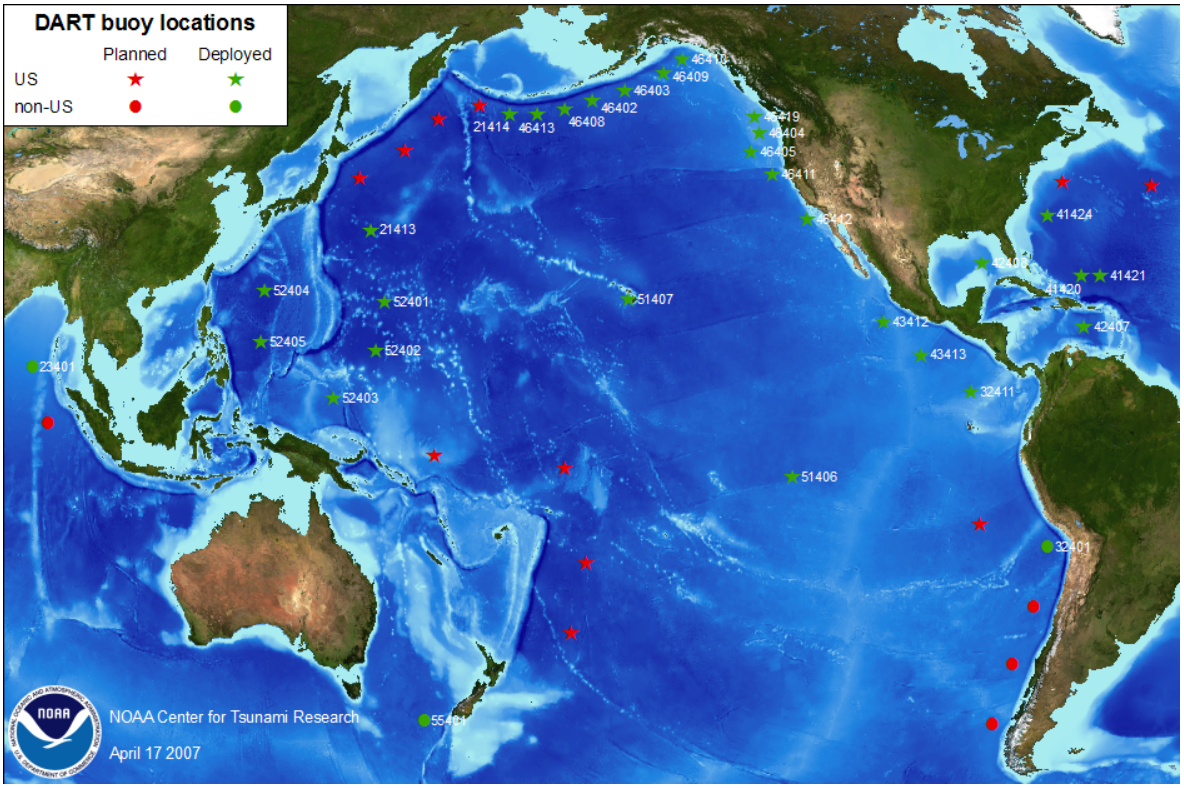
Description of Real-time DART System Messages



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1. System Overview

The Deep-ocean Assessment and Reporting of Tsunamis (DART) real-time tsunami buoy system is comprised of two parts – the Bottom Pressure Recorder (BPR) and the accompanying surface buoy with its related electronics. The BPR resides on the ocean bottom and monitors water pressure with a resolution of approximately 1 mm seawater. Samples integrated over a 15-second time window are recorded internally by the BPR and provide the base sampling interval for all real-time transmissions. Data are transmitted from the BPR to the surface buoy via an acoustic modem which in turn transmits the data to ground systems via Iridium satellites.

All Tsunami data use a simple data compression scheme. The first data value in each message is the full water column height in millimeters of seawater. All following values in a message are signed 16-bit deviations from the full value height in millimeters of seawater.

1.1. Standard Reporting

Under normal conditions (no event), the BPR reports data on a six-hour transmission schedule. Six, hourly messages, of four 15-second observations at 15-minute intervals each, are reported in these transmission blocks. Data transmission is typically successful after one attempt but the BPR will try a maximum of three times until it receives acknowledgement from the surface buoy. The surface buoy transmits a position message once each day.

1.2. Event Reporting

An algorithm running in the Bottom Pressure Recorder (BPR) generates predicted water height values and compares all new samples with predicted values. (A complete description of this algorithm can be found at http://www.pmel.noaa.gov/tsunami/tda_documentation.html). If two 15-second water level values exceed the predicted pre-set threshold, a software flag is raised and the system goes into Event Mode. Data are then transmitted for a minimum period of 3 hours. During this time, four minutes of 15-second observations are reported followed by 1-minute averages for the remainder of Event Mode. Every transmission includes the time at T=0, defined to be the time at which the second out-of-bound value was detected, or the 'trigger time.' Every Event Mode message also includes an ID that identifies the type of data and the time of the data in the message as minutes after T=0 as shown in the table. When the time of the hourly self-timed transmission occurs during a Event Mode, the BPR will send one-minute data (averages of four 15 second values) for the preceding two hours (120 values). If the ocean is still perturbed after the nominal 3 hours of the Event Mode, the hourly self-timed transmissions of 120 one minute averaged values will continue. The system returns to normal or 'standard' mode only after 3 hours of undisturbed water heights.

2. Message Types

2.1. D$0 Position

2.1.1. Description

Position messages are transmitted once per day, giving the location of the surface buoy.

2.1.2. Message Breakdown

“D$0 NS Date Time lat_deg lat_min N/S lon_deg lon_min E/W * checksum”

<cr> = 0x0D
<cr>D$0 = message ID
C/I = message status; C=corrupted, I=Intact
Date = mm/dd/yyyy
Time [UTC] = hr:mn:se
Lat_deg = latitude of buoy, degrees
Lat_min = latitude of buoy, decimal minutes
N/S = North or South
Lon_deg = longitude of buoy, degrees
Lon_min = longitude of buoy, decimal minutes
E/W = East or West
* = checksum delimiter
checksum = exclusive OR of all characters preceding "*", hexadecimal

2.1.3. Example Message

D$0 11/15/2006 13:05:28 3214.2972 N 12041.3991 W* 46

2.2 D$1 Standard Hourly

2.2.1.Description

Standard hourly data messages are transmitted four times a day in six, one-hour bundles.

Data are 15-sec samples at the following times and integrated over periods in brackets:
ht1= 15min 00sec (15-second sample integrated over xx:14:45 – xx:15:00)
ht2= 30min 00sec (15-second sample integrated over xx:29:45 – xx:30:00)
ht3= 45min 00sec (15-second sample integrated over xx:44:45 – xx:45:00)
ht4= 00min 00sec (15-second sample integrated over xx:59:45 – xx+1:00:00)

ht1 … ht4 are converted from units of pressure [psia] to units of height [millimeters] prior to real-time transmission using the conversion factor 670 mm/psia

2.2.2.Message Breakdown

"<cr>D$1C/I Date Time batv1 batv2 batv3 ht1 ht2 ht3 ht4 tries * checksum"
"<cr>D$1C/I Date Time batv1 batv2 batv3 ht1 ht2 ht3 ht4 tries * checksum"
"<cr>D$1C/I Date Time batv1 batv2 batv3 ht1 ht2 ht3 ht4 tries * checksum"
"<cr>D$1C/I Date Time batv1 batv2 batv3 ht1 ht2 ht3 ht4 tries * checksum"
"<cr>D$1C/I Date Time batv1 batv2 batv3 ht1 ht2 ht3 ht4 tries * checksum"
"<cr>D$1C/I Date Time batv1 batv2 batv3 ht1 ht2 ht3 ht4 tries * checksum"

<cr> = 0x0D
<cr>D$1 = message ID
C/I = message status; C=corrupted, I=Intact
Date = mm/dd/yyyy
Time [UTC] = hr:mn:se
batv1 = BPR battery voltage in 10ths of a volt, or error code
batv2 = acoustic Modem DSP battery in 10^{th} of a volt
batv3 = acoustic Modem battery in integer volt
ht1 … ht4 = water column height in millimeters
tries = number of tries to deliver BPR data (up to 3)
* = checksum delimiter
checksum = exclusive OR of all characters preceding "*", hexadecimal

2.2.3.Example Message

D$1I 11/14/2006 18:15:00 1634146 3772376 3772344 3772313 3772294 1* 39
D$1I 11/14/2006 19:15:00 1634146 3772275 3772262 3772251 3772249 1* 38
D$1I 11/14/2006 20:15:00 1634146 3772249 3772257 3772271 3772293 1* 3E
D$1I 11/14/2006 21:15:00 1634146 3772315 3772341 3772373 3772407 1* 39
D$1I 11/14/2006 22:15:00 1634146 3772440 3772472 3772506 3772540 1* 3C
D$1I 11/14/2006 23:15:00 1634146 3772572 3772603 3772631 3772657 1* 3B

2.3.D$2 Tsunami Report Mode

T=0 is the time the threshold is reached and the FLAG is raised. (two values must exceed the expected value by the threshold to be recognized, so T=0 is the UTC of the second of the these two values.)

When the tsunami FLAG is first raised by the algorithm, the system will go into a Event Mode Data will be transmitted for a period of 3 hours, giving high frequency data on short intervals with 100% repeated data for redundancy for the first hour. For a period of 6 hours following the FLAG, the hourly standard transmissions will be filled with 120 1 minute values, made of the previous 2 hours data. After the 6 hour period, the system will check for the FLAG, if it is still raised, another hour of tsunami data will be sent. This will continue until the FLAG is lowered (or the batteries are depleted). Every Iridium transmission will include the UTC of T=0 and the message ID that will represent the time after T=0 of the message.

Report time	Msg ID	First data	Last data	Data type
T=0=tt	*D$2 00*	*-0.75 from tt*	*0 = tt*	*15 sec*
3	*D$2 01*	*-0.75*	*3*	*15 sec*
7	*D$2 02*	*-8*	*7*	*1 min avg.*
15	*D$2 03*	*0*	*15*	*1 min avg.*
23	*D$2 04*	*8*	*23*	*1 min avg.*
31	*D$2 05*	*16*	*31*	*1 min avg.*
39	*D$2 06*	*24*	*39*	*1 min avg.*
47	*D$2 07*	*32*	*47*	*1 min avg.*
55	*D$2 08*	*40*	*55*	*1 min avg.*
63	*D$2 09*	*48*	*63*	*1 min avg.*
71	*D$2 10*	*56*	*71*	*1 min avg.*
87	*D$2 11*	*72*	*87*	*1 min avg.*
103	*D$2 12*	*88*	*103*	*1 min avg.*
119	*D$2 13*	*104*	*119*	*1 min avg.*
135	*D$2 14*	*120*	*135*	*1 min avg.*
151	*D$2 15*	*136*	*151*	*1 min avg.*
167	*D$2 16*	*152*	*167*	*1 min avg.*
183	*D$2 17*	*168*	*183*	*1 min avg.*

2.3.1.First Message

2.3.1.1.Description

All data in message #1 are values integrated over the base sampling period of 15-seconds

2.3.1.2.Message Breakdown

"<cr>D$2C/I Msg# tt ttTime ts tsTime height
dev1 dev2 dev3 tries * checksum"

<cr> = 0x0D
<cr>D$2 = message ID
C/I = message status; C=corrupted, I=Intact
Msg# = Sequential message number; this message is #00 of event mode
tt = tsunami trigger designation
ttTime = time tsunami detected; corresponds with 2nd elevated sample (observation #4)
ts = time stamp designation
tsTime = time of first data sample in message
height = water column height in millimeters, hexadecimal
<cr>dev1 = deviation from ht1 in millimeters, 4 hexadecimal characters
dev2 = deviation from ht1 in millimeters, 4 hexadecimal characters
dev3 = deviation from ht1 in millimeters, 4 hexadecimal characters
tries = number of tries to deliver BPR data (up to 3)
* = checksum delimiter
checksum = exclusive OR of all characters preceding "*", hexadecimal

2.3.1.3.Example Message

D$2I 00 tt 18:32:45 ts 18:32:00 3772311
00000063006201* 22

2.3.2.Second Message

2.3.2.1.Description

All data in message #2 (D$2C/I 01) are values integrated over the base sampling period of 15-seconds. The first four observations are repeats of message #1.

2.3.2.2.Message Breakdown

"<cr>D$2C/I Msg# tt ttTime ts tsTime height
dev1 dev2 dev3 … dev15 tries * checksum"

<cr> = 0x0D
<cr>D$2 = message ID
C/I = message status; C=corrupted, I=Intact
Msg# = Sequential message number; this message is #01 of event mode
tt = tsunami trigger designation
ttTime = time tsunami detected; corresponds with 2nd elevated sample (observation #4)
ts = time stamp designation
tsTime = time of first data sample in message
height = water column height in millimeters, hexadecimal
<cr>dev1 = deviation from ht1 in millimeters, 4 hexadecimal characters
dev2 = deviation from ht1 in millimeters, 4 hexadecimal characters

dev15 = deviation from ht1 in millimeters, 4 hexadecimal characters
tries = number of tries to deliver BPR data (up to 3)
* = checksum delimiter
checksum = exclusive OR of all characters preceding "*", hexadecimal

2.3.2.3.Example Message

D$2I 01 tt 18:32:45 ts 18:32:00 3772311
0000006300627069006000061005f005ffffafff9fff8fff8fff7fff6fff401* 21

2.3.3.Additional Messages

2.3.3.1.Description

All D$2 data in messages #3 until end of event mode are 1-minute averages of four 15-second samples. The 15-second values used to compute 1-minute averages are ALWAYS: xx:xx:00 xx:xx:15 xx:xx:30 xx:xx45. The 1-minute value time stamp ALWAYS corresponds with xx:xx:00.

2.3.3.2.Message Breakdown

"<cr>D$2C/I Msg# tt ttTime ts tsTime height
dev1 dev2 dev3 … dev15 tries * checksum"

<cr> = 0x0D
<cr>D$2 = message ID
C/I = message status; C=corrupted, I=Intact
Msg# = Sequential message number beginning with #02
tt = tsunami trigger designation
ttTime = time tsunami detected; corresponds with 2nd elevated sample (observation #4)
ts = time stamp designation
tsTime = time of first data sample in message
height = water column height in millimeters, hexadecimal
<cr>dev1 = deviation from ht1 in millimeters, 4 hexadecimal characters
dev2 = deviation from ht1 in millimeters, 4 hexadecimal characters

dev15 = deviation from ht1 in millimeters, 4 hexadecimal characters
tries = number of tries to deliver BPR data (up to 3)
* = checksum delimiter
checksum = exclusive OR of all characters preceding "*", hexadecimal

2.3.3.3.Example Message

D$2I 02 tt 18:32:45 ts 18:32:00 3772335
fffdfffafff7fff5fff1ffeeffea00190048ffe1ffddffdaffd8ffd5ffd101* 21

2.4. D$3 Tsunami Report Mode Hourly

2.4.1. Description

D$3 messages are reported on an hourly schedule. They are interspersed with D$2 messages while a unit is reporting in Event Mode. 120 samples are reported; 60 previously reported samples provide redundancy and 60 'new' samples are reported in each message.

All D$3 data are 1-minute averages of four 15-second samples. The 15-second values used to compute 1-minute averages are ALWAYS: xx:xx:00 xx:xx:15 xx:xx:30 xx:xx45. The 1-minute value time stamp ALWAYS corresponds with xx:xx:00.

2.4.2. Message Breakdown

"<cr>D$3C/Itt ttTime ts tsTime height
<cr>dev1 dev2 dev3 … dev24
<cr>dev25 … dev48
<cr>dev49 … dev72
<cr>dev73 … dev96
<cr>dev97 … dev119 tries * checksum"

<cr> = 0x0D
<cr>D$2 = message ID
C/I = message status; C=corrupted, I=Intact
tt = tsunami trigger designation
ttTime = time tsunami detected; corresponds with 2nd elevated sample (observation #4)
ts = time stamp designation
tsTime = time of first data sample in message
height = water column height in millimeters, hexadecimal
<cr>dev1 → dev24 = deviation from ht1 in millimeters, 4 hexadecimal characters
<cr>dev25 → dev48 = deviation from ht1 in millimeters, 4 hexadecimal characters
<cr>dev49 → dev72 = deviation from ht1 in millimeters, 4 hexadecimal characters
<cr>dev73 → dev96 = deviation from ht1 in millimeters, 4 hexadecimal characters
<cr>dev97 → dev119 = deviation from ht1 in millimeters, 4 hexadecimal characters
tries = number of tries to deliver BPR data (up to 3)
* = checksum delimiter
checksum = exclusive OR of all characters preceding "*", hexadecimal

2.4.3. Example Message

D$3Itt 18:32:45 ts 17:00:00 3772621
fffdfffbfff6fff3fff0ffecffe9ffe6ffe3ffdfffddffd9ffd6ffd3ffcfffccffc9ffc5ffc2ffbfffbdffbaffb7ffb4
ffb1ffaeffabffa9ffa5ffa2ff9effcdfffcff95ff91ff8eff8cff89ff85ff84ff81ff7fff7cff7aff78ff75ff73ff6f
ff6cff68ff66ff63ff60ff5eff5bff58ff55ff52ff50ff4dff4aff49ff46ff42ff41ff3dff3bff38ff36ff34ff32ff2f
ff2dff2bff29ff28ff25ff23ff21ff1eff1cff1aff18ff17ff14ff12ff10ff0dff0dff0bff0aff07ff06ff04ff03ff00
fefefefdfefbfef9fef8fef5fef5fef3fef1fef0feeefeeefeedfeeafee9fee8fee6fee4fee3fee2fee1fedffedf01* 3D

2.5 D$MI Meteorological Data

2.5.1 Description

Wind, SST, and Baro report a variable number of observations dependant upon buffer contents at time of transmission.

D$MI message reports regardless of system operating mode

Message is specific to ETD system and is not currently reported by DART II system.

2.5.2 Message Breakdown

<cr>D$MI
<cr> WIND wdate wtime int
<cr> windU1,windV1 …. windUx, windVx
<cr> SST date time
<cr> sst1 …. sst1x
<cr> BARO date time
<cr> baro1 …. barox

<cr> = 0x0D
<cr>D$MI = Met data header
<cr>WIND
wdate = mm/dd/yyyy
wtime [UTC] = hr:mn:se
<cr> windU1,windV1 → windUx, windVx = vector pairs of u and v components
<cr>SST
sdate = mm/dd/yyyy
stime [UTC] = hr:mn:se
<cr> sst1 → sstx = sea surface temperature [degrees C]
<cr>BARO
bdate = mm/dd/yyyy
btime [UTC] = hr:mn:se
<cr> baro1 → barox = barometric pressure [mb]

2.5.3 Example Message

D$MI
WIND 05/21/2007 18:32:00 00:20:00
000.9 -01.6 000.8 -01.3 000.4 -01.0 000.3 -00.8 000.5 -01.0 -00.7 -00.3 001.2 -01.3 000.9 -01.4 000.8 -02.6 -00.8 001.6 -02.4 000.2 000.3 -02.1 -00.3 -01.9 -00.1 -02.8 -00.2 -02.0 -00.7 -01.9 001.3 -01.2 -00.3 -02.0
SST 05/21/2007 18:30:00 00:20:00
25.597 25.636 25.687 25.795 25.773 25.830 25.882 25.930 25.979 26.038 26.067 26.061 26.118 26.121 26.113 26.149 26.121 26.165
BARO 05/21/2007 18:32:00 00:20:00
1020.12 1020.20 1020.45 1020.64 1020.55 1020.45 1020.04 1019.77 1019.58 1019.56 1019.31 1019.15 1018.96 1018.71 1018.58 1018.55 1018.46 1018.15

2.6 BATT Battery Data

2.6.1 Description

Reports CPU and Acoustic Modem battery information. Message is specific to ETD system and is not currently reported by DART II system.

2.6.2 Message Breakdown

BATT date time int
cpu acMo mode

<cr> = 0x0D
<cr>BATT = message ID
Date = mm/dd/yyyy
Time [UTC] = Time of sample: hr:mn:se
Int = Sampling Interval
cpu = central processing unit battery voltage at time of sample
acMo = acoustic modem battery voltage at time of sample
mode = system operating mode

2.6.3 Example Message

BATT 05/21/2007 13:21:00 24:00:00
14.50 27.1 STANDARD MODE

2.7 D$4 Deployment Data

2.7.1 Description

BPR sends a string of data (heights in mm) every other minute. Buffering occurs after 6 or 7 messages and transmissions continue for 2-hours.

Duration of depmode is 8 hours. Standard reporting continues while unit is in depmode, but Event Mode is not operational until depmode terminates.

2.7.2 Message Breakdown

"D$4C/I time tf= rf= x= y= ht1 ht2 ht3 ht4

D$4 = message id
C/I = message status, C = corrupted, I = intact
Time= hr:mn:sec [UTC]
tf = Tsunami flag setting
rf = acoustic modem receive flag
x= tilt meter x
y= tilt meter y
ht1 ... ht4 = water column height in millimeters

2.7.3 Example Message

D$4I 06:43:51 tf=255 rf= 1 x= 1 y= 0 4705020 4705018 4705015 4705013
D$4I 06:47:51 tf=255 rf= 0 x= 1 y= 0 4704986 4704984 4704983 4704981
D$4I 06:51:51 tf=255 rf= 0 x= 1 y= 0 4704958 4704957 4704955 4704953
D$4I 06:55:51 tf=255 rf= 0 x= 1 y= 0 4704930 4704928 4704927 4704925
D$4I 06:57:51 tf=255 rf= 0 x= 1 y= 0 4704918 4704917 4704915 4704914
D$4I 07:01:51 tf=255 rf= 0 x= 1 y= 0 4704896 4704896 4704895 4704893
D$4I 07:05:51 tf=255 rf= 0 x= 1 y= 0 4704877 4704876 4704874 4704873
D$4I 07:07:51 tf=255 rf= 1 x= 1 y= 0 4704867 4704866 4704865 4704864

3. Revision Control

1. 24 May 2007 Contents: Page # for section 2.3.1 changed from 6 to 7 (MCE)
2. 24 May 2007 Section 2.3. Label corrected from 2.2. on page 6 (MCE)
3. 18 June 2007 Section 2.1.2 Line #3 of message breakdown D$1 to D$0, page 4 (MCE)
4. 18 June 2007 Section 2.2.2 batv3: 10^{th} of a volt corrected to integer volt. pg 5 (MCE)
5 17 July 2007 Section 2.2.1 correction to ht1 … ht4 times, page 5 (MCE)
6. 31 July 2007 Title and author page added (MCE)