BARREL Data Definitions

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April 2013

1 Introduction

This document will outline the different types of data products by BARREL. There are four types of data files that can be obtained: Raw data packets, Level 0, Level 1, and Level 2. Raw data packets are files that have a .pkt suffix and contain flight data exactly as they are received. Level 0 files are still in the raw data frame format but have been compiled into day-long files and had any bad frames removed. These files have a .tlm suffix.

Level 1 files are the first level of CDF files. they contain the exact integer numbers for each data type that is transmitted by the payload. That means that for digital values such as GPS_TIME and X-Ray counts, the actual values are transmitted. However, with analog values such as housekeeping data, the data must be scaled before use. This means that much of the L1 data are not in physical units. Level 2 files are the same data from the L1 files, but with some additional processing. All analog values have been scaled, all accumulated values are converted to have /second units, spectral values are rebinned, and magnetometer values are gain corrected.

2 File Name Conventions

Raw Data Files, Level 0, and Level 1 and 2 files all have slightly different file name formats:

Raw Data Files: bar_YYMMDD_HHMMSS_PP_GG.pkt
L0: barCLL_PP_S_LV_YYYYMMDD_vVV.tlm
L1/2: barCLL_PP_S_LV_TTTT_YYYYMMDD_vVV.cdf

YYMMDD / YYYYMMDD = Date
HHMMSS = Time
GG = Ground Station (SC - Santa Cruz, DC - Dartmouth College, SA - SANAE, HB - Halley Bay)
C = Campaign number (0 for non-campaign data, 1 for 2012/2013, 2 for 2013/2014)

PP = Payload ID
S = Launch Site (0 for non-campaign data, 1 for SANAE, 2 for Halley Bay)
LV = Level (l0, l1, or l2)
LL = Launch order code (00 for non-campaign data)
VV = Version Number
TTTT = Data Type (sspc, mspc, fspc, gps-, pps-, magn, hkgn)

3 Raw Telemetry and Level 0 Files

Data are transmitted from the payloads to the ground station via Iridium modems. When a call between the two modems is connected a raw telemetry file is created. As data are received at the ground station, they are written, byte-by-byte to the data file with no integrity checks. Data are written to the file until the modem link fails and the call is dropped. When the call resumes, a new file is created.

These files are stored in a network accessible location and are downloaded daily by the CDF Generator. The data frame format for these files is described in the "BARREL Telemetry Interface Control Document" located at http://www.datmouth.edu/~barrel/documents.html.

After the CDF Generator has downloaded the .pkt files, its first output is a L0 file. This file is produced by checking the integrity of each frame in the raw data files and saving the good frames to the L0 file and rejecting the corrupt ones. Frames are flagged as being corrupt if they have a bad checksum, are too long or too short.

During this process all of the .pkt files from a single date directory are processed. Unfortunately, because the call durations are arbitrary, it is possible for some of the previous or following day's data to be collected and saved to the wrong L0 file. This will be corrected in future versions of the CDF Generator.

4 Level 1 and 2 Files

The CDF Generator uses the daily L0 data to create L1 and L2 files. Level 1 and 2 data each split into 6 files based on data type: GPS, Magnetometer, Light Curves, Medium Spectra, Slow Spectra, and Housekeeping Data.

Before the L1 and L2 files are created, a time stamp is calculated for each frame. This is calculated by creating a linear model to convert frame number to time stamp based on groups of up to 2000 frames. This time stamp is recorded as the Epoch variable in each file. Epoch is stored as a TT2000 variable which is an integer that represents the number of nanoseconds since J2000.

In addition to the Epoch variable, each file contains a variable called FrameGroup. This variable contains the frame number provided by the payload for the data in each record. In the case of records that contain multiple frames of data, FrameGroup corresponds to the first frame in the group.

4.1 GPS

The GPS file contains mod4 data from the GPS antenna (Latitude, Longitude, Altitude and GPS Time).

The differences between the L1 and L2 versions of the GPS file are shown in Tables 1 and 2.

Table 1: L1 GPS Variables

Variable Name	Variable Type	Description
GPS_Lat	INT4	Latitude in 2^{31} semicircle
GPS_Lon	INT8	Longitude in 2^{31} semicircle
GPS_Alt	INT8	Altitude in mm above sea level
ms_of_week	INT8	Milliseconds of week starting 0000 UTC Monday morning.

Table 2: L2 GPS Variables

Variable Name	Variable Type	Description
GPS_Lat	INT4	Latitude in degrees
GPS_Lon	FLOAT	Longitude in degrees
GPS_Alt	FLOAT	Altitude in km above sea level
ms_of_week	INT8	Milliseconds of week starting 0000 UTC Monday morning.

4.2 PPS

The PPS file contains 1Hz data. It holds both the PPS variable and the DPU version number that is transmitted in each frame. In both L1 and L2 the PPS variable is an INT4 that represents the number of milliseconds in to the frame that the GPS PPS signal was received. The DPU Version variable is INT2 in both L1 and L2 and has a valid range from 0-31.

4.3 Rate Counters

High Level, Low Level, and Peak Detector are counted on the analog board. Low Level and Peak Detector are for circuit diagnostics. Low Level counts excursions above a baseline and includes rejected events. Peak Detector counts peaks detected on the ADC board. For low count rate, low-noise environment, and at room temperature: Low Level = Peak Detect + High Level and Peak Detector = Interrupt.

Interrupt counts analyzed (ADC) x-rays as accepted by the DPU board.

The only difference between L1 and L2 data is that in L1 the units are counts/4seconds and in L2 the units are counts/second.

4.4 Spectral Data

Spectral data are collected by a 4096 bin NaI scintillator with a nominal bin to energy conversion of 2.4keV/bin. These data are collected and stored using three timing schemes: Fast, Medium, and Slow spectra.

4.4.1 FSPC

FSPC is the four-channel, fast spectra data which is recorded at 20Hz. Each frame is split into 20 CDF records, each record containing a variable for each channel.

The differences between L1 and L2 FSPC files are outlined in Tables 3 and 4.

Table 3: L1 FSPC Variables

Variable Name	Variable Type	Units	Description
LC1	INT4	cnts/.05sec	Bin Range:0-75, Energy Range:0-180keV
LC2	INT4	cnts/.05sec	Bin Range:76-230, Energy Range:182.4-552keV
LC3	INT4	cnts/.05sec	Bin Range:231-350, Energy Range:554.4-840keV
LC4	INT4	cnts/.05sec	Bin Range:351-620, Energy Range:842.4-1488keV

Table 4: L2 FSPC Variables

Variable Name	Variable Type	Units	Description
LC1	DOUBLE	cnts/sec	Counts are rebinned based on scintilator and DPU temperature, and 511 line location
LC2	DOUBLE	cnts/sec	
LC3	DOUBLE	cnts/sec	
LC4	DOUBLE	cnts/sec	
LC1_ERROR	DOUBLE	cnts/keV/sec	Square root of counts in each channel
LC2_ERROR	DOUBLE	cnts/keV/sec	
LC3_ERROR	DOUBLE	cnts/keV/sec	
LC4_ERROR	DOUBLE	cnts/keV/sec	

4.4.2 MSPC

MSPC is 48 channel, medium spectra data which is an accumulation of counts over 4 seconds. Each record contains all 48 channels and is comprised of 4 frames. Unlike the FSPC spectra, all of the channels in the record are stored in an array who's indices are the channel number. A description of the nominal energy binning scheme can be found in the "BARREL Telemetry Interface Control Document" located at http://www.datmouth.edu/˜barrel/documents.html

The differences between L1 and L2 MSPC files are outlined in Tables 5 and 6.

Table 5: L1 MSPC Variables

Variable Name	Variable Type	Units	Description
MSPC	INT4[48]	cnts/4sec	Four second accumulation of 48 channel spectral data. Nominal energy bin scheme.
ch	UINT[48]	NA	Values 1-48 used by the CDF for labeling the MSPC array.

Table 6: L1 MSPC Variables

Variable Name	Variable Type	Units	Description
MSPC	DOUBLE[48]	cnts/keV/sec	L1 counts rebinned according to DPU and scintillator temp and 511 line.
MSPC_ERROR	DOUBLE[48]	cnts/keV/sec	Square root of binned counts.
ch	UINT[48]	NA	Values 1-48 used by the CDF for labeling the MSPC array.

4.4.3 SSPC

SSPC is very similar to MSPC with the main difference that counts are accumulated over 32 seconds and split into 256 channels. Again, a description of the nominal energy binning scheme can be found in the "BARREL Telemetry Interface Control Document" located at http://www.datmouth.edu/˜barrel/documents.html

The differences between L1 and L2 SSPC files are outlined in Tables 7 and 8.

Table 7: L1 SSPC Variables

Variable Name	Variable Type	Units	Description
SSPC	INT4[256]	cnts/32sec	32 second accumulation of 256 channel spectral data. Nominal energy bin scheme.
ch	UINT[256]	NA	Values 1-256 used by the CDF for labeling the MSPC array.

Table 8: L1 SSPC Variables

Variable Name	Variable Type	Units	Description
SSPC	DOUBLE[256]	cnts/keV/sec	L1 counts rebinned acording to DPU and scintillator temp and 511 line.
SSPC_ERROR	DOUBLE[256]	cnts/keV/sec	Square root of binned counts.
ch	UINT[256]	NA	Values 1-256 used by the CDF for labeling the SSPC array.

4.5 Magnetometer

The analog magnetometer data is encoded by a stand alone ADC. The data are collected from the X, Y, and Z axes at 4Hz and are transmitted in each frame. Each frame is split into 4 records. The digital word transmitted by the payload can be decoded with the following formula: $B_{analog} = \frac{B_{digital} - 8388608.0}{83886.070}$.

Gain correction is done based on temperature calibrations done preflight.

Tables 9 and 10 give info on L1 and L2 magnetometer files

Table 9: L1 Magnetometer Variables

Variable Name	Variable Type	Units	Description
MAG_X	INT8	uT	Digital word from magnetometer ADC X axis.
MAG_Y	INT8	uT	Digital word from magnetometer ADC Y axis.
MAG_Z	INT8	uT	Digital word from magnetometer ADC Z axis.

Table 10: L1 Magnetometer Variables

Variable Name	Variable Type	Units	Description
MAG_X	DOUBLE	uT	Nominal conversion of magnetometer X axis.
MAG_Y	DOUBLE	uT	Nominal conversion of magnetometer Y axis.
MAG_Z	DOUBLE	uT	Nominal conversion of magnetometer Z axis.
Total	DOUBLE	uT	Magnitude of B under nominal conversion.
MAG_X_ADJ	DOUBLE	uT	Gain corrected value of magnetometer X axis.
MAG_Y_ADJ	DOUBLE	uT	Gain corrected value of magnetometer Y axis.
MAG_Z_ADJ	DOUBLE	uT	Gain corrected value of magnetometer Z axis.
Total_ADJ	DOUBLE	uT	Gain corrected magnitude of B.

4.6 Housekeeping

Housekeeping data are transmitted as digital words calculated by an ADC and multiplexed as mod40. These values are saved to the L1 files while the scaled (physical units) values are saved to the L2 files. The "BARREL Housekeeping Assignments" document gives the conversion factors for scaling the digital data and the "BARREL Telemetry Interface Control Document" lists the order in which the housekeeping data are transmitted.

Table 11 lists the variable information for L1 and L2 housekeeping files.

Table 11: Housekeeping Variables

Variable Name	L1 Variable Type	L2 Variable Type	Units	Description
T0_Scint	INT8	DOUBLE	$°C$	Scintillator Temp
T1_Mag	INT8	DOUBLE	$°C$	Magnetometer Temp
T2_ChargeCont	INT8	DOUBLE	$°C$	Charge Controller Temp
T3_Battery	INT8	DOUBLE	$°C$	Battery Temp
T4_PowerConv	INT8	DOUBLE	$°C$	Power Converter Temp
T5_DPU	INT8	DOUBLE	$°C$	Data Processing Unit Temp
T6_Modem	INT8	DOUBLE	$°C$	Modem Temp
T7_Structure	INT8	DOUBLE	$°C$	Payload Structure Temp
T8_Solar1	INT8	DOUBLE	$°C$	Solar Panel 1 Temp
T9_Solar2	INT8	DOUBLE	$°C$	Solar Panel 2 Temp
T10_Solar3	INT8	DOUBLE	$°C$	Solar Panel 3 Temp
T11_Solar4	INT8	DOUBLE	$°C$	Solar Panel 4 Temp
T12_TermTemp	INT8	DOUBLE	$°C$	Terminate Temp
T13_TermBatt	INT8	DOUBLE	$°C$	Terminate Battery
T14_TermCap	INT8	DOUBLE	$°C$	Terminate Capacitor
T15_CCStat	INT8	DOUBLE	$°C$	Charge Controller Status
V0_VoltAtLoad	INT8	DOUBLE	V	Voltage at Load
V1_Battery	INT8	DOUBLE	V	Battery Voltage
V2_Solar1	INT8	DOUBLE	V	Solar Panel 1 Voltage
V3_POS_DPU	INT8	DOUBLE	V	Data Processing Unit Positive Voltage
V4_POS_XRayDet	INT8	DOUBLE	V	X-ray detector Positive Voltage
V5_Modem	INT8	DOUBLE	V	Modem Voltage
V6_NEG_XRayDet	INT8	DOUBLE	V	X-ray detector Negative Voltage
V7_NEG_DPU	INT8	DOUBLE	V	Data Processing Unit Negative Voltage
V8_Mag	INT8	DOUBLE	V	Magnetometer Voltage
V9_Solar2	INT8	DOUBLE	V	Solar Panel 2 Voltage
V10_Solar3	INT8	DOUBLE	V	Solar Panel 3 Voltage
V11_Solar4	INT8	DOUBLE	V	Solar Panel 4 Voltage
I0_TotalLoad	INT8	DOUBLE	mA	Total Current at Load
I1_TotalSolar	INT8	DOUBLE	mA	Total Solar Current
I2_Solar1	INT8	DOUBLE	mA	Solar Panel 1 Current
I3_POS_DPU	INT8	DOUBLE	mA	Data Processing Unit Positive Current
I4_POS_XRayDet	INT8	DOUBLE	mA	X-ray Detector Positive Current
I5_Modem	INT8	DOUBLE	mA	Modem Current
I6_NEG_XRayDet	INT8	DOUBLE	mA	X-ray Detector Negative Current
I7_NEG_DPU	INT8	DOUBLE	mA	Data Processing Unit Negative Current
numOfSats	INT2	INT2	NA	Number of GPS satellites in view.
timeOffset	INT2	INT2	NA	Number of leap seconds.
termStatus	INT2	INT2	NA	Terminate Status
cmdCounter	INT4	INT4	NA	Command Counter
modemCounter	INT2	INT2	NA	Modem Reset Counter
dcdCounter	INT2	INT2	NA	Number of times DCD has been de-asserted.
weeks	INT4	INT4	NA	Number of weeks since 6 Jan 1980.