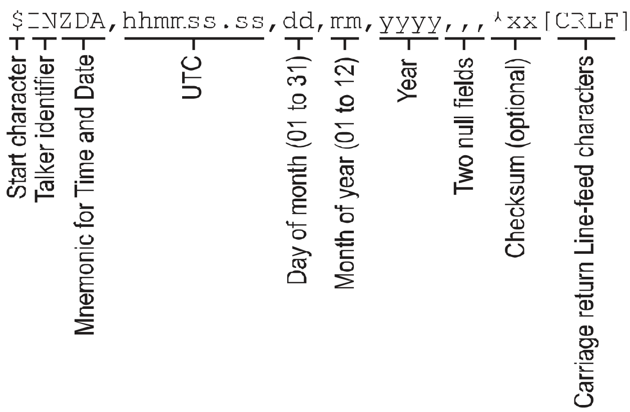
- A checksum will always be output before the carriage return line feed characters as specified by the IEC 61162 standard. It is calculated by exclusive-ORing each valid character proceeding the '$' start character and formatted as the HEX value of the checksum in ASCII characters.

Table 6-28: VTG mode indicator flags

Mode Indicator	Description
A	Autonomous mode
D	Differential mode
E	Estimated (dead reckoning) mode
M	Manual input mode
S	Simulator mode
N	Data not valid

6.2.21 IEC 61162 ZDA Format

Figure 6-44: IEC 61162 ZDA data format



- This output is a standard IEC 61162 data format.
- The start character is '$' and packet is variable length dependent upon data validity.
- The talker indentifier mnemonic is 'IN' (integrated navigation), as specified in IEC 61162-1 Table 8.2.
- The format specifier for time and date is 'ZDA'.
- If the Orion is not operating in GPS aided mode, all fields will be output as NULL. When the Orion receives valid GGA and VTG GPS data and is operating in Ready (Aligned) mode, the fields will be formatted as shown in Figure 6-44.

6.2.22 IEC 61162 THS Format

Figure 6-45: IEC 61162 THS data format

```
$INTHS,XXX.X,X,*xx[CRLF]
```

- Start character
- Talker identifier (any characters)
- Mnemonic for True heading status
- Heading in degrees
- Mode indicator
- Checksum (optional)
- Carriage return Line-feed characters

- This output is a standard IEC 61162 data format.
- The start character is '$' and packet is variable length dependent upon data validity.
- The talker indentifier mnemonic is 'IN' (integrated navigation), as specified in IEC 61162-1 Table 8.2.
- The format specifier for heading is 'THS'.
- If the Orion is not operating in GPS aided mode, all fields will be output as NULL. When the Orion receives valid GGA and VTG GPS data and is operating in Ready (Aligned) mode, the fields will be formatted as shown in Figure 6-45.

6.2.23 IEC 61162 GGA/VTG Format

This format supplies alternate packets including IEC 61162 GGA format described in sub-section 6.2.19 and IEC 61162 VTG format shown in sub-section 6.2.20.

6.2.24 IEC 61162 ZDA/GGA/VTG Format

This format supplies alternate packets including IEC 61162 ZDA format described in sub-section 6.2.21, IEC 61162 VTG format shown in sub-section 6.2.19 and IEC 61162 VTG format described in sub-section 6.2.20.

6.3 GPS AIDING DATA FORMATS (INPUTS)

Orion accepts GPS aiding from the following NMEA 0183/IEC 61162 data formats to enable operation in Aided Mode and provide a position output.

- NMEA 0183 VTG (velocity aiding) - refer to section 6.3.1 "NMEA 0183 VTG Data Format", or
- IEC 61162 VTG (velocity aiding) - refer to section 6.3.2 "IEC 61162 VTG Data Format"
- IEC 61162 GGA (latitude aiding) - refer to section 6.3.3 "IEC 61162 GGA Data Format"

It can also be optionally aided with the following additional IEC 61162 data format to reduce the duration of the alignment process:

- IEC 61162 ZDA - refer to section 6.3.5 "IEC 61162 ZDA Data Format"

Orion uses the NMEA 0183/IEC 61162 GGA, VTG and, optionally, ZDA data formats as its input from a GPS receiver. If additional sentences are provided to the Orion they will have no effect on the performance of the unit.

6.3.1 NMEA 0183 VTG Data Format

Figure 6-46: NMEA 0183 VTG data format

```
$??VTG,?.?,?,?.?,?,X.X,X,XX.X,X*hh[CRLF]
```

- Start character
- Talker identifier (any characters)
- Mnemonic for ground course and speed
- Course, True
- Mnemonic for True heading
- Course, Magnetic
- Mnemonic for Magnetic heading
- Speed in knots
- Mnemonic for knots
- SOG in km/h
- Mnemonic for km/h
- Carriage return Line-feed characters

6.3.2 IEC 61162 VTG Data Format

Figure 6-47: IEC 61162 VTG data format

```
$??VTG,?.?,?,?.?,?,X.X,X,XX.X,X,X[CRLF]
```

- Start character
- Talker identifier (any characters)
- Mnemonic for ground course and speed
- Course, True
- Mnemonic for True heading
- Course, Magnetic
- Mnemonic for Magnetic heading
- Speed in knots
- Mnemonic for knots
- Speed in km/h
- Mnemonic for km/h
- Mode indicator
- Carriage return Line-feed characters

s The mode indicator flags are outlined in Table 6-28 on page 20.

6.3.3 IEC 61162 GGA Data Format

Figure 6-48: IEC 61162 GGA data format

```
$??GGA,??????.??,XXXX.XX,X,?????.??,?,X,??,?.?,?.?,?,?.?,?,?.?,????[CRLF]
```

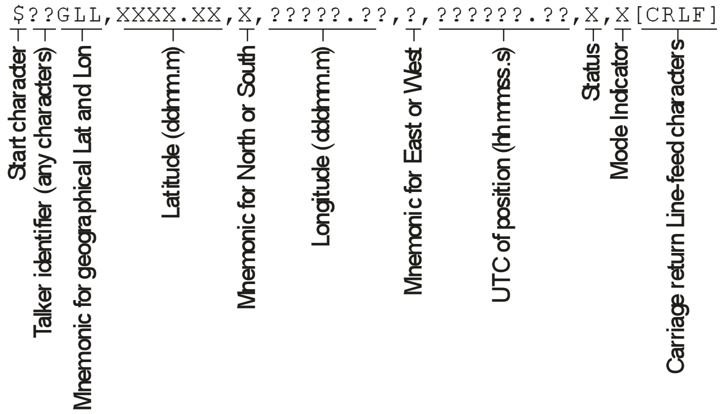
- Start character
- Talker identifier (any characters)
- Mnemonic for GPS fix data
- UTC of position (hhmmss.s)
- Latitude (ddmm.m
- Mnemonic for North or South
- Longitude (dddmm.m)
- Mnemonic for East or West
- GPS quality indicator (see Note 1)
- Number of satellites in use (00 - 12)
- Horizontal dilution of precision
- Antenna altitude relative to mean sea level
- Mnemonic for metres
- Geoidal separation
- Mnemonic for metres
- Age of differential GPS data
- Differential reference station (0000 - 1023)
- Carriage return Line-feed characters

Notes:

1. The quality indicator flags are outlined in Table 6-27 on page 19.

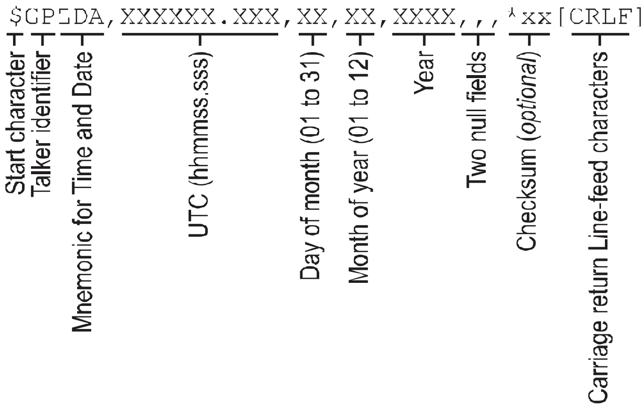
6.3.4 IEC 61162 GLL Data Format

Figure 6-49: IEC61162 GLL Data Format



6.3.5 IEC 61162 ZDA Data Format

Figure 6-50: IEC 61162 ZDA data format



6.4 EM SPEED LOG AIDING FORMATS (INPUTS)

If unable to aid the Orion with a GPS receiver input, for example subsea ROV deployment, it can aided with an EM Speed Log input providing the following NMEA 0183/IEC 61162 data formats:

- NMEA 0183 VBW (velocity aiding) - refer to section 6.4.1 "NMEA 0183 VBW Data Format".
- IEC 61162 VBW (velocity aiding) - refer to section 6.4.2 "IEC 61162 VBW Data Format".

NOTE

If additional aiding data formats are provided to the Orion they will have no effect on the performance of the unit.

6.4.1 NMEA 0183 VBW Data Format

Figure 6-51: NMEA 0183 VBW data format

```
$??VBW,?.?,?.?,?,X.X,?.?,X,*hh[CRLF]
```

- Start character
- Talker identifier (any characters)
- Mnemonic for Dual ground/water speed
- Longitudinal water speed, knots
- Transverse water speed, knots
- Status: water speed
- Longitudinal ground speed, knots
- Transverse ground speed, knots
- Status: ground speed
- Checksum field
- Carriage return Line-feed characters

6.4.2 IEC 61162 VBW Data Format

Figure 6-52: IEC 61162 VBW data format

```
$??VBW,?.?,?.?,?,X.X,?.?,X,?.?,?,?.?,?*hh[CRLF]
```

- Start character
- Talker identifier (any characters)
- Mnemonic for Dual ground/water speed
- Longitudinal water speed, knots (see Note 1)
- Transverse water speed, knots
- Status: water speed (see Note 2)
- Longitudinal ground speed, knots
- Transverse ground speed, knots
- Status: ground speed (see Note 2)
- Stern transverse water speed, knots
- Status: stern water speed (see Note 2)
- Stern transverse ground speed, knots
- Status: stern ground speed (see Note 2)
- Checksum field
- Carriage return Line-feed characters

Notes:

1. Transverse speed: “-” = port,

   Longitudinal speed: “-” astern.

2. The status field should not be a null field.

