The PD0 Bottom Track High Resolution Velocity Output (velocity in 0.01mm/s) and PD3 through PD26 data formats assume that the bottom is stationary and that the DVL or vessel is moving.

- If Beam 3 is going forward, then the Y velocity is positive.
- If Beam 2 is going forward, then X velocity is positive.
- If the bottom is going towards the face of a down facing DVL, then Z is positive.

PD0 has distance made good in the output if the Bottom Track High Resolution Velocity Output Format is selected. This format is selected via the #BJ command (see BJ – Data Type Output Control).

PD0 Output Data Format

The following description is for the standard PD0 Pathfinder output data format. Figure 30 through Figure 44 shows the ASCII and binary data formats for the Pathfinder PD0 mode. Table 32 through Table 47 defines each field in the output data structure.

The binary output data formats are composed of at least one data type, i.e. a group of bytes all related by their dynamic or field. For instance in the PD0 data format, variables that do not change during the deployment are stored in the Fixed Leader data type of leader ID 0000h, whereas the dynamic variables, except velocities, which dynamically change during the deployment are stored under the Variable Leader data type of leader ID 0080h. This distinction is based on the dynamic; other distinctions are present such as velocity types such as data type of leader ID 0100h which groups all the Water Profile Velocity data and leader ID 0600h stores all Bottom Track Velocity data. The Pathfinder sends all the data for a given type for all depth cells and all beams before the next data type begins.

The PD0 Header ID is 7F7Fh, which makes it easy to detect. In the PD0 Header are the number of bytes in the ensemble, the number of data types and the offset respective to each data type location in the binary ensemble.

PD0 is the only binary output data format which provides a Header that describes the data included in the ensemble since some data types presence in the PD0 output are dependent on commands parameters. For example, if the number of Bottom Track pings is 0 (BP0), then there will be no Bottom track data type in the ensemble. The table below shows which data types are always output against command dependable data types:

Output	ID (MSB LSB)	Description
ALWAYS OUTPUT	**7F 7Fh**	**HEADER** (6 BYTES + [2 x No. OF DATA TYPES])
	00 00h	**FIXED LEADER DATA** (58 BYTES)
	00 80h	**VARIABLE LEADER DATA** (77 BYTES)
WATER PROFILING DATA WD command WP command	**01 00h**	**VELOCITY** (2 BYTES + 8 BYTES PER DEPTH CELL)
	02 00h	**CORRELATION MAGNITUDE** (2 BYTES + 4 BYTES PER DEPTH CELL)
	03 00h	**ECHO INTENSITY** (2 BYTES + 4 BYTES PER DEPTH CELL)
	04 00h	**PERCENT GOOD** (2 BYTES + 4 BYTES PER DEPTH CELL)
BP command #BJ command	**06 00h**	**BOTTOM TRACK DATA** (81 BYTES)
	58 00h	**BOTTOM TRACK COMMAND OUTPUT** (43 BYTES)
	58 03h	**BOTTOM TRACK HIGH RESOLUTION VELOCITY** (70 BYTES)
	58 04h	**BOTTOM TRACK RANGE** (41 BYTES)
	20 13h	**NAVIGATION PARAMETERS DATA** (85 BYTES)
#EE command	**30 00h**	**ENVIRONMENT COMMAND PARAMETERS OUTPUT** (47 BYTES)
	30 01h	**SENSOR SOURCE FOR DOPPLER PROCESSING** (62 BYTES)
ALWAYS OUTPUT		**CHECKSUM** (2 BYTES)

Figure 29. PD0 Standard Output Data Buffer Format

The Pathfinder always sends the Least Significant Byte (LSB) first.

Some data outputs are in bytes per depth cell. For example, if the WN-command = 30 (default), WD command = WD 111 110 000 (default), WP command > 0, BP command > 0, the required data buffer storage space is 951 bytes per ensemble. There are seven data types output for this example: Fixed Leader, Variable Leader, Velocity, Correlation Magnitude, Echo Intensity, Percent Good, and Bottom Track.

```
 20  BYTES OF HEADER DATA (6 + [2 x 7 Data Types])
 58  BYTES OF FIXED LEADER DATA (FIXED)
 77  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)
122  BYTES OF PROFILE STATUS DATA (2 + 4 x 30)
 81  BYTES OF BOTTOM TRACK DATA (FIXED)
  2  BYTES OF CHECKSUM DATA (FIXED)
968  BYTES OF DATA PER ENSEMBLE
```

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 32 for a description of the fields.

Figure 30. Binary Header Data Format

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

Table 32: 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 Pathfinder).
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 44).
9,10	5	Spare	3-byte checksum offset, which would allow the output of a very large data type in the PD0 message, although no data type can start beyond the reach of a 16-bit offset word in the header.
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 Pathfinder 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 Pathfinder 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 Pathfinder 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).

Fixed Leader Data Format

BYTE	BIT POSITIONS 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	LAG LENGTH	
9	NUMBER OF BEAMS	
10	NUMBER OF CELLS	
11	PINGS PER ENSEMBLE	LSB
12		MSB
13	DEPTH CELL LENGTH	LSB
14		MSB
15	BLANK AFTER TRANSMIT	LSB
16		MSB
17	PROFILING MODE	
18	LOW CORR THRESH	
19	NO. CODE REPS	
20		
21	ERROR VELOCITY MAXIMUM	LSB
22		MSB
23	TPP MINUTES	
24	TPP SECONDS	
25	TPP HUNDREDTHS	
26	COORDINATE TRANSFORM	
27	HEADING ALIGNMENT	LSB
28		MSB

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
29	HEADING BIAS								LSB
30									MSB
31	SENSOR SOURCE								
32	SENSORS AVAILABLE								
33	BIN 1 DISTANCE								
34									
35	XMIT PULSE LENGTH								LSB
36									MSB
37	SPARE								LSB
38									MSB
39	FALSE TARGET THRESH								
40	SPARE								
41	TRANSMIT LAG DISTANCE								LSB
42									MSB
43	SPARE								LSB
↓									↓
50									MSB
51	SYSTEM BANDWIDTH								LSB
52									MSB
53	SPARE								
54	SPARE								
55	System Serial Number								LSB
↓									↓
58									MSB

See Table 33 for a description of the fields

Figure 31. Fixed Leader Data Format

Fixed Leader data refers to the non-dynamic Pathfinder data that only changes when certain commands are changed. Fixed Leader data also contains hardware information. The Pathfinder always sends Fixed Leader data as output data (LSBs first).

Table 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FID / Fixed Leader ID	Stores the Fixed Leader identification word (00 00h).
5,6	3	fv / CPU F/W Ver.	Contains the version number of the CPU firmware.
7,8	4	fr / CPU F/W Rev.	Contains the revision number of the CPU firmware.

9-12	5,6	Sys Cfg / System Configuration	This field defines the Pathfinder hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows.
			`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)`
			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).

13,14	7	PD / Real/Sim Flag	This field is set by default as real data (0).
15,16	8	Lag Length	Lag Length. The lag is the time period between sound pulses.
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Pathfinder 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 Pathfinder does not make this validity check. Table 38 (Percent-Good Data Format) has more information.

Table 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Pathfinder collects data (WN – Number of Depth Cells). Scaling: LSD = 1 depth cell; Range = 1 to 255 depth cells
21-24	11,12	WP / Pings Per Ensemble	Contains the number of pings averaged together during a data ensemble (WP – Pings Per Ensemble). If WP = 0, the Pathfinder does not collect the WD water-profile data. Note: The Pathfinder 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 = 1 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS – Depth Cell Size). Scaling: LSD = 1 centimeter; Range = 1 to 1600 cm (52.5 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Pathfinder to allow the transmit circuits time to recover before the receive cycle begins (WF – Blank after Transmit). 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 - Low Correlation Threshold). 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	% Good Minimum	Contains the minimum percentage of water-profiling pings in an ensemble that must be considered good to output velocity data. 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 Pathfinder flags all four beams of the affected bin as bad (see WE - Error Velocity Threshold). Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46 47,48 49,50	23 24 25	Minutes Seconds Hundredths	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The Pathfinder automatically extends the ensemble interval (set by TE) if (WP x TP > TE). See TP – Time Between Pings.

Table 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX – Coordinate Transformation). These firmware switches indicate how the Pathfinder 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 - Heading Alignment). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees
57-60	29,30	#EV / Heading Bias	Contains a correction factor for electrical/magnetic heading bias (EV - Heading Bias). 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 - Sensor Source). These firmware switches indicate the following. FIELD DESCRIPTION 1xxxxxxx = CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET x1xxxxxx = USES ED FROM DEPTH SENSOR xx1xxxxx = USES EH FROM TRANSDUCER HEADING SENSOR xxx1xxxx = USES EP FROM TRANSDUCER PITCH SENSOR xxxx1xxx = USES ER FROM TRANSDUCER ROLL SENSOR xxxxx1xx = USES ES (SALINITY) FROM CONDUCTIVITY SENSOR xxxxxx1x = USES ET FROM TRANSDUCER TEMPERATURE SENSOR xxxxxxx1 = USES EU FROM TRANSDUCER TEMPERATURE SENSOR NOTE: If the field = 0, or if the sensor is not available, the Pathfinder uses the manual command setting. If the field = 1, the Pathfinder uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although a “2” in the EZ-command string can be entered, the Pathfinder 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 33: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command (WT - Transmit Length), contains the length of the transmit pulse. When the Pathfinder receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS – Depth Cell Size). This means the Pathfinder 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	Spare	Spare
77,78	39	#WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA - False Target Threshold Maximum). 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	Spare	Spare
101-105	51-52	System Bandwidth	Contains the system bandwidth setting. Range = 0 to 1
106-107	53	Spare	Spare
108-109	54	Spare	Spare
110-119	55-58	System Serial Number	System Serial Number

Variable Leader Data Format

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

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
32	HDG STD DEV								
33	PITCH STD DEV								
34	ROLL STD DEV								
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)								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								
↓									↓
↓									↓
66									

BYTE	BIT POSITIONS 7 6 5 4 3 2 1 0	
67	HEALTH STATUS	
68	LEAK A COUNT	LSB
69		MSB
70	LEAK B COUNT	LSB
71		MSB
72	TX VOLTAGE	LSB
73		MSB
74	TX CURRENT	LSB
75		MSB
76	TRANSDUCER IMPEDANCE	LSB
77		MSB

Figure 32. Variable Leader Data Format

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

Table 34: Variable Leader Data Format

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

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 11,12 13,14 15,16 17,18 19,22 21,22	5 6 7 8 9 10 11	RTC Year RTC Month RTC Day RTC Hour RTC Minute RTC Second RTC Hundredths	These fields contain the time from the Pathfinder’s real-time clock (RTC) that the current data ensemble began. The TS-command (TS – Set Real-Time Clock) initially sets the clock. The Pathfinder does account for leap years.
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.

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description

25-28	13,14	BIT / BIT Result	This field contains the results of the Pathfinder's Built-in Test function. A zero code indicates a successful BIT result. See BIT Decoding Method for non-zero values.
			`BIT  byte13`
			`Error`
			`Code     Description`
			`0x01     Transmitter Shutdown`
			`0x02     Transmitter Overcurrent`
			`0x03     Transmitter Undercurrent`
			`0x04     Transmitter Undervoltage`
			
			`0x10     FIFO interrupt missed`
			`0x11     FIFO ISR re-entry`
			
			`0x21     Sensor start failure`
			`0x22     temperature sensor failure`
			`0x23     pressure sensor failure`
			`0x27     Bad Comms with sensor`
			`0x28     Bad Comms with sensor`
			`0x29     Sensor Cal Data checksum failure`
			`0x2A     Sensor Stream Data Fault`
			
			`0x30     Stuck UART`
			`0x31     QUART Transmit timeout`
			`0x32     QUART IRQ Stuck`
			`0x33     QUART Buffer stuck`
			`0x34     QUART IRQ Active`
			`0x35     QUART cannot clear interrupt`
			
			`0x50     RTC low battery`
			`0x51     RTC time not set`
			
			`0x60     Lost Nonvolatile pointers`
			`0x61     Erase operation failed`
			`0x62     Error writing from flash to buffer 1`
			`0x63     Error writing from buffer 1 to flash`
			`0x64     Timed out checking if page is erased`
			`0x65     Bad return when checking page`
			`0x66     Loop recorder Slate Full`
			
			`0x70     Unable to write to FRAM`
			
			`0x80     HEM data corrupt or not initialized.`
			`0x81     HEM data corrupt or not initialized.`
			`0x82     Failed to update HEM data.`
			`0x83     Failed to update HEM data.`
			`0x84     Failed to read HEM time data.`
			`0x85     Failed to read HEM pressure data.`
			`0x86     Failed to read HEM SPI state.`
			`0x87     Operating time over max.`
			`0x88     Pressure reading over sensor limit.`
			`0x89     Leak detected in sensor A.`
			`0x8A     Leak detected in sensor B.`
			
			`0xFF     Power failure`
			
			`BIT Number of Errors byte 14`
			`Number of BIT errors`

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

Table 34: Variable Leader Data Format

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 - Depth of Transducer). 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 Pathfinder heading angle. This value may be a manual setting (EH - Heading) or a reading from a heading sensor. The variation angle from the EV command is added to heading before output. The coordinate frame this data is referenced to is specified by the EH command. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
41-44	21,22	EP / Pitch (Tilt 1)	Contains the Pathfinder pitch angle. This value may be a manual setting (EP - Pitch and Roll Angles) or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. The coordinate frame this data is referenced to is specified by the EP command. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
45-48	23,24	ER / Roll (Tilt 2)	Contains the Pathfinder roll angle. This value may be a manual setting (ER - Roll Angle) or a reading from a tilt sensor. For an up-facing Pathfinder system, positive values mean that Beam #2 is above the earth's horizontal while than Beam #1is below the earth's horizontal. For a down-facing Pathfinder system, positive values mean that Beam #1 is above the earth's horizontal and then Beam #2 is below the earth's horizontal. The coordinate frame this data is referenced to is specified by the EP command. 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 – Salinity). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40
53-56	27,28	ET / Temperature	Contains the temperature of the water at the transducer head. This value may be a manual setting (ET - Temperature) or a reading from a temperature sensor. Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees
57,58 59,60 61,62	29 30 31	MPT minutes MPT seconds MPT hundredths	This field contains the Minimum Pre-Ping Wait Time between ping groups in the ensemble.
63,64 65,66 67,68	32 33 34	H/Hdg Std Dev P/Pitch Std Dev R/Roll Std Dev	These fields contain the standard deviation (accuracy) of the heading and tilt angles from the gyrocompass/pendulums. Scaling (Heading): LSD = 1°; Range = 0 to 180° Scaling (Tilts): LSD = 0.1°; Range = 0.0 to 20.0°

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description

69-70
71-72
73-74
75-76
77-78
79-80
81-82
83-84
	35
	36
	37
	38
	39
	40
	41
	42
		ADC Channel 0
		ADC Channel 1
		ADC Channel 2
		ADC Channel 3
		ADC Channel 4
		ADC Channel 5
		ADC Channel 6
		ADC Channel 7
			These fields contain the outputs of the Analog-to-Digital Converter (ADC). The ADC channels in the Pathfinder are defined as follows:
			`CHANNEL  DESCRIPTION`
			`0        Not Used`
			`1        Rounded voltage as measured during pinging`
			`2        Not Used`
			`3        Not Used`
			`4        Not Used`
			`5        Not Used`
			`6        Not Used`
			`7        Not Used`
			Note that the ADC values may be "noisy" from sample-to-sample, but are useful for detecting long-term trends.

85-86	43	Error Status Word	Reserved for TRDI use.
87-88	44		Reserved for TRDI use.
89-90	45		Reserved for TRDI use.
91-92	46		Reserved for TRDI use.
93-96	47-48	Reserved	Reserved for TRDI 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	57-66	Spare	Spare

133-134	67	Health Status	Contains the leak sensor flags and flags to indicate whether the transmit voltage, transmit current, and transducer impedance have been updated. These update flags are set when the measurement is made, and cleared after each ensemble output.
			`BITS  07 06 05 04 03 02 01 00`
			`      *  *  *  *  *  *  *  1    Leak sensor A leak detected`
			`      *  *  *  *  *  *  1  *    Leak sensor A open circuit`
			`      *  *  *  *  *  1  *  *    Leak sensor B leak detected`
			`      *  *  *  *  1  *  *  *    Leak sensor B open circuit`
			`      *  *  *  1  *  *  *  *    Tx voltage updated`
			`      *  *  1  *  *  *  *  *    Tx current updated`
			`      *  1  *  *  *  *  *  *    Transducer impedance updated`

135-138	68-69	Leak A Count	Raw A/D reading, in counts, for leak sensor A. See PC5/50 command for more details on how to decode the raw A/D counts into Leak Status.

Table 34: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
139-142	70-71	Leak B Count	Raw A/D reading, in counts, for leak sensor B. See PC5/50 command for more details on how to decode the raw A/D counts into Leak Status.
143-146	72-73	Tx Voltage	Voltage delivered to transducer during transmit. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 volt (Value set to 0xFFFF if a valid reading is not available.)
147-150	74-75	Tx Current	Current delivered to transducer during transmit. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 ampere (Value set to 0xFFFF if a valid reading is not available.)
151-154	76-77	Transducer Impedance	Measured impedance of transducer, calculated by dividing voltage by current. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 ohm (Value set to 0xFFFF if a valid reading is not available or for any reading greater than 65.535 ohms.)

If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be Bytes13, 14 = 03,xx on ensemble n, Bytes13, 14 = 03,yy on ensemble n+1, and Bytes13, 14 = 03,zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.

BIT Decoding Method

In order to verify if the system has a BIT set for an ensemble, run the file through *BBCheck.exe* or decode it from the PD0 binary output using *BBConv.exe*.

BBCheck and *BBConv* are included with RDI Tools.

In any case, one will obtain a decimal value greater than zero if a BIT was set during the ensemble.

To decode it, simply convert the decimal value to Hexadecimal and take the first number to the far left as being the number of BIT failure occurrences during the ensemble and the 2 other numbers on the far right to be the BIT code.

For example:

- BIT obtained from *BBCheck* or *BBConv.exe* is ‘290’.
- Converted to hexadecimal (one can use the Windows calculator for this) gives: ‘122’.
- Where ‘1’ is the number of occurrences for that BIT and ‘22’ is the BIT failure code which means “Temperature Sensor failure” (see binary bytes 13 and 14).

Transducer Voltage, Current, and Impedance

The Transmit Voltage, Transmit Current, and Transducer Impedance values output in the PD0 Variable Leader are obtained from the Transducer Health Monitor measurement, which is part of the HEM features. The measurement is made at the following times:

- During the transmit pulse of a BM8 ping, if the expected altitude >= 20 m
- During the transmit pulse of a BM9 ping, if the expected altitude >= 20 m

The transmit signal needs to be at least a certain length in order to make a valid measurement.

The measurement is not made during any profile ping or water mass layer ping. Therefore, if bottom pings are not enabled (or not working), then the output of these parameters will be 0xFFFF (i.e. hex FFFF) to mark them as invalid (Note that hex FFFF is equal to decimal 65535 if interpreted as an unsigned number, or -1 if interpreted as a signed number).

If bottom pings are enabled, but the altitude never attains 20 m or above, then the outputs for these parameters will remain at their initial values of 0xFFFF.

If a bottom track ping ever sees an altitude >= 20 m then these parameters will be measured and output. If the altitude then goes below 20 m, the output of these parameters will remain at their last measured value; i.e. you need a bottom track ping with altitude >= 20 m to update these values.

Velocity Data Format

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 35 for description of fields

Figure 33. Velocity Data Format

The number of depth cells is set by the WN-command (WN – Number of Depth Cells).

The Pathfinder 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 Pathfinder 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 Pathfinder references the velocity data as shown below.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
01xxx	INST	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

POSITIVE VALUES INDICATE WATER MOVEMENT

Table 35: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (MSB=01h LSB=00h).
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 WN – Number of Depth Cells). These fields follow the same format as listed above for depth cell 1.

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

BYTE	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 36 through Table 39 for a description of the fields.

Figure 34. Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format

The number of depth cells is set by the WN-command (WN – Number of Depth Cells).

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Pathfinder 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 36: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (MSB=02h LSB=00h).
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 WN – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.61 dB per Pathfinder count. The Pathfinder does not directly check for the validity of echo intensity data.

Table 37: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (MSB=03h LSB=00h).
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 WN – Number of Depth Cells) 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 Pathfinder references percent-good data as shown below.

EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of Good Pings For:			
00xxx	Beam	Beam 1	BEAM 2	BEAM 3	BEAM 4

EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of:			
01xxx 10xxx 11xxx	Instrument Ship Earth	3-Beam Transformations (note 1)	Transformations Rejected (note 2)	More Than One Beam Bad In Bin	4-Beam Transformations

Note 1. Because profile data did not exceed correlation threshold (WC command).

Note 2. Because the error velocity threshold was exceeded (WE command).

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the DVL 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 DVL to reject some of its depth cell data. This causes the DVL to calculate velocities with three beams instead of four beams. When the DVL does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the DVL 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 neither typical nor desired percentages. Typically, all four beams should 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 command) 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 2000 mm/s. This large WE setting effectively prevents the DVL 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 38: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (MSB=04h LSB=00h).
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 WN – Number of Depth Cells), following the same format as listed above for depth cell 1.

These fields contain information about the status and quality of DVL data. A value of 0 means the measurement was good. A value of 1 means the measurement was bad.

Table 39: Status Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the status data identification word (MSB=05h LSB=00h)
5,6	3	Depth cell 1, Field 1	Stores status data for depth cell #1, beam #1. See above.
7,8	4	Depth cell 1, Field 2	Stores status data for depth cell #1, beam #2. See above.
9,10	5	Depth cell 1, Field 3	Stores status data for depth cell #1, beam #3. See above.
11,12	6	Depth cell 1, Field 4	Stores status data for depth cell #1, beam #4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store status data for depth cells 2 through 128 (depending on the WN – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

Binary Bottom-Track Data Format

BYTE	BIT POSITIONS 7/S 6 5 4 3 2 1 0	
1	BOTTOM-TRACK ID	LSB 00h
2		MSB 06h
3	BT PINGS PER ENSEMBLE	LSB
4		MSB
5	RESERVED	LSB
6		MSB
7	BT CORR MAG MIN	
8	BT EVAL AMP MIN	
9	RESERVED	
10	BT MODE	
11	BT ERR VEL MAX	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
33	BEAM#1 BT CORR.	
34	BEAM#2 BT CORR.	
35	BEAM#3 BT CORR.	
36	BEAM#4 BT CORR.	

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
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								LSB
46									MSB
47	REF LAYER NEAR								LSB
48									MSB
49	REF LAYER FAR								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								
67	BM#1 REF %GOOD								
68	BM#2 REF %GOOD								
69	BM#3 REF %GOOD								
70	BM#4 REF %GOOD								
71	BT MAX. DEPTH								LSB
72									MSB

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0
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)							
79	(*SEE BYTE 19)							
80	(*SEE BYTE 21)							
81	(*SEE BYTE 23)							

Figure 35. Binary Bottom-Track Data Format

This data is output only if the BP-command is > 0 and PD0 is selected. See Table 40 for a description of the fields.

The PD0 output data format assumes that the instrument is stationary and the bottom is moving. Pathfinder (Speed Log) output data formats (see Special Output Data Formats) assume that the bottom is stationary and that the Pathfinder or vessel is moving.

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

Table 40: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (MSB=06h LSB=00h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP – Bottom-Track Pings per Ensemble). If BP = 0, the Pathfinder does not collect bottom-track data. The Pathfinder automatically extends the ensemble interval (TE – Time Per Ensemble) if BP x TP > TE. Scaling: LSD = 1 ping; Range = 1 to 999 pings
9-12	5,6	Reserved	Reserved
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC - Correlation Magnitude Minimum). Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA - Evaluation Amplitude Minimum). Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	Reserved	Reserved
19,20	10	BM/BT Mode	Stores the bottom-tracking mode.

Table 40: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE - Error Velocity Maximum). 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 Pathfinder 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 coordinate system command setting (EX – Coordinate Transformation). For more information on coordinate transformations, see Beam Coordinate Systems, page 29. 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, Mast, Error d) Earth Coordinates: East, North, Upward, Error Scaling: LSD = 1 mm/s; Range = -10,000mm/s to +10,000mm/s
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.
73-80	37-40	BTEA/Beam #1-4 BT Eval Amp	Contains the evaluation amplitude of the matching filter used in determining the strength of the bottom echo. 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 Pathfinder'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 bottom track water-reference layer (BL - Water-Mass Layer Parameters). Scaling (minimum layer size): LSD = 1 dm; Range = 1-999 dm Scaling (near/far boundaries): LSD = 1 dm; Range = 6-9999 dm
101- 116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water mass for each beam. Water mass velocities have the same format and scale factor as water-profiling velocities (Table 35). The BL-command explains the water mass.

Table 40: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
117- 124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water mass for each beam. Water mass correlation magnitudes have the same format and scale factor as water-profiling magnitudes.
125- 132	63-66	RLEI/Bm #1-4 Ref Int	Contains echo intensity data for the Water mass for each beam. Water mass 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 mass for each beam. They indicate the reliability of water mass data. It is the percentage of bottom-track pings that have passed a water mass 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 – Maximum Tracking Depth). Scaling: LSD = 1 decimeter; Range = 10 to 65535 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 ≈ 0.61 dB per count; Range = 0 to 255 counts
153, 154	77	GAIN	Contains the Gain level for shallow water. See WJ - Receiver Gain Select.
155-162	78-81	BT Range MSB/Bm #1-4	Contains the most significant byte of the vertical range from the Pathfinder 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

Environmental Command Parameters Output Format

<table>
<tr><th rowspan="2">BYTE</th><th colspan="8">BIT POSITIONS</th><th rowspan="2"></th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td colspan="8" rowspan="2">FIXED ATTITUDE ID</td><td>LSB 00h</td></tr>
<tr><td>2</td><td>MSB 30h</td></tr>
<tr><td>3</td><td colspan="8" rowspan="8">ATTITUDE OUTPUT COORDINATES and
PROCESSING CONTROL USING INTERPOLATED ATTITUDE
(#EE)</td><td></td></tr>
<tr><td>4</td><td></td></tr>
<tr><td>5</td><td></td></tr>
<tr><td>6</td><td></td></tr>
<tr><td>7</td><td></td></tr>
<tr><td>8</td><td></td></tr>
<tr><td>9</td><td></td></tr>
<tr><td>10</td><td></td></tr>
<tr><td>11</td><td colspan="8">RESERVED</td><td></td></tr>
<tr><td>12</td><td colspan="8" rowspan="2">FIXED HEADING SCALING (#EH)</td><td></td></tr>
<tr><td>13</td><td></td></tr>
<tr><td>14</td><td colspan="8">FIXED HEADING COORDINATE FRAME (#EH)</td><td></td></tr>
<tr><td>15</td><td colspan="8" rowspan="2">ROLL MISALIGNMENT (#EI)</td><td></td></tr>
<tr><td>16</td><td></td></tr>
<tr><td>17</td><td colspan="8" rowspan="2">PITCH MISALIGNMENT (#EJ)</td><td></td></tr>
<tr><td>18</td><td></td></tr>
<tr><td>19</td><td colspan="8" rowspan="5">USER INPUT FOR PITCH, ROLL, and COORDINATE FRAME (#EP)</td><td></td></tr>
<tr><td>20</td><td></td></tr>
<tr><td>21</td><td></td></tr>
<tr><td>22</td><td></td></tr>
<tr><td>23</td><td></td></tr>
<tr><td>24</td><td colspan="8">USER INPUT FOR UP/DOWN ORIENTATION (#EU)</td><td></td></tr>
<tr><td>25</td><td colspan="8" rowspan="2">USER INPUT FOR
HEADING BIAS/VARIATION/SYNCHRO OFFSET (#EV)</td><td></td></tr>
<tr><td>26</td><td></td></tr>
<tr><td>27</td><td colspan="8" rowspan="3">SENSOR SOURCE (EZ)</td><td></td></tr>
<tr><td>↓</td><td>↓</td></tr>
<tr><td>34</td><td></td></tr>
<tr><td>35</td><td colspan="8" rowspan="4">TRANSDUCER DEPTH (ED)</td><td></td></tr>
<tr><td>36</td><td></td></tr>
<tr><td>37</td><td></td></tr>
<tr><td>38</td><td></td></tr>
</table>

BYTE	7	6	5	4	3	2	1	0
39	SALINITY (ES)							
40	WATER TEMPERATURE (ET)							
41								
42	SPEED OF SOUND (EC)							
43								
44	COORDINATE TRANSFORMATION (EX)							
45	3 BEAM SOLUTION (EX)							
46	BIN MAP (EX)							
47	MSB COORDINATE TRANSFORMATION (EX)							

Figure 36. Environmental Command Parameters Output Format

Environmental Command Parameters correspond to the most useful "E" menu command parameters. The Pathfinder will output Fixed Attitude data as output data (LSBs first). See Command Descriptions for detailed descriptions of commands used to set these values.

Table 41: Environmental Command Parameters Output Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FAID / Fixed Attitude ID	Environmental Command Parameters Output word (MSB=30h, LSB=00h).
5-20	3-10	Attitude Output Coordinates	Stores the setting of the #EE command; a user input for the Variable Attitude data to be output (EE - Environmental Data Output).
21,22	11	Reserved	
23-27	12-13	Fixed Heading Scaling	Stores the setting of the #EH command; a user input for heading (EH - Heading).
28	14	Fixed Heading Coordinate Frame	Stores the setting of the #EH command coordinate frame: 1 is ship, 0 is instrument (EH - Heading).
29-32	15,16	Roll Misalignment	Stores the setting of the #EI command; a user input for the roll misalignment (EI - Roll Misalignment Angle).
33-36	17,18	Pitch Misalignment	Stores the setting of the #EJ command; a user input for the pitch misalignment (EJ - Pitch Misalignment Angle).
37-46	19-23	Pitch, Roll and Coordinate Frame	Stores the setting of the #EP command; a user input for the pitch, roll, and coordinate (instrument or ship) frame (EP - Pitch and Roll Angles).
47,48	24	Orientation	Stores the setting of the #EU command; a user input for the up/down orientation (EU - Up/Down Orientation).
49-52	25,26	Heading Offset	Stores the setting of the #EV command; a user input for the heading offset due to heading bias, variation, or synchro initialization (EV - Heading Bias).

Table 41: Environmental Command Parameters Output Format

Hex Digit	Binary Byte	Field	Description
53-68	27-34	Sensor Source	Stores the setting of the EZ command; a user input defining the use of internal, external, or fixed sensors (EZ - Sensor Source).
69-76	35-38	Transducer Depth	Stores the setting of the ED command; a user input defining depth of the transducer (see ED - Depth of Transducer).
77-78	39	Salinity	Stores the setting of the ES command; a user input defining the salinity of the water (see ES – Salinity).
79-82	40,41	Water Temp	Stores the setting of the ET command; a user input defining the temperature of the water (see ET - Temperature).
83-86	42,43	SoS	Stores the setting of the EC command; a user input defining the speed of sound (see EC - Speed of Sound).
87-88	44	Transform	Stores the setting of the right two digits of the EX command that describe the coordinate transformations (see EX – Coordinate Transformation).
89-90	45	3 Beam Solution	Stores the setting of the fourth bit of the EX command that allows 3 beams good (instead of 4) transformations.
91-92	46	Bin Map	Stores the setting of the fifth bit of the EX command that controls bin mapping.
93-94	47	MSB of EX transformation	Stores the setting of the left digit of the EX command that describes the coordinate transformations.

Bottom Track Command Output Format

BYTE	BIT POSITIONS 7 6 5 4 3 2 1 0	
1. 2.	BOTTOM TRACK COMMAND ID	LSB 00h MSB 58h
3.	AMPLITUDE THRESHOLD	
4.	CORRELATION MAGNITUDE	
5. 6.	RESERVED	
7. 8.	ERROR VELOCITY MAXIMUM	
9. 10.	DEPTH GUESS	
11.	RESERVED	
12.	GAIN SWITCH THRESHOLD LOW	
13.	GAIN SWITCH THRESHOLD HIGH	

<table>
<tr><th rowspan="2">BYTE</th><th colspan="8">BIT POSITIONS</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>14.</td><td colspan="8" rowspan="2">GAIN SWITCH ALTITUDE</td></tr>
<tr><td>15.</td></tr>
<tr><td>16.</td><td colspan="8">WATER MASS LAYER MODE</td></tr>
<tr><td>17.</td><td colspan="8" rowspan="2">WATER MASS LAYER MIN SIZE</td></tr>
<tr><td>18.</td></tr>
<tr><td>19.</td><td colspan="8" rowspan="2">WATER MASS LAYER NEAR BOUNDARY</td></tr>
<tr><td>20.</td></tr>
<tr><td>21.</td><td colspan="8" rowspan="2">WATER MASS LAYER FAR BOUNDARY</td></tr>
<tr><td>22.</td></tr>
<tr><td>23.</td><td colspan="8">BOTTOM TRACK MODE</td></tr>
<tr><td>24.</td><td colspan="8">SPEED LOG HOLD TRACK</td></tr>
<tr><td>25.</td><td colspan="8" rowspan="2">SPEED LOG TIME-OUT</td></tr>
<tr><td>26.</td></tr>
<tr><td>27.</td><td colspan="8">SPEED LOG FILTER TIME CONSTANT</td></tr>
<tr><td>28.</td><td colspan="8" rowspan="2">PINGS PER ENSEMBLE</td></tr>
<tr><td>29.</td></tr>
<tr><td>30.</td><td colspan="8" rowspan="7">RESERVED</td></tr>
<tr><td>31.</td></tr>
<tr><td>32.</td></tr>
<tr><td>33.</td></tr>
<tr><td>34.</td></tr>
<tr><td>35.</td></tr>
<tr><td>36.</td></tr>
<tr><td>37.</td><td colspan="8" rowspan="2">BT MAXIMUM TRACKING DEPTH</td></tr>
<tr><td>38.</td></tr>
<tr><td>39.</td><td colspan="8" rowspan="2">RESERVED</td></tr>
<tr><td>40.</td></tr>
<tr><td>41.</td><td colspan="8">TRANSMIT LENGTH</td></tr>
<tr><td>42.</td><td colspan="8" rowspan="2">RESERVED</td></tr>
<tr><td>43.</td></tr>
</table>

Figure 37. Bottom Track Command Output Data Format

This format is selected via the #BJ command (see BJ – Data Type Output Control).

Table 42. Bottom Track Command Output Data Format

Binary Byte	Field	Description
1-2	ID	Stores the bottom-track command identification word (MSB=58h LSB=00h)
3	Evaluation Amplitude	Stores the setting of the BA command; Units are 1 to 255 counts (see #BA – Evaluation Amplitude Minimum)
4	Correlation Magnitude	Stores the setting of the BC command; Units are 0 to 255 counts (see #BC – Correlation Magnitude Minimum)
5-6	Reserved	Reserved
7-8	Error Velocity Maximum	Stores the setting of the BE command; Units are 0 to 9999 mm/s (see #BE – Error Velocity Maximum)
9-10	Depth Guess	Stores the setting of the BF command; Units are 1 to 65535 dm (0 for automatic search) (see #BF – Depth Guess)
11	Reserved	Reserved
12	Gain Threshold Low	Stores the setting of the #BH command low threshold; Units are 0 to 255 counts (see #BH – Gain Switch Threshold)
13	Gain Threshold High	Stores the setting of the #BH command high threshold; Units are 0 to 255 counts (see #BH – Gain Switch Threshold)
14-15	Gain Switch Altitude	Stores the setting of the #BI command; Units are 0 to 25 meters (300 kHz), 0 to 3 meters (600 kHz) (see #BI – Gain Switch Altitude)
16	Water Mass Layer Mode	Stores the setting of the #BK command; Setting are 0 to 3 [0=off, 1=WB, 2=LostB, 3=W] (see #BK – Water-Mass Layer Mode)
17-18	Water Mass Layer Min Size	Stores the setting of the #BL command; Setting are 1 to 999 dm (see #BL – Water-Mass Layer Parameters)
19-20	Water Mass Layer Near Boundary	Stores the setting of the #BL command; Setting are 6 to 9999 dm (see #BL – Water-Mass Layer Parameters)
21-22	Water Mass Layer Far Boundary	Stores the setting of the #BL command; Setting are 7 to 9999 dm (see #BL – Water-Mass Layer Parameters)
23	Bottom Track Mode	Stores the setting of the #BM command; Setting are 8 or 9 (see #BM – Bottom Mode)
24	Speed Log Hold	Stores the setting of the #BN command; Hold Distance or zero if timeout (see #BN – Speed Log Hold/Drop Control)
25-26	Speed Log Drop Control	Stores the setting of the #BN command; Speed log time-out units in 0 to 999 seconds (see #BN – Speed Log Hold/Drop Control)
27	Speed Log Time Constant	Stores the setting of the #BO command; Settings are 0 to 100 (see #BO – Distance Measure Filter Constant)
28-29	Pings Per Ensemble	Stores the setting of the BP command; Setting are 0 to 999 pings (see BP – Bottom-Track Pings per Ensemble)
30 - 36	Reserved	Reserved

Table 42. Bottom Track Command Output Data Format

Binary Byte	Field	Description
37-38	Maximum Tracking Depth	Stores the setting of the BX command; Setting are 10 to 65535 dm (see BX – Maximum Tracking Depth)
39 - 40	Reserved	Reserved
41	Transmit Length	Stores the setting of the #BY command; Setting are 0 to 100% (see #BY – Transmit Length)
42-43	Reserved	Reserved

Bottom Track High Resolution Velocity Format

BYTE	BIT POSITIONS 7 6 5 4 3 2 1 0	
1.	BOTTOM TRACK HIGH RESOLUTION VELOCITY ID	LSB 03h
2.		MSB 58h
3.	BT VELOCITY 1	
4.		
5.		
6.		
7.	BT VELOCITY 2	
8.		
9.		
10.		
11.	BT VELOCITY 3	
12.		
13.		
14.		
15.	BT VELOCITY 4	
16.		
17.		
18.		
19.	BT DISTANCE MADE GOOD 1	
20.		
21.		
22.		

BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0
23.	BT DISTANCE MADE GOOD 2							
24.								
25.								
26.								
27.	BT DISTANCE MADE GOOD 3							
28.								
29.								
30.								
31.	BT DISTANCE MADE GOOD 4							
32.								
33.								
34.								
35.	WATER MASS VELOCITY 1							
36.								
37.								
38.								
39.	WATER MASS VELOCITY 2							
40.								
41.								
42.								
43.	WATER MASS VELOCITY 3							
44.								
45.								
46.								
47.	WATER MASS VELOCITY 4							
48.								
49.								
50.								
51.	WATER MASS DISTANCE MADE GOOD 1							
52.								
53.								
54.								

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0
55.	WATER MASS DISTANCE MADE GOOD 2							
56.								
57.								
58.								
59.	WATER MASS DISTANCE MADE GOOD 3							
60.								
61.								
62.								
63.	WATER MASS DISTANCE MADE GOOD 4							
64.								
65.								
66.								
67.	SPEED OF SOUND							
68.								
69.								
70.								

Figure 38. Bottom Track High Resolution Velocity Output Format

The sign of the bottom track and water mass layer velocities in the Bottom Track High Resolution Velocity Format indicate the direction the DVL or vessel is moving with respect to a stationary bottom and is the opposite sign of the velocities in the Binary Bottom Track Data Format.

This format is selected via the #BJ command (see BJ – Data Type Output Control).

Table 43: Bottom Track High Resolution Velocity Output Format

Binary Byte	Field	Description
1-2	ID	PD0 ID (MSB=58h LSB=03h)
3-6	BT Velocity 1	Bottom Track Axis 1 Velocity in 0.01mm/s. Reference frame dependent on EX – Coordinate Transformation.
7-10	BT Velocity 2	Bottom Track Axis 2 Velocity in 0.01mm/s. Reference frame dependent on EX command.
11-14	BT Velocity 3	Bottom Track Axis 3 Velocity in 0.01mm/s. Reference frame dependent on EX command.
15-18	BT Velocity 4	Bottom Track Axis 4 Velocity in 0.01mm/s. Reference frame dependent on EX command.

Table 43: Bottom Track High Resolution Velocity Output Format

Binary Byte	Field	Description
19-22	BT DMG 1	Bottom Track Axis 1 Distance in 0.01mm made good. Reference frame dependent on EX command.
23-26	BT DMG 2	Bottom Track Axis 2 Distance in 0.01mm made good. Reference frame dependent on EX command.
27-30	BT DMG 3	Bottom Track Axis 3 Distance in 0.01mm made good. Reference frame dependent on EX command.
31-34	BT DMG 4	Bottom Track Axis 4 Distance in 0.01mm made good. Reference frame dependent on EX command.
35-38	WM Velocity 1	Water Mass Axis 1 Velocity in 0.01mm/s. Reference frame dependent on EX command.
39-42	WM Velocity 2	Water Mass Axis 2 Velocity in 0.01mm/s. Reference frame dependent on EX command.
43-46	WM Velocity 3	Water Mass Axis 3 Velocity in 0.01mm/s. Reference frame dependent on EX command.
47-50	WM Velocity 4	Water Mass Axis 4 Velocity in 0.01mm/s. Reference frame dependent on EX command.
51-54	WM DMG 1	Water Mass Axis 1 Distance in 0.01mm made good. Reference frame dependent on EX command.
55-58	WM DMG 2	Water Mass Axis 2 Distance in 0.01mm made good. Reference frame dependent on EX command.
59-62	WM DMG 3	Water Mass Axis 3 Distance in 0.01mm made good. Reference frame dependent on EX command.
63-66	WM DMG 4	Water Mass Axis 4 Distance in 0.01mm made good. Reference frame dependent on EX command.
67-70	SoS	Speed of Sound * 10^6.

Bottom Track Range Format

BYTE	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK RANGE ID								LSB 04h
2.									MSB 58h
3.	Slant Range								
4.									
5.									
6.									
7.	Axis Delta Range								
8.									
9.									
10.									
11.	Vertical Range								
12.									
13.									
14.									
15.	% Good 4 Bm								
16.	% Good Bm 1&2								
17.	% Good Bm 3 & 4								
18.	BEAM 1 Raw Range								
19.									
20.									
21.									
22.	BEAM 2 Raw Range								
23.									
24.									
25.									
26.	BEAM 3 Raw Range								
27.									
28.									
29.									

BYTE	7	6	5	4	3	2	1	0
30.	BEAM 4 Raw Range							
31.								
32.								
33.								
34.	BEAM 1 Raw Max BT Filter							
35.	BEAM 2 Raw Max BT Filter							
36.	BEAM 3 Raw Max BT Filter							
37.	BEAM 4 Raw Max BT Filter							
38.	BEAM 1 RAW MAX BT AMPLITUDE							
39.	BEAM 2 RAW MAX BT AMPLITUDE							
40.	BEAM 3 RAW MAX BT AMPLITUDE							
41.	BEAM 4 RAW MAX BT AMPLITUDE							

Figure 39. Bottom Track Range Output Data Format

This data type is output when selecting PD0 and the High Accuracy Bottom Track feature is installed (see OL – Display Feature List) and then selected via the #BJ command (see BJ – Data Type Output Control).

Table 44: Bottom Track Range Output Data Format

Binary Bytes	Field	Description
1-2	ID	PD0 ID (MSB=58h LSB=04h)
3-6	Slant Range	Average range to bottom along the Z axis of the instrument frame, averaged over the ensemble. Valid only for at least 2 beams good on axis; zero is output for invalid data. Units are 0.1mm.
7-10	Axis Delta Range	Difference in slant range between beam 1 & 2 estimate and beam 3 & 4 estimate averaged over the ensemble. Valid only for 4 beam good pings. Units are 0.1mm.
11-14	Vertical Range	Average vertical range (altitude) of bottom depth (accounting for instrument tilt) over the ensemble. Zero is output if vertical range cannot be calculated because less than three beams are good, etc. Units are 0.1mm.
15	% Good 4 Bm	Percent Good 2 axis (4 Bm) slant range solutions.
16	% Good Bm 1&2	Percent Good axis Bm 1 & 2 slant range solutions.
17	% Good Bm 3 & 4	Percent Good axis Bm 3 & 4 slant range solutions.
18-21	BM 1 Raw Range	Slant range to the bottom along beam 1 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm

Table 44: Bottom Track Range Output Data Format

Binary Bytes	Field	Description
22-25	BM 2 Raw Range	Slant range to the bottom along beam 2 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
26-29	BM 3 Raw Range	Slant range to the bottom along beam 3 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
30-33	BM 4 Raw Range	Slant range to the bottom along beam [n] multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
34	BM 1 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 1 even if less than 3 beams detecting bottom.
35	BM 2 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 2 even if less than 3 beams detecting bottom.
36	BM 3 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 3 even if less than 3 beams detecting bottom.
37	BM 4 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 4 even if less than 3 beams detecting bottom.
38	BM 1 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 1 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
39	BM 2 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 2 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
40	BM 3 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 3 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
41	BM 4 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 4 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.

Navigation Parameters Data Format

BYTE	7	6	5	4	3	2	1	0	
1	ID_NAV_PARAMS								LSB 13h
2									MSB 20h
3	TIME-TO-BOTTOM BEAM 1								LSB
4									
5									
6									MSB
7	TIME-TO-BOTTOM BEAM 2								LSB
8									
9									
10									MSB
11	TIME-TO-BOTTOM BEAM 3								LSB
12									
13									
14									MSB
15	TIME-TO-BOTTOM BEAM 4								LSB
16									
17									
18									MSB
19	BOTTOM TRACK STANDARD DEVIATION BEAM 1								LSB
20									MSB
21	BOTTOM TRACK STANDARD DEVIATION BEAM 2								LSB
22									MSB
23	BOTTOM TRACK STANDARD DEVIATION BEAM 3								LSB
24									MSB
25	BOTTOM TRACK STANDARD DEVIATION BEAM 4								LSB
26									MSB
27	SHALLOW OPERATION FLAG								
28	TIME-TO-WATER MASS LAYER BEAM 1								LSB
29									
30									
31									MSB

BYTE	7	6	5	4	3	2	1	0	
32	TIME-TO-WATER MASS LAYER BEAM 2								LSB
33									
34									
35									MSB
36	TIME-TO-WATER MASS LAYER BEAM 3								LSB
37									
38									
39									MSB
40	TIME-TO-WATER MASS LAYER BEAM 4								LSB
41									
42									
43									MSB
44	RANGE TO WATER MASS CELL								LSB
45									MSB
46	WATER TRACK STANDARD DEVIATION BEAM 1								LSB
47									MSB
48	WATER TRACK STANDARD DEVIATION BEAM 2								LSB
49									MSB
50	WATER TRACK STANDARD DEVIATION BEAM 3								LSB
51									MSB
52	WATER TRACK STANDARD DEVIATION BEAM 4								LSB
53									MSB
54	BOTTOM TRACK TIME-OF-VALIDITY BEAM 1								LSB
55									
56									
57									MSB
58	BOTTOM TRACK TIME-OF-VALIDITY BEAM 2								LSB
59									
60									
61									MSB

<table>
<tr><th colspan="10">BIT POSITIONS</th></tr>
<tr><th>BYTE</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th></th></tr>
<tr><td>62</td><td colspan="8" rowspan="4">BOTTOM TRACK TIME-OF-VALIDITY BEAM 3</td><td>LSB</td></tr>
<tr><td>63</td><td></td></tr>
<tr><td>64</td><td></td></tr>
<tr><td>65</td><td>MSB</td></tr>
<tr><td>66</td><td colspan="8" rowspan="4">BOTTOM TRACK TIME-OF-VALIDITY BEAM 4</td><td>LSB</td></tr>
<tr><td>67</td><td></td></tr>
<tr><td>68</td><td></td></tr>
<tr><td>69</td><td>MSB</td></tr>
<tr><td>70</td><td colspan="8" rowspan="4">WATER TRACK TIME-OF-VALIDITY BEAM 1</td><td>LSB</td></tr>
<tr><td>71</td><td></td></tr>
<tr><td>72</td><td></td></tr>
<tr><td>73</td><td>MSB</td></tr>
<tr><td>74</td><td colspan="8" rowspan="4">WATER TRACK TIME-OF-VALIDITY BEAM 2</td><td>LSB</td></tr>
<tr><td>75</td><td></td></tr>
<tr><td>76</td><td></td></tr>
<tr><td>77</td><td>MSB</td></tr>
<tr><td>78</td><td colspan="8" rowspan="4">WATER TRACK TIME-OF-VALIDITY BEAM 3</td><td>LSB</td></tr>
<tr><td>79</td><td></td></tr>
<tr><td>80</td><td></td></tr>
<tr><td>81</td><td>MSB</td></tr>
<tr><td>82</td><td colspan="8" rowspan="4">WATER TRACK TIME-OF-VALIDITY BEAM 4</td><td>LSB</td></tr>
<tr><td>83</td><td></td></tr>
<tr><td>84</td><td></td></tr>
<tr><td>85</td><td>MSB</td></tr>
</table>

Figure 40. Navigation Parameters Data Format

This data type is output when selecting PD0 and the High Accuracy Bottom Track feature is installed (see OL – Display Feature List) and then selected via the #BJ command (see BJ – Data Type Output Control).

Table 45. Navigation Parameters Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1, 2	ID_NAV_PARAMS / Navigation Parameters ID	Stores the navigation parameters identification word, ID_NAV_PARAMS, (MSB=20h LSB=13h)
5-36	3-18	TIME-TO-BOTTOM BEAMS 1-4	Stores T_{bot}, the time interval between the DVL Ensemble/hardware trigger and the center time, or “time the ping hits the bottom,” of the bottom track measurement for Beams 1-4 (see Figure 41 and Figure 42). Unit is 8 carrier cycles (52.08 μs for 153.6 kHz). Unsigned integer.

DVL Type	Frequency	Carrier Cycle	8 x Carrier Cycles
600	614.4 KHz	1.628 uSec	13.02 uSec
300	307.2 KHz	3.255 uSec	26.04 uSec
150	153.6 KHz	6.510 uSec	52.08 uSec

Hex Digit	Binary Byte	Field	Description
37-52	19-26	BOTTOM TRACK STD DEVIATION BEAMS 1-4	Stores a prediction of the single ping bottom-track standard deviation calculated with the velocity variance model. Units are mm/sec.
53	27	SHALLOW OPERATION FLAG	Stores the flag indicating whether the Pathfinder is operating in shallow mode or not. If this value is set to 1, then the Pathfinder is operating in shallow mode with one beam pinging at a time. If this value is 0, then the Pathfinder is operating in Deep Mode with all beams pinging at the same time.
54-86	28-43	TIME-TO-WATER MASS BEAMS 1-4	Stores T_{wm}, the time interval between the hardware trigger (defined by the CX command) and the center time, or “time the ping hits the center of the water mass layer,” of the water mass measurement for Beams 1-4. Unit is 8 carrier cycles (52.08 μs for 153.6 kHz). Unsigned integer.
87-90	44-45	RANGE TO WATER MASS CELL	The range to the water mass cell being tracked. Units are in carrier cycles (6.51μs for 153.6 kHz).
91-106	46-53	WATER TRACK STD DEVIATION BEAMS 1-4	Stores a prediction of the single ping water-track standard deviation calculated with the velocity variance model. Units are mm/sec.
107-138	54-69	BOTTOM TRACK TIME-OF-VALIDITY BEAMS 1-4	Stores the time elapsed between when the bottom track echo is centered on the bottom and the first character in the PD0 sentence. Unit is 1µsec. Accuracy is within ± 5msec. Unsigned integer. Note the value will be set to zero if the bottom track velocity for the corresponding beam is bad.

Table 45. Navigation Parameters Data Format

Hex Digit	Binary Byte	Field	Description
139-170	70-85	WATER TRACK TIME-OF-VALIDITY BEAMS 1-4	Stores the time elapsed between when the water mass layer echo is centered on the tracking bin and the first character in the PD0 sentence. Unit is 1µsec. Accuracy is within ± 5msec. Unsigned integer. Note the value will be set to zero if the bottom track velocity for the corresponding beam is bad.

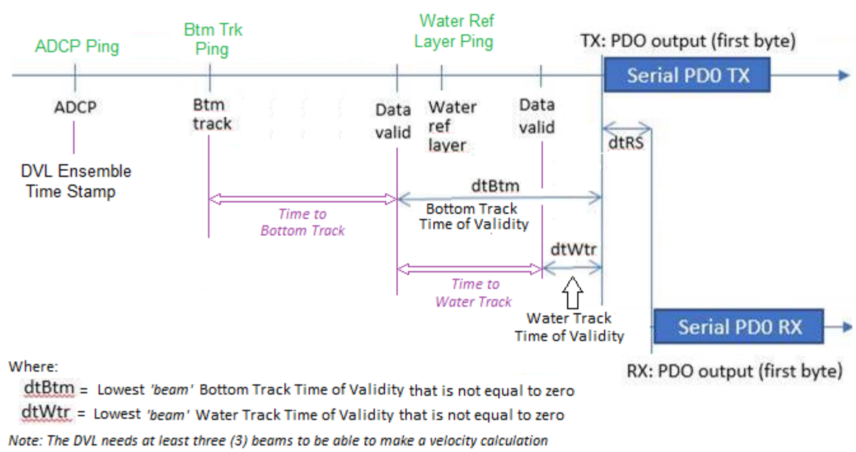

Figure 41. No Trigger Timing

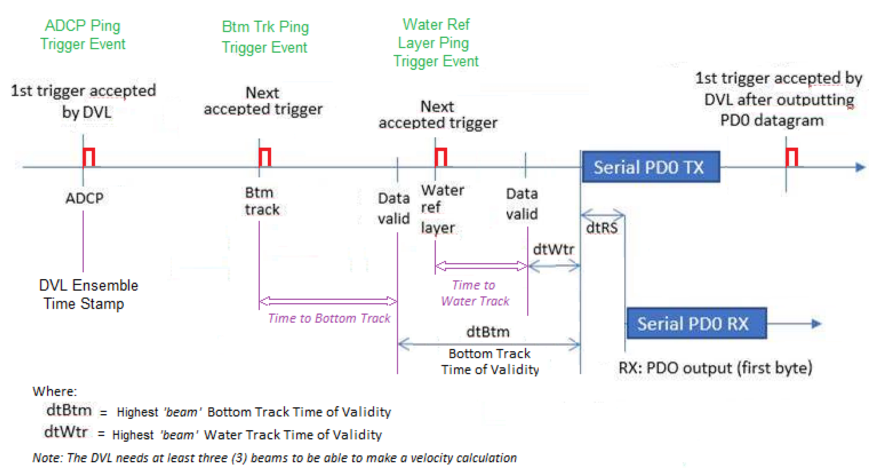

Figure 42. External Trigger Timing

Sensor Source for Doppler Processing Format

BYTE	7	6	5	4	3	2	1	0	
1.	SENSOR SOURCE FOR DOPPLER PROCESSING FORMAT ID								01h LSB
2.									30h MSB
3.	HEADING								
4.									
5.									
6.									
7.	HEADING STATUS								
8.	HEADING SOURCE								
9.									
10.	PITCH								
11.									
12.									
13.									
14.	PITCH STATUS								
15.	PITCH SOURCE								
16.									
17.	ROLL								
18.									
19.									
20.									
21.	ROLL STATUS								
22.	ROLL SOURCE								
23.									
24.	SOS								
25.									
26.									
27.									
28.	SOS STATUS								
29.	SOS SOURCE								
30.									
31.	TEMPERATURE								

	BIT POSITIONS							
BYTE	7	6	5	4	3	2	1	0
32.								
33.								
34.								
35.	TEMPERATURE STATUS							
36.	TEMPERATURE SOURCE							
37.								
38.	SALINITY							
39.								
40.								
41.								
42.	SALINITY STATUS							
43.	SALINITY SOURCE							
44.								
45.	DEPTH							
46.								
47.								
48.								
49.	DEPTH STATUS							
50.	DEPTH SOURCE							
51.								
52.	PRESSURE							
53.								
54.								
55.								
56.	PRESSURE STATUS							
57.	PRESSURE SOURCE							
58.								
59.	ENSEMBLE TIMER TICKS							
60.								
61.								
62.								

Figure 43. Sensor Source for Doppler Processing Output Format

This format is selected via the #EE command (see EE - Environmental Data Output).

Table 46: Sensor Source for Doppler Processing Output Format

Binary Bytes	Field	Description
1-2	ID	PD0 ID (MSB=30h LSB=01h)
3-6	Heading	Heading in 1/100ths of a degree.
7	Heading Status	A value of 0 indicates no valid data; 1 indicates sensor data valid from sensor specified by EZ - Sensor Source; A value of 2 indicates sensor data valid from alternate sensor or user input.
8-9	Heading Source	See notes, below.
10-13	Pitch	Pitch in 1/100ths of a degree.
14	Pitch Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
15-16	Pitch Source	See notes, below.
17-20	Roll	Roll in 1/100ths of a degree.
21	Roll Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
22-23	Roll Source	See notes, below.
24-27	SOS	Speed of Sound 1/100ths of a m/s.
28	SOS Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
29-30	SOS Source	See notes, below.
31-34	Temperature	Temperature in 1/100ths of a °C.
35	Temperature Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
36-37	Temperature Source	See notes, below.
38-41	Salinity	Salinity in parts-per-ten thousand
42	Salinity Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
43-44	Salinity Source	See notes, below.
45-48	Depth	Depth in centimeters
49	Depth Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.

Table 46: Sensor Source for Doppler Processing Output Format

Binary Bytes	Field	Description
50-51	Depth Source	See notes, below.
52-55	Pressure	Pressure in kPa.
56	Pressure Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
57-58	Pressure Source	See notes, below.
59-62	Ensemble Timer Ticks	Timer Ticks Recorded when the RTC clock was read at the start of the ensemble. Intended for use in matching sensor TimeTags to RTC based ensemble time.

This data corresponds to the last ping of the ensemble for those sensors sampled at ping intervals. It is intended for single ping ensembles.

Output of this data is controlled by the 7th bit of the EE command (EE - Environmental Data Output).

The sensor source is identified by the detailed list of sensors in the table of the main text or the #EY description (EY – Sensor Source Override for Doppler Parameters). In addition to the sensors in that command, a sensor ID of -1 indicates that the parameter has been calculated based on other parameters (for example, speed of sound calculated based on salinity, pressure and temperature). A sensor ID of 0 indicates the parameter is from a user input command.

Binary Checksum Data Format

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

Figure 44. Binary Checksum Data Format

Table 47: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65536 checksum. If the sum is 12345678, then it is divided by 65536, and the remainder is output; For example, 12345678 / 65536 = 188.3800964 = 188 + 24910/65536, so the number 24910, converted to hex as 614E would be output. An easier way to compute the checksum is using the sum 12345678; converted to hex it is the number 00BC614E. The least-significant four hex digits are output; i.e. 614E.