4.2 Binary Output Data Format

Use the binary format (CFxx1xx) when recording/processing Workhorse data on an external device. The binary format uses less storage space and has a faster transmission time than the HexAscii format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.

NOTE. All of RDI's software supports binary PD0 formatted data only.

5 PD0 Output Data Format

The following description is for the standard PD0 Workhorse output data format. Figure 8, page 116 through Figure 15, page 141 shows the ASCII and binary data formats for the Workhorse PD0 mode. Table 28, page 117 through Table 37, page 141 defines each field in the output data structure.

After completing a data collection cycle, the Workhorse immediately sends a data ensemble. The following pages show the types and sequence of data that you may include in the Workhorse output data ensemble and the number of bytes required for each data type. The Workhorse sends all the data for a given type for all depth cells and all beams before the next data type begins.

The Workhorse by default is set to collect velocity, correlation data, echo intensity, and percent good data. The data, preceded by ID code 7F7F, contains header data (explained in Table 28, page 117). The fixed and variable leader data is preceded by ID codes 0000 and 8000, (explained in Table 29, page 120 and Table 30, page 126). The Workhorse always collects Header and Leader.

The remaining lines include velocity (ID Code: 0001), correlation magnitude (0002), echo intensity (0003), and percent good (0004). The final field is a data-validity checksum.

ALWAYS OUTPUT	**HEADER** (6 BYTES + [2 x No. OF DATA TYPES])
	FIXED LEADER DATA (53 BYTES)
	VARIABLE LEADER DATA (65 BYTES)
WD-command WP-command	**VELOCITY** (2 BYTES + 8 BYTES PER DEPTH CELL)
	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
BP-command	**BOTTOM TRACK DATA** (85 BYTES)
ALWAYS OUTPUT	**RESERVED** (2 BYTES)
	CHECKSUM (2 BYTES)

Figure 7. PD0 Standard Output Data Buffer Format

NOTE. Some data outputs are in bytes per depth cell. For example, if the WN-command (number of depth cells) = 30 (default), and the following data are selected for output, the required data buffer storage space is 835 bytes per ensemble.

```
WD-COMMAND = WD 111 100 000 (default), WP-COMMAND > 0, BP-COMMAND > 0
    20  BYTES OF HEADER DATA (6 + [2x Number Of Data Types])
    53  BYTES OF FIXED LEADER DATA (FIXED)
    65  BYTES OF VARIABLE LEADER DATA (FIXED)
   242  BYTES OF VELOCITY DATA (2 + 8 x 30)
   122  BYTES OF CORRELATION MAGNITUDE DATA (2 + 4 x 30)
   122  BYTES OF ECHO INTENSITY (2 + 4 x 30)
   122  BYTES OF PERCENT-GOOD DATA (2 + 4 x 30)
    85  BYTES OF BOTTOM TRACK DATA (FIXED)
     2  BYTES OF RESERVED FOR RDI USE (FIXED)
     2  BYTES OF CHECKSUM DATA (FIXED)
   835  BYTES OF DATA PER ENSEMBLE
```

NOTE. *WinRiver* and *VmDas* may add additional bytes.

For example, WinRiver does not add any bytes to the Bottom Track data, but does insert data in place of other bytes. The Navigation NMEA strings (up to 275 bytes) are stored in the *r.000 raw data between the Bottom Track data and the Reserved/Checksum data. WinRiver output data format is described in the WinRiver User's Guide.

VmDas adds 78 bytes of Navigation data between the Bottom Track data and the Reserved/Checksum data. The ENR file (raw data from the ADCP) does not have these bytes, only the ENS, ENX, STA and LTA files. VmDas output data format is described in the VmDas User's Guide.

5.1 Header Data Format

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	HEADER ID (7Fh)								
2	DATA SOURCE ID (7Fh)								
3	NUMBER OF BYTES IN ENSEMBLE								LSB
4									MSB
5	SPARE								
6	NUMBER OF DATA TYPES								
7	OFFSET FOR DATA TYPE #1								LSB
8									MSB
9	OFFSET FOR DATA TYPE #2								LSB
10									MSB
11	OFFSET FOR DATA TYPE #3								LSB
12									MSB
↓	(SEQUENCE CONTINUES FOR UP TO N DATA TYPES)								↓
2N+5	OFFSET FOR DATA TYPE #N								LSB
2N+6									MSB

See Table 28, page 117 for a description of the fields.

Figure 8. Binary Header Data Format

NOTE. This data is always output in this format.

Header information is the first item sent by the ADCP to the output buffer. The Workhorse always sends the Least Significant Byte (LSB) first.

Table 28: Header Data Format

Hex Digit	Binary Byte	Field	Description
1,2	1	HDR ID / Header ID	Stores the header identification byte (7Fh).
3,4	2	HDR ID / Data Source ID	Stores the data source identification byte (7Fh for the Workhorse).
5-8	3,4	Bytes / Number of bytes in ensemble	This field contains the number of bytes from the start of the current ensemble up to, but not including, the 2-byte checksum (Figure 15, page 141).
9,10	5	Spare	Undefined.
11,12	6	No. DT / Number of Data Types	This field contains the number of data types selected for collection. By default, fixed/variable leader, velocity, correlation magnitude, echo intensity, and percent good are selected for collection. This field will therefore have a value of six (4 data types + 2 for the Fixed/Variable Leader data).
13-16	7,8	Address Offset for Data Type #1 / Offset for Data Type #1	This field contains the internal memory address offset where the Workhorse will store information for data type #1 (with this firmware, always the Fixed Leader). Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #1 begins (the first byte of the ensemble is Binary Byte #1).
17-20	9,10	Address Offset for Data Type #2 / Offset for Data Type #2	This field contains the internal memory address offset where the Workhorse will store information for data type #2 (with this firmware, always the Variable Leader). Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #2 begins (the first byte of the ensemble is Binary Byte #1).
21-24 thru 2n+13 to 2n+16	11,12 thru 2n+5, 2n+6	Address Offsets for Data Types #3-n / Offset for Data Type #3 through #n	These fields contain internal memory address offset where the Workhorse will store information for data type #3 through data type #n. Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Types #3-n begin (first byte of ensemble is Binary Byte) #1).

5.2 Fixed Leader Data Format

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	FIXED LEADER ID								LSB 00h
2									MSB 00h
3	CPU F/W VER.								
4	CPU F/W REV.								
5	SYSTEM CONFIGURATION								LSB
6									MSB
7	REAL/SIM FLAG								
8	SPARE								
9	NUMBER OF BEAMS								
10	NUMBER OF CELLS {WN}								
11	PINGS PER ENSEMBLE {WP}								LSB
12									MSB
13	DEPTH CELL LENGTH {WS}								LSB
14									MSB
15	BLANK AFTER TRANSMIT {WF}								LSB
16									MSB
17	PROFILING MODE {WM}								
18	LOW CORR THRESH {WC}								
19	NO. CODE REPS								
20	%GD MINIMUM {WG}								
21	ERROR VELOCITY MAXIMUM {WE}								LSB
22									MSB
23	TPP MINUTES								
24	TPP SECONDS								
25	TPP HUNDREDTHS {TP}								
26	COORDINATE TRANSFORM {EX}								
27	HEADING ALIGNMENT {EA}								LSB
28									MSB

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29	HEADING BIAS {EB}	LSB
30		MSB
31	SENSOR SOURCE {EZ}	
32	SENSORS AVAILABLE	
33	BIN 1 DISTANCE	
34		
35	XMIT PULSE LENGTH BASED ON {WT}	LSB
36		MSB
37	(starting cell) WP REF LAYER AVERAGE {WL} (ending cell)	LSB
38		MSB
39	FALSE TARGET THRESH {WA}	
40	SPARE	
41	TRANSMIT LAG DISTANCE	LSB
42		MSB
43	CPU BOARD SERIAL NUMBER	LSB
↓		↓
50		MSB
51	SYSTEM BANDWIDTH {WB}	LSB
52		MSB
53	SYSTEM POWER {CQ} / SPARE (for Navigator)	
54	SPARE (Navigator only)	
55	RESERVED (Navigator only)	
↓		
59		

See Table 29, page 120 for a description of the fields

Figure 9. Fixed Leader Data Format

NOTE. This data is always output in this format.

NOTE. The Fixed Leader is 52 bytes long for the Rio Grande and 53 bytes for WorkHorse Monitor/Sentinel/Long Ranger ADCPs. Bytes 54 through 59 are included in the Navigator ADCP/DVL Output Data Format only.

Fixed Leader data refers to the non-dynamic Workhorse data that only changes when you change certain commands. Fixed Leader data also contain hardware information. The Workhorse always sends Fixed Leader data as output data (LSBs first).

Table 29: Fixed Leader Data Format

<table>
<tr><th>Hex Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
<tr><td>1-4</td><td>1,2</td><td>FID / Fixed Leader ID</td><td>Stores the Fixed Leader identification word (00 00h).</td></tr>
<tr><td>5,6</td><td>3</td><td>fv / CPU F/W Ver.</td><td>Contains the version number of the CPU firmware.</td></tr>
<tr><td>7,8</td><td>4</td><td>fr / CPU F/W Rev.</td><td>Contains the revision number of the CPU firmware.</td></tr>
<tr><td>9-12</td><td>5,6</td><td>Sys Cfg / System Configuration</td><td>This field defines the Workhorse hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows.<pre>
LSB
BITS 7 6 5 4 3 2 1 0
      - - - - - 0 0 0   75-kHz SYSTEM
      - - - - - 0 0 1   150-kHz SYSTEM
      - - - - - 0 1 0   300-kHz SYSTEM
      - - - - - 0 1 1   600-kHz SYSTEM
      - - - - - 1 0 0 1200-kHz SYSTEM
      - - - - - 1 0 1 2400-kHz SYSTEM
      - - - - 0 - - - CONCAVE BEAM PAT.
      - - - - 1 - - - CONVEX BEAM PAT.
      - - 0 0 - - - - SENSOR CONFIG #1
      - - 0 1 - - - - SENSOR CONFIG #2
      - - 1 0 - - - - SENSOR CONFIG #3
      - 0 - - - - - - XDCR HD NOT ATT.
      - 1 - - - - - - XDCR HD ATTACHED
      0 - - - - - - - DOWN FACING BEAM
      1 - - - - - - - UP-FACING BEAM

MSB
BITS 7 6 5 4 3 2 1 0
      - - - - - - 0 0 15E BEAM ANGLE
      - - - - - - 0 1 20E BEAM ANGLE
      - - - - - - 1 0 30E BEAM ANGLE
      - - - - - - 1 1 OTHER BEAM ANGLE
      0 1 0 0 - - - - 4-BEAM JANUS CONFIG
      0 1 0 1 - - - - 5-BM JANUS CFIG DEMOD)
      1 1 1 1 - - - - 5-BM JANUS CFIG.(2 DEMD)
</pre>Example: Hex 5249 (i.e., hex 49 followed by hex 52) identifies a 150-kHz system, convex beam pattern, down-facing, 30E beam angle, 5 beams (3 demods).</td></tr>
<tr><td>13,14</td><td>7</td><td>PD / Real/Sim Flag</td><td>This field is set by default as real data (0).</td></tr>
</table>

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Table 29: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
15,16	8	Spare	Undefined.
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Workhorse needs only three beams to calculate water-current velocities. The fourth beam provides an error velocity that determines data validity. If only three beams are available, the Workhorse does not make this validity check. Table 34, page 135 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Workhorse collects data (WN-command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
21-24	11,12	WP / Pings Per Ensemble	Contains the number of pings averaged together during a data ensemble (WP-command). If WP = 0, the Workhorse does not collect the WD water-profile data. Note: The Workhorse automatically extends the ensemble interval (TE) if the product of WP and time per ping (TP) is greater than TE (i.e., if WP x TP > TE). Scaling: LSD = 1 ping; Range = 0 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS-command). Scaling: LSD = 1 centimeter; Range = 1 to 6400 cm (210 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Workhorse to allow the transmit circuits time to recover before the receive cycle begins (WF-command). Scaling: LSD = 1 centimeter; Range = 0 to 9999 cm (328 feet)
33,34	17	Signal Processing Mode	Contains the Signal Processing Mode. This field will always be set to 1.
35,36	18	WC / Low Corr Thresh	Contains the minimum threshold of correlation that water-profile data can have to be considered good data (WC-command). Scaling: LSD = 1 count; Range = 0 to 255 counts
37,38	19	cr# / No. code reps	Contains the number of code repetitions in the transmit pulse. Scaling: LSD = 1 count; Range = 0 to 255 counts
39,40	20	WG / %Gd Minimum	Contains the minimum percentage of water-profiling pings in an ensemble that must be considered good to output velocity data (WG-command). Scaling: LSD = 1 percent; Range = 1 to 100 percent
41-44	21,22	WE / Error Velocity Threshold	This field, initially set by the WE-command, contains the actual threshold value used to flag water-current data as good or bad. If the error velocity value exceeds this threshold, the Workhorse flags all four beams of the affected bin as bad. Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46	23	Minutes	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The Workhorse automatically extends the ensemble interval (set by TE) if (WP x TP > TE).
47,48	24	Seconds	
49,50	25	Hundredths	

Table 29: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description

51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX-command). These firmware switches indicate how the Workhorse collected data.
			`xxx00xxx = NO TRANSFORMATION (BEAM COORDINATES)`
			`xxx01xxx = INSTRUMENT COORDINATES`
			`xxx10xxx = SHIP COORDINATES`
			`xxx11xxx = EARTH COORDINATES`
			`xxxxx1xx = TILTS (PITCH AND ROLL) USED IN SHIP OR EARTH TRANSFORMATION`
			`xxxxxx1x = 3-BEAM SOLUTION USED IF ONE BEAM IS BELOW THE CORRELATION THRESHOLD SET BY THE WC-COMMAND`
			`xxxxxxx1 = BIN MAPPING USED`

53-56	27,28	EA / Heading Alignment	Contains a correction factor for physical heading misalignment (EA-command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees
57-60	29,30	EB / Heading Bias	Contains a correction factor for electrical/magnetic heading bias (EB-command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees

61,62	31	EZ / Sensor Source	Contains the selected source of environmental sensor data (EZ-command). These firmware switches indicate the following.
			`FIELD DESCRIPTION`
			`x1xxxxxx = CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET`
			`xx1xxxxx = USES ED FROM DEPTH SENSOR`
			`xxx1xxxx = USES EH FROM TRANSDUCER HEADING SENSOR`
			`xxxx1xxx = USES EP FROM TRANSDUCER PITCH SENSOR`
			`xxxxx1xx = USES ER FROM TRANSDUCER ROLL SENSOR`
			`xxxxxx1x = USES ES (SALINITY) FROM CONDUCTIVITY SENSOR`
			`xxxxxxx1 = USES ET FROM TRANSDUCER TEMPERATURE SENSOR`
			NOTE: If the field = 0, or if the sensor is not available, the Workhorse uses the manual command setting. If the field = 1, the Workhorse uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although you can enter a “2” in the EZ-command string, the Workhorse only displays a 0 (manual) or 1 (int/ext sensor).

63,64	32	Sensor Avail	This field reflects which sensors are available. The bit pattern is the same as listed for the EZ-command (above).
65-68	33,34	dis1 / Bin 1 distance	This field contains the distance to the middle of the first depth cell (bin). This distance is a function of depth cell length (WS), the profiling mode (WM), the blank after transmit distance (WF), and speed of sound. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)

Table 29: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command, contains the length of the transmit pulse. When the Workhorse receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS-command). This means the Workhorse uses a WT command of zero. However, the WT field contains the actual length of the transmit pulse used. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)
73,74 75,76	37,38	WL / WP Ref Lyr Avg (Starting cell, Ending cell)	Contains the starting depth cell (LSB, byte 37) and the ending depth cell (MSB, byte 38) used for water reference layer averaging (WL-command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
77,78	39	WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA-command). Scaling: LSD = 1 count; Range = 0 to 255 counts (255 disables)
79,80	40	Spare	Contains the CX-command setting. Range = 0 to 5
81-84	41,42	LagD / Transmit lag distance	This field, determined mainly by the setting of the WM-command, contains the distance between pulse repetitions. Scaling: LSD = 1 centimeter; Range = 0 to 65535 centimeters
85-100	43-50	CPU Board Serial Number	Contains the serial number of the CPU board.
101-105	51-52	WB / System Bandwidth	Contains the WB-command setting. Range = 0 to 1
106-107	53	System Power	Contains the CQ-command setting for WorkHorse Monitor/Sentinel/Long Ranger ADCPs. Range 0 to 255. This byte is Spare for Navigator ADCP/DVLS.
108-109	54	Spare	Spare – only included in Navigator Output Data Format.
110-121	55-59	Reserved	Reserved – only included in Navigator Output Data Format.

5.3 Variable Leader Data Format

BYTE	BIT POSITIONS 7 6 5 4 3 2 1 0	
1	VARIABLE LEADER ID	80h
2		00h
3	ENSEMBLE NUMBER	LSB
4		MSB
5	RTC YEAR {TS}	
6	RTC MONTH {TS}	
7	RTC DAY {TS}	
8	RTC HOUR {TS}	
9	RTC MINUTE {TS}	
10	RTC SECOND {TS}	
11	RTC HUNDREDTHS {TS}	
12	ENSEMBLE # MSB	
13	BIT RESULT	LSB
14		MSB
15	SPEED OF SOUND {EC}	LSB
16		MSB
17	DEPTH OF TRANSDUCER {ED}	LSB
18		MSB
19	HEADING {EH}	LSB
20		MSB
21	PITCH (TILT 1) {EP}	LSB
22		MSB
23	ROLL (TILT 2) {ER}	LSB
24		MSB
25	SALINITY {ES}	LSB
26		MSB
27	TEMPERATURE {ET}	LSB
28		MSB
29	MPT MINUTES	
30	MPT SECONDS	
31	MPT HUNDREDTHS	
32	HDG STD DEV	
33	PITCH STD DEV	
34	ROLL STD DEV	

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35	ADC CHANNEL 0	
36	ADC CHANNEL 1	
37	ADC CHANNEL 2	
38	ADC CHANNEL 3	
39	ADC CHANNEL 4	
40	ADC CHANNEL 5	
41	ADC CHANNEL 6	
42	ADC CHANNEL 7	
43	ERROR STATUS WORD (ESW) {CY?}	LSB
44		
45		
46		MSB
47	SPARE	
48		
49	PRESSURE	LSB
50		
51		
52		MSB
53	PRESSURE SENSOR VARIANCE	LSB
54		
55		
56		MSB
57	SPARE	
58	RTC CENTURY	
59	RTC YEAR	
60	RTC MONTH	
61	RTC DAY	
62	RTC HOUR	
63	RTC MINUTE	
64	RTC SECOND	
65	RTC HUNDREDTH	

See Table 30, page 126 for a description of the fields.

Figure 10. Variable Leader Data Format

NOTE. This data is always output in this format.

Variable Leader data refers to the dynamic Workhorse data (from clocks/sensors) that change with each ping. The Workhorse always sends Variable Leader data as output data (LSBs first).

Table 30: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (80 00h).

5-8	3,4	Ens / Ensemble Number	This field contains the sequential number of the ensemble to which the data in the output buffer apply.
			Scaling: LSD = 1 ensemble; Range = 1 to 65,535 ensembles
			NOTE: The first ensemble collected is #1. At “rollover,” we have the following sequence:
			`1 = ENSEMBLE NUMBER 1`
			`↓`
			`65535 = ENSEMBLE NUMBER 65,535 | ENSEMBLE`
			`0 = ENSEMBLE NUMBER 65,536 | #MSB FIELD`
			`1 = ENSEMBLE NUMBER 65,537 | (BYTE 12)`
			`INCR.`

9,10	5	RTC Year	These fields contain the time from the Workhorse’s real-time clock (RTC) that the current data ensemble began. The TS-command (Set Real-Time Clock) initially sets the clock. The Workhorse <u>does</u> account for leap years.
11,12	6	RTC Month	
13,14	7	RTC Day	
15,16	8	RTC Hour	
17,18	9	RTC Minute	
19,22	10	RTC Second	
21,22	11	RTC Hundredths	
23-24	12	Ensemble # MSB	This field increments each time the Ensemble Number field (bytes 3,4) “rolls over.” This allows ensembles up to 16,777,215. See Ensemble Number field above.

25-28	13,14	BIT / BIT Result	This field contains the results of the Workhorse’s Built-in Test function. A zero code indicates a successful BIT result.
			`BYTE 13   BYTE 14` (BYTE 14 RESERVED FOR FUTURE USE)
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = TIMING CARD ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

29-32	15,16	EC / Speed of Sound	Contains either manual or calculated speed of sound information (EC-command). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s

Continued next page

Table 30: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
33-36	17,18	ED / Depth of Transducer	Contains the depth of the transducer below the water surface (ED-command). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
37-40	19,20	EH / Heading	Contains the Workhorse heading angle (EH-command). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
41-44	21,22	EP / Pitch (Tilt 1)	Contains the Workhorse pitch angle (EP-command). This value may be a manual setting or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
45-48	23,24	ER / Roll (Tilt 2)	Contains the Workhorse roll angle (ER-command). This value may be a manual setting or a reading from a tilt sensor. For up-facing Workhorses, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing Workhorses, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
49-52	25,26	ES / Salinity	Contains the salinity value of the water at the transducer head (ES-command). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40 ppt
53-56	27,28	ET / Temperature	Contains the temperature of the water at the transducer head (ET-command). This value may be a manual setting or a reading from a temperature sensor. Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees
57,58	29	MPT minutes	This field contains the Minimum Pre-Ping Wait Time between ping groups in the ensemble.
59,60	30	MPT seconds	
61,62	31	MPT hundredths	
63,64	32	H/Hdg Std Dev	These fields contain the standard deviation (accuracy) of the heading and tilt angles from the gyrocompass/pendulums.
65,66	33	P/Pitch Std Dev	
67,68	34	R/Roll Std Dev	Scaling (Heading): LSD = 1°; Range = 0 to 180° Scaling (Tilts): LSD = 0.1°; Range = 0.0 to 20.0°

Table 30: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
69-70	35	ADC Channel 0	These fields contain the outputs of the Analog-to-Digital Converter (ADC) located on the DSP board. The ADC sequentially samples one of the eight channels per ping group (the number of ping groups per ensemble is the maximum of the WP). These fields are zeroed at the beginning of the deployment and updated each ensemble at the rate of one channel per ping group. For example, if the ping group size is 5, then:
71-72	36	ADC Channel 1	
73-74	37	ADC Channel 2	
75-76	38	ADC Channel 3	
77-78	39	ADC Channel 4	
79-80	40	ADC Channel 5	
81-82	41	ADC Channel 6	
83-84	42	ADC Channel 7	

```
END OF ENSEMBLE No.      CHANNELS UPDATED
       Start             All channels = 0
         1               0, 1, 2, 3, 4
         2               5, 6, 7, 0, 1
         3               2, 3, 4, 5, 6
         4               7, 0, 8, 2, 3
         ↓                   ↓
```

Here is the description for each channel:

```
CHANNEL  DESCRIPTION
0        XMIT CURRENT
1        XMIT VOLTAGE
2        AMBIENT TEMP
3        PRESSURE (+)
4        PRESSURE (-)
5        ATTITUDE TEMP
6        ATTITUDE
7        CONTAMINATION SENSOR
```

Note that the ADC values may be "noisy" from sample-to-sample, but are useful for detecting long-term trends.

Hex Digit	Binary Byte	Field	Description
85-86	43	Error Status Word	Contains the long word containing the bit flags for the CY? Command. The ESW is cleared (set to zero) between each ensemble.

Note that each number above represents one bit set – they may occur in combinations. For example, if the long word value is 0000C000 (hexadecimal), then it indicates that both a cold wake-up (0004000) and an unknown wake-up (00008000) occurred.

```
Low 16 BITS
LSB
BITS 07 06 05 04 03 02 01 00
      x  x  x  x  x  x  x  1  Bus Error
      x  x  x  x  x  x  1  x  Address Error
      x  x  x  x  x  1  x  x  Illegal Instruction
      x  x  x  x  1  x  x  x  Divide by Zero
      x  x  x  1  x  x  x  x  Emulator
      x  x  1  x  x  x  x  x  Unassigned
      x  1  x  x  x  x  x  x  Not Used
      1  x  x  x  x  x  x  x  Not Used
```

87-88 44

```
Low 16 BITS
MSB
BITS 15 14 13 12 11 10 09 08
      x  x  x  x  x  x  x  1  Pinging
      x  x  x  x  x  x  1  x  Not Used
      x  x  x  x  x  1  x  x  Not Used
      x  x  x  x  1  x  x  x  Not Used
      x  x  x  1  x  x  x  x  Not Used
      x  x  1  x  x  x  x  x  Not Used
      x  1  x  x  x  x  x  x  Cold Wakeup
      1  x  x  x  x  x  x  x  Unknown Wakeup
```

Table 30: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description

89-90	45		`High 16 BITS`
			`LSB`
			`BITS 24 23 22 21 20 19 18 17`
			`      x  x  x  x  x  x  x  1  Clock Read Error`
			`      x  x  x  x  x  x  1  x  Not Used`
			`      x  x  x  x  x  1  x  x  Not Used`
			`      x  x  x  x  1  x  x  x  Not Used`
			`      x  x  x  1  x  x  x  x  Not Used`
			`      x  x  1  x  x  x  x  x  Not Used`
			`      x  1  x  x  x  x  x  x  Not Used`
			`      1  x  x  x  x  x  x  x  Not Used`

91-92	46		`High 16 BITS`
			`MSB`
			`BITS 32 31 30 29 28 27 26 25`
			`      x  x  x  x  x  x  x  1  Not Used`
			`      x  x  x  x  x  x  1  x  Not Used`
			`      x  x  x  x  x  1  x  x  Not Used`
			`      x  x  x  x  1  x  x  x  Not Used`
			`      x  x  x  1  x  x  x  x  Not Used`
			`      x  x  1  x  x  x  x  x  Spurious UART IRQ`
			`      x  1  x  x  x  x  x  x  Spurious CLOCK IRQ`
			`      1  x  x  x  x  x  x  x  Power Failure`

93-96	47-48	Reserved	Reserved for RDI use.
97-104	49-52	Pressure	Contains the pressure of the water at the transducer head relative to one atmosphere (sea level). Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
105-112	53-56	Pressure variance	Contains the variance (deviation about the mean) of the pressure sensor data. Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
113-114	57	Spare	Spare
115-116	58	RTC Century	These fields contain the time from the Workhorse's Y2K compliant real-time clock (RTC) that the current data ensemble began. The TT-command (Set Real-Time Clock) initially sets the clock. The Workhorse <u>does</u> account for leap years.
117-118	59	RTC Year	
119-120	60	RTC Month	
121-122	61	RTC Day	
123-124	62	RTC Hour	
125-126	63	RTC Minute	
127-128	64	RTC Seconds	
129-130	65	RTC Hundredths	

5.4 Velocity Data Format

BIT POSITIONS

BYTE	7/S	6	5	4	3	2	1	0	
1	VELOCITY ID								LSB 00h
2									MSB 01h
3	DEPTH CELL #1, VELOCITY 1								LSB
4									MSB
5	DEPTH CELL #1, VELOCITY 2								LSB
6									MSB
7	DEPTH CELL #1, VELOCITY 3								LSB
8									MSB
9	DEPTH CELL #1, VELOCITY 4								LSB
10									MSB
11	DEPTH CELL #2, VELOCITY 1								LSB
12									MSB
13	DEPTH CELL #2, VELOCITY 2								LSB
14									MSB
15	DEPTH CELL #2, VELOCITY 3								LSB
16									MSB
17	DEPTH CELL #2, VELOCITY 4								LSB
18									MSB
↓	(SEQUENCE CONTINUES FOR UP TO 128 CELLS)								↓
1019	DEPTH CELL #128, VELOCITY 1								LSB
1020									MSB
1021	DEPTH CELL #128, VELOCITY 2								LSB
1022									MSB
1023	DEPTH CELL #128, VELOCITY 3								LSB
1024									MSB
1025	DEPTH CELL #128, VELOCITY 4								LSB
1026									MSB

See Table 31, page 131 for description of fields

Figure 11. Velocity Data Format

NOTE. The number of depth cells is set by the WN-command.

The Workhorse packs velocity data for each depth cell of each beam into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The Workhorse scales velocity data in millimeters per second (mm/s). A value of –32768 (8000h) indicates bad velocity values.

All velocities are relative based on a stationary instrument. To obtain absolute velocities, algebraically remove the velocity of the instrument. For example,

```
RELATIVE WATER CURRENT VELOCITY:    EAST 650 mm/s
INSTRUMENT VELOCITY            : (-) EAST 600 mm/s
ABSOLUTE WATER VELOCITY        :     EAST  50 mm/s
```

The setting of the EX-command (Coordinate Transformation) determines how the Workhorse references the velocity data as shown below.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
xxx00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
xxx01xxx	INST	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
xxx10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
xxx11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

POSITIVE VALUES INDICATE WATER MOVEMENT

Table 31: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (00 01h).
5-8	3,4	Depth Cell 1, Velocity 1	Stores velocity data for depth cell #1, velocity 1. See above.
9-12	5,6	Depth Cell 1, Velocity 2	Stores velocity data for depth cell #1, velocity 2. See above.
13-16	7,8	Depth Cell 1, Velocity 3	Stores velocity data for depth cell #1, velocity 3. See above.
17-20	9,10	Depth Cell 1, Velocity 4	Stores velocity data for depth cell #1, velocity 4. See above.
21-2052	11-1026	Cells 2 – 128 (if used)	These fields store the velocity data for depth cells 2 through 128 (depending on the setting of the WN-command). These fields follow the same format as listed above for depth cell 1.

5.5 Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
1	ID CODE								LSB
2									MSB
3	DEPTH CELL #1, FIELD #1								
4	DEPTH CELL #1, FIELD #2								
5	DEPTH CELL #1, FIELD #3								
6	DEPTH CELL #1, FIELD #4								
7	DEPTH CELL #2, FIELD #1								
8	DEPTH CELL #2, FIELD #2								
9	DEPTH CELL #2, FIELD #3								
10	DEPTH CELL #2, FIELD #4								
↓	(SEQUENCE CONTINUES FOR UP TO 128 BINS)								↓
511	DEPTH CELL #128, FIELD #1								
512	DEPTH CELL #128, FIELD #2								
513	DEPTH CELL #128, FIELD #3								
514	DEPTH CELL #128, FIELD #4								

See Table 32, page 133 through Table 34, page 135 for a description of the fields.

Figure 12. Binary Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

NOTE. The number of depth cells is set by the WN-command.

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Workhorse represents this magnitude by a linear scale between 0 and 255, where 255 is perfect correlation (i.e., a solid target). A value of zero indicates bad correlation values.

Table 32: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (00 02h).
5,6	3	Depth Cell 1, Field 1	Stores correlation magnitude data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores correlation magnitude data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores correlation magnitude data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores correlation magnitude data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store correlation magnitude data for depth cells 2 through 128 (depending on the WN-command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.45 dB per Workhorse count. The Workhorse does not directly check for the validity of echo intensity data.

Table 33: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (00 03h).
5,6	3	Depth Cell 1, Field 1	Stores echo intensity data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores echo intensity data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores echo intensity data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores echo intensity data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store echo intensity data for depth cells 2 through 128 (depending on the WN-command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The percent-good data field is a data-quality indicator that reports the percentage (0 to 100) of good data collected for each depth cell of the velocity profile. The setting of the EX-command (Coordinate Transformation) determines how the Workhorse references percent-good data as shown below.

EX-Command	Coord. Sys	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of Good Pings For:			
		Beam 1	BEAM 2	BEAM 3	BEAM 4
xxx00xxx	Beam	Percentage Of:			
xxx01xxx	Inst	3-Beam Transformations (note 1)	Transformations Rejected (note 2)	More Than One Beam Bad In Bin	4-Beam Transformations
xxx10xxx	Ship				
xxx11xxx	Earth				

1. Because profile data did not exceed correlation threshold (WC).
2. Because the error velocity threshold (WE) was exceeded.

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the Workhorse uses all four beams to calculate the orthogonal and error velocities. As the echo returns from far away depth cells, echo intensity decreases. At some point, the echo will be weak enough on any given beam to cause the Workhorse to reject some of its depth cell data. This causes the Workhorse to calculate velocities with three beams instead of four beams. When the Workhorse does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the Workhorse rejects all cell data because of the weak echo. As an example, let us assume depth cell 60 has returned the following percent-good data.

```
FIELD #1 = 50, FIELD #2 = 5, FIELD #3 = 0, FIELD #4 = 45
```

If the EX-command was set to collect velocities in BEAM coordinates, the example values show the percentage of pings having good solutions in cell 60 for each beam based on the Low Correlation Threshold (WC-command). Here, beam 1=50%, beam 2=5%, beam 3=0%, and beam 4=45%. These are not typical nor desired percentages. Typically, you would want all four beams to be about equal and greater than 25%.

On the other hand, if velocities were collected in INSTRUMENT, SHIP, or EARTH coordinates, the example values show:

FIELD 1 – Percentage of good 3-beam solutions – Shows percentage of successful velocity calculations (50%) using 3-beam solutions because the correlation threshold (WC) was not exceeded.

FIELD 2 – Percentage of transformations rejected – Shows percent of error velocity (5%) that was less than the WE-command setting. WE has a default of 5000 mm/s. This large WE setting effectively prevents the Workhorse from rejecting data based on error velocity.

FIELD 3 – Percentage of more than one beam bad in bin – 0% of the velocity data were rejected because not enough beams had good data.

FIELD 4 – Percentage of good 4-beam solutions – 45% of the velocity data collected during the ensemble for depth cell 60 were calculated using four beams.

Table 34: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (00 04h).
5,6	3	Depth cell 1, Field 1	Stores percent-good data for depth cell #1, field 1. See above.
7,8	4	Depth cell 1, Field 2	Stores percent-good data for depth cell #1, field 2. See above.
9,10	5	Depth cell 1, Field 3	Stores percent-good data for depth cell #1, field 3. See above.
11,12	6	Depth cell 1, Field 4	Stores percent-good data for depth cell #1, field 4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store percent-good data for depth cells 2 through 128 (depending on the WN-command), following the same format as listed above for depth cell 1.

5.6 Binary Bottom-Track Data Format

BIT POSITIONS

BYTE	7/S	6	5	4	3	2	1	0	
1	BOTTOM-TRACK ID								LSB 00h
2									MSB 06h
3	BT PINGS PER ENSEMBLE {BP}								LSB
4									MSB
5	BT DELAY BEFORE RE-ACQUIRE {BD}								LSB
6									MSB
7	BT CORR MAG MIN {BC}								
8	BT EVAL AMP MIN {BA}								
9	BT PERCENT GOOD MIN {BG}								
10	BT MODE {BM}								
11	BT ERR VEL MAX {BE}								LSB
12									MSB
13	RESERVED								
14									
15									
16									
17	BEAM#1 BT RANGE								LSB
18									MSB
19	BEAM#2 BT RANGE								LSB
20									MSB
21	BEAM#3 BT RANGE								LSB
22									MSB
23	BEAM#4 BT RANGE								LSB
24									MSB
25	BEAM#1 BT VEL								LSB
26									MSB
27	BEAM#2 BT VEL								LSB
28									MSB
29	BEAM#3 BT VEL								LSB
30									MSB
31	BEAM#4 BT VEL								LSB
32									MSB

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33	BEAM#1 BT CORR.	
34	BEAM#2 BT CORR.	
35	BEAM#3 BT CORR.	
36	BEAM#4 BT CORR.	
37	BEAM#1 EVAL AMP	
38	BEAM#2 EVAL AMP	
39	BEAM#3 EVAL AMP	
40	BEAM#4 EVAL AMP	
41	BEAM#1 BT %GOOD	
42	BEAM#2 BT %GOOD	
43	BEAM#3 BT %GOOD	
44	BEAM#4 BT %GOOD	
45	REF LAYER MIN {BL}	LSB
46		MSB
47	REF LAYER NEAR {BL}	LSB
48		MSB
49	REF LAYER FAR {BL}	LSB
50		MSB
51	BEAM#1 REF LAYER VEL	LSB
52		MSB
53	BEAM #2 REF LAYER VEL	LSB
54		MSB
55	BEAM #3 REF LAYER VEL	LSB
56		MSB
57	BEAM #4 REF LAYER VEL	LSB
58		MSB
59	BM#1 REF CORR	
60	BM#2 REF CORR	
61	BM#3 REF CORR	
62	BM#4 REF CORR	
63	BM#1 REF INT	
64	BM#2 REF INT	
65	BM#3 REF INT	
66	BM#4 REF INT	

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67	BM#1 REF %GOOD	
68	BM#2 REF %GOOD	
69	BM#3 REF %GOOD	
70	BM#4 REF %GOOD	
71	BT MAX. DEPTH {BX}	LSB
72		MSB
73	BM#1 RSSI AMP	
74	BM#2 RSSI AMP	
75	BM#3 RSSI AMP	
76	BM#4 RSSI AMP	
77	GAIN	
78	(*SEE BYTE 17)	MSB
79	(*SEE BYTE 19)	MSB
80	(*SEE BYTE 21)	MSB
81	(*SEE BYTE 23)	MSB
82	RESERVED	
83		
84		
85		

Figure 13. Binary Bottom-Track Data Format

NOTE. This data is output only if the BP-command is > 0 and PD0 is selected. See Table 35, page 139 for a description of the fields.

NOTE. The PD0 output data format assumes that the **instrument** is stationary and the **bottom** is moving. DVL (Speed Log) output data formats (see “Special Output Data Formats,” page 142) assume that the bottom is stationary and that the ADCP or vessel is moving.

NOTE. Bytes 82 through 85 have been added in firmware version 8.17 (WorkHorse Monitor/Sentinel/Long Ranger) and firmware version 9.12 for WorkHorse Navigator ADCP/DVLs.

NOTE. Bottom Track is a feature upgrade for WorkHorse Monitor and Sentinel ADCPs (see “Feature Upgrades,” page 4).

NOTE. Bottom Track is not available for Long Ranger ADCPs.

This data is output only if the BP-command is greater than zero and PD0 is selected. The LSB is always sent first.

Table 35: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (06 00h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP-command). If BP = 0, the ADCP does not collect bottom-track data. The ADCP automatically extends the ensemble interval (TE) if BP x TP > TE. Scaling: LSD = 1 ping; Range = 0 to 999 pings
9-12	5,6	BD/BT delay before reacquire	Stores the number of ADCP ensembles to wait after losing the bottom before trying to reacquire it (BD-command). Scaling: LSD = 1 ensemble; Range = 0 to 999 ensembles
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC-command). Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA-command). Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	BG/BT %Gd Minimum	Stores the minimum percentage of bottom-track pings in an ensemble that must be good to output velocity data (BG-command).
19,20	10	BM/BT Mode	Stores the bottom-tracking mode (BM-command).
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE-command). Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s (0 = did not screen data)
25-32	13–16	Reserved	Reserved
33-48	17-24	BT Range/Beam #1-4 BT Range	Contains the two lower bytes of the vertical range from the ADCP to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = 0. See bytes 78 through 81 for MSB description and scaling. Scaling: LSD = 1 cm; Range = 0 to 65535 cm
49-64	25-32	BT Velocity/Beam #1-4 BT Vel	The meaning of the velocity depends on the EX (coordinate system) command setting. The four velocities are as follows: a) Beam Coordinates: Beam 1, Beam 2, Beam 3, Beam 4 b) Instrument Coordinates: 1->2, 4->3, toward face, error c) Ship Coordinates: Starboard, Fwd, Upward, Error d) Earth Coordinates: East, North, Upward, Error
65-72	33-36	BTCM/Beam #1-4 BT Corr.	Contains the correlation magnitude in relation to the sea bottom (or surface) as determined by each beam. Bottom-track correlation magnitudes have the same format and scale factor as water-profiling magnitudes (Table 5).

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Table 35: Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
73-80	37-40	BTEA/Beam #1-4	Contains the evaluation amplitude of the matching filter used in determining the strength of the bottom echo.
		BT Eval Amp	Scaling: LSD = 1 count; Range = 0 to 255 counts
81-88	41-44	BTPG/Beam #1-4 BT %Good	Contains bottom-track percent-good data for each beam, which indicate the reliability of bottom-track data. It is the percentage of bottom-track pings that have passed the ADCP's bottom-track validity algorithm during an ensemble.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
89-92 93-96 97 – 100	45,46 47,48 49,50	Ref Layer (Min, Near, Far)	Stores the minimum layer size, the near boundary, and the far boundary of the BT water-reference layer (BL-command).
			Scaling (minimum layer size): LSD = 1 dm; Range = 0-999 dm
			Scaling (near/far boundaries): LSD = 1 dm; Range = 0-9999 dm
101-116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water reference layer for each beam. Reference layer velocities have the same format and scale factor as water-profiling velocities (Table 31, page 131). The BL-command explains the water reference layer.
117-124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water reference layer for each beam. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes (Table 5).
125-132	63-66	RLEI/Bm #1-4 Ref Int	Contains echo intensity data for the reference layer for each beam. Reference layer intensities have the same format and scale factor as water-profiling intensities.
133-140	67-70	RLPG/Bm #1-4 Ref %Good	Contains percent-good data for the water reference layer for each beam. They indicate the reliability of reference layer data. It is the percentage of bottom-track pings that have passed a reference layer validity algorithm during an ensemble.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
141-144	71,72	BX/BT Max. Depth	Stores the maximum tracking depth value (BX-command).
			Scaling: LSD = 1 decimeter; Range = 80 to 9999 decimeters
145-152	73-76	RSSI/Bm #1-4 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam.
			Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
153, 154	77	GAIN	Contains the Gain level for shallow water. See WJ-command.
155-162	78-81	BT Range MSB/Bm #1-4	Contains the most significant byte of the vertical range from the ADCP to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range=0. See bytes 17 through 24 for LSB description and scaling.
			Scaling: LSD = 65,536 cm, Range = 65,536 to 16,777,215 cm
163-170	82-85	Reserved	Reserved

5.7 Binary Reserved BIT Data Format

	BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0	
1	RESERVED FOR RDI USE								LSB
2									MSB

Figure 14. Binary Reserved BIT Data Format

NOTE. The data is always output in this format. See Table 36 for a description of the fields.

Table 36: Reserved for RDI Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Reserved for RDI's use	This field is for RDI (internal use only).

5.8 Binary Checksum Data Format

	BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0	
1	CHECKSUM DATA								LSB
2									MSB

Figure 15. Binary Checksum Data Format

NOTE. The data is always output in this format. See Table 37 for a description of the fields..

Table 37: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65535 checksum. The Workhorse computes the checksum by summing all the bytes in the output buffer excluding the checksum.