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THE CRRES MICROELECTRONICS PACKAGE (MEP) DATA PROCESSING SYSTEM

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AIR FORCE SYSTEMS COMMAND
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Details of the development and operation of the MEP Data Processing System are given, along with a general discussion of the telemetry format. Correlation of MEP data with CRRES ephemeris parameters is described. The creation, maintenance, and utilization of permanent MEP databases are discussed. A variety of sample tables and graphical data presentations are included.

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1.0 OVERVIEW

The Combined Release and Radiation Effects Satellite (CRRES) Microelectronics Package (MEP) data processing software must recognize 141 different data packet headers and unpack the parameter bytes accordingly. The time of the measurements is determined by monitoring the time pulses embedded in the data stream. Missing data and time jumps must be accounted for, if this is to be done accurately. Software has been developed for the NOS/VE environment in parallel with the RTDS (Real Time Data Acquisition System) package. The complete processing system, input and output data formats, and samples of the various print-outs and plots are described in this report.

2.0 MEP SERIAL TELEMETRY

The GL 701-1A data files (format shown below in Table 1) are composed of a series of 7080 byte records, each containing 8 master (major) frames [*Griffin*, 1989]. The first eight bytes of a record give the current universal time and vehicle time code word (VTCW). A master frame occurs every 4.096 seconds and yields 32 minor frames of five bytes for a total of 160 bytes of serial telemetry data (science words) [*CRRES Microelectronics Package Serial Telemetry Manual*, 1989].

Table 1. GL 701-1A Data File Format

Byte Number	Contents
1-4	Universal Time (ms) for minor frame 0
5-8	Vehicle Time Code Word for minor frame 0
9	Frame counter
10-14	Science words for minor frame 0
15	B35 for minor frame 0
16-35	Subcom words 0-19 for minor frame 0
36-62	Repeat order of bytes 9-35 for minor frame 1
.	
.	
846-872	Repeat order of bytes 9-35 for minor frame 32
873-1744	Repeat order of bytes 1-872 for second master frame
.	
.	
6105-6976	Repeat order of bytes 1-872 for eighth master frame
6977-7080	Vacant (0 filled)

The first minor frame of each master frame contains a fixed set of status indicators, including a 24 bit segment (512 millisecond resolution) of the 32 bit MEP internal software clock. The remaining 155 bytes of serial data are interpreted as a packetized stream, where each packet is identified by a one byte header [*CRRES Microelectronics Package User's Guide*, 1989]. The header implies both the length and contents of the packet; the complete packet formats are defined in the CRRES Microelectronics Package Serial Telemetry Manual [*NRL*, 1989]. Two of the 141 packet types are variable length, and include a packet length specifier immediately following the header byte. Note that the minor frame divisions within a master frame are arbitrary, as the entire 155 bytes are treated as a single stream. However, the packets are not permitted to overlap master frame boundaries. If the next packet will not fit in the current master frame, or if there is no packet waiting to be transmitted, a null packet is sent. A null packet is simply a header byte of $0F (hexadecimal 0F) and serves only as a place holder. Empty (unused) master frames at the end of an orbit are "1's filled."

Data may be missing due to telemetry dropout for a portion of a master frame. In this case, the serial data is "1's filled", containing header bytes of $FF. When this occurs, the remainder of the master frame must be discarded. Otherwise, it is impossible to re-synchronize on a packet header. If there is telemetry dropout anywhere within a master frame, the most significant bit of the VTCW is set to 1 [*Griffin*, 1989]. No filling is necessary if there is dropout for a complete master frame.

The serial data includes "time tick" packets, which report the status of the internal software clock once every eight minor frames (1.024 seconds). Therefore, the time of occurrence of an event may be accurately determined even if the telemetry buffer is being filled at a rate greater than the data transmission rate. This buffer overflow may occur during periods of extremely high activity, which typically result from the detection of a large number of Single Event Upsets (SEU's). The correlation between the internal software clock (time tick values) and universal time is given by the time values at the start of the record. If two successive time ticks are separated only by the proper number of null packets (i.e, the telemetry buffer is not full), the second time tick packet may serve as a reference for the correlation between MEP time and the VTCW. The vehicle time code word is known at a resolution of 128 ms because its least significant bit is equivalent to one minor frame.

3.0 MEP DATA PROCESSING SYSTEM

3.1 MEP SERIAL DATA PROCESSING AND ARCHIVING

The MEP serial data processing begins with the creation of a sequential listing of the MEP data packets, which is performed by the program READMEP. This program reads the GL 701-1A file along with the associated header file, and creates a time sequential event history, presenting all serial data, except JPL Timing and Transistor packets, in a text format. The volume of JPL data is quite high, approximately four megabytes per orbit. It is stored separately in a compact binary format and sent to JPL, where it can be analyzed by JPL engineers. Null packets are discarded, and time tick packets are processed internally so that all other data packets may be time tagged. Table 2 shows a sample of READMEP output for orbit 703 (the right column shows universal time in seconds):

Table 2. Sample of READMEP Output, Orbit 703

Soft SEU - ICU B Address 025B Mask: 01 Pat: 1	57233.516
Block: C4-2 (Am92L44CDMB)	
DUT Block Power Measurement, ICU B: Block E4 = .013 Amps	57235.564
Rate Meter Data Update ICU B Counter A = 00 Counter B = 01	57237.612
DUT Block Power Measurement, ICU B: Block E5 = .007 Amps	57239.660
Rate Meter Data Update ICU B Counter A = 00 Counter B = 00	57239.660
DUT Block Power Measurement, ICU B: Block E6 = 0.000 Amps	57243.756
DUT Block Power Measurement, ICU B: Block E7 = .005 Amps	57247.852
DUT Block Power Measurement, ICU B: Block E8 = .002 Amps	57251.948
DUT Block Power Measurement, ICU B: Block E9 = .002 Amps	57256.044
DUT Block Power Measurement, ICU B: Block EA = .003 Amps	57260.140
DUT Block Power Measurement, ICU B: Block EB = 0.000 Amps	57264.236
DUT Block Power Measurement, ICU B: Block EC = .013 Amps	57268.332
DUT Block Power Measurement, ICU B: Block ED = .007 Amps	57272.427
Rate Meter Data Update ICU B Counter A = 01 Counter B = 00	57274.475
DUT Block Power Measurement, ICU B: Block EE = 0.000 Amps	57276.523
Rate Meter Data Update ICU B Counter A = 00 Counter B = 00	57276.523
Soft SEU - ICU B Address 00DC Mask: 20 Pat: 1	57278.571
Block: C11-2 (Am93422DM)	
Soft SEU - ICU B Address 012F Mask: 20 Pat: 1	57278.571
Block: C11-3 (N82S212F/883B)	
DUT Block Power Measurement, ICU B: Block EF = .005 Amps	57280.619
Rate Meter Data Update ICU B Counter A = 00 Counter B = 01	57281.643
Rate Metei Data Update ICU B Counter A = 00 Counter B = 00	57283.691
DUT Block Power Measurement, ICU B: Block F0 = 0.000 Amps	57284.715
DUT Block Power Measurement, ICU B: Block F1 = 0.000 Amps	57288.811
DUT Block Power Measurement, ICU B: Block F2 = 0.000 Amps	57292.907
DUT Block Power Measurement, ICU B: Block F3 = 0.000 Amps	57297.003
DUT Block Power Measurement, ICU B: Block F4 = 0.000 Amps	57301.099
DUT Block Power Measurement, ICU B: Block F5 = 0.000 Amps	57305.195
DUT Block Power Measurement, ICU B: Block F6 = 0.000 Amps	57309.291
DUT Block Power Measurement, ICU B: Block F7 = 0.000 Amps	57313.387
DUT Block Power Measurement, ICU B: Block F8 = 0.000 Amps	57317.483
DUT Block Power Measurement, ICU B: Block F9 = 0.000 Amps	57321.579
DUT Block Power Measurement, ICU B: Block FA = 0.000 Amps	57325.675
DUT Block Power Measurement, ICU B: Block FB = 0.000 Amps	57329.771
DUT Block Power Measurement, ICU B: Block FC = 0.000 Amps	57333.867
DUT Block Power Measurement, ICU B: Block FD = 0.000 Amps	57337.963
DUT Block Power Measurement, ICU B: Block FE = 0.000 Amps	57342.059
Soft SEU - ICU B Address 0D12 Mask: 02 Pat: 1	57346.155
Block: C6-5 (WH VHSIC)	
DUT Block Power Measurement, ICU B: Block FF = 0.000 Amps	57346.155
ICU B TD Reference +0 Volt Ref. measured 0.000 Volts	57358.443
ICU B TD Reference +10.000 Volt Ref. measured 9.997 Volts	57362.539
ICU B TD Reference ICU Temperature measured 17.952 C	57366.634
ICU B TD Reference ICU +5 V. Supply measured 5.302 Volts	57370.730
ICU B TD Reference ICU +10 V. Supply measured 9.997 Volts	57374.826
ICU B TD Reference ICU +15 V. Supply measured 14.994 Volts	57378.922
ICU B TD Reference ICU -15 V. Supply measured -15.080 Volts	57383.018
ICU B TD Reference Ext +5.000 V. Ref. measured 4.988 Volts	57387.114

These files are transferred to PC's using the high speed Ethernet link, and compressed using the popular PKZIP utility. Typical compression achieved is approximately 85%; the .ZIP files are then archived on two Bernoulli disks. The binary version of the time history is also saved on NOS/VE, and serves as the input for the second program, READSEQ.

Each run of the READMEP program generates an update to the "Audit" file, which serves as a quick reference for the entire MEP data processing system. A separate program is run periodically to sort this file, since orbits are not necessarily processed in order; a sample is shown in Table 3 below.

Table 3. Sample of Update to the "Audit" File

```
ORBIT       3 DAY 90208  CREATED   1990249    PROCESSED 1990-09-06 12:00:02
   FILL MIN FR:    36  MISS MAST FR:     3  TIME RANGE:   18239.948 TO   40679.744
   JPL RANGE:      -1.000 TO      -1.000    4007 RANGE:      -1.000 TO      -1.000
   FILLS:     0    DROPOUTS:     12    NEW CODES:     8    RECORDS:  685
   READSEQ PROCESSING COMPLETED FOR ORBIT     3:  1990-09-06 12:00:56
ORBIT       4 DAY 90208  CREATED   1990303    PROCESSED 1990-12-13 17:35:44
   FILL MIN FR: 1462  MISS MAST FR:   215  TIME RANGE:   40501.535 TO   76138.592
   JPL RANGE:  75091.045 TO  76135.520    4007 RANGE:   71904.374 TO   72690.802
   FILLS:     3    DROPOUTS:     43    NEW CODES:   142    RECORDS: 1061
   READSEQ PROCESSING COMPLETED FOR ORBIT     4:  1990-12-13 17:50:10
ORBIT       5 DAY 90208  CREATED   1990276    PROCESSED 1990-10-04 14:31:21
   FILL MIN FR:   285  MISS MAST FR:    65  TIME RANGE:   75960.511 TO 111658.976
   JPL RANGE:  75960.511 TO 111655.904    4007 RANGE: 108157.941 TO 108944.369
   FILLS:     0    DROPOUTS:      7    NEW CODES:    11    RECORDS: 1082
   READSEQ PROCESSING COMPLETED FOR ORBIT     5:  1990-10-04 14:35:35
ORBIT       6 DAY 90209  CREATED   1990257    PROCESSED 1990-09-14 11:20:15
   FILL MIN FR:    29  MISS MAST FR:    15  TIME RANGE:   25080.767 TO   60779.360
   JPL RANGE:  25080.767 TO  43853.837    4007 RANGE:   58017.639 TO   58806.117
   FILLS:     0    DROPOUTS:      1    NEW CODES:     1    RECORDS: 1088
   READSEQ PROCESSING COMPLETED FOR ORBIT     6:  1990-09-14 11:30:17
ORBIT       7 DAY 90209  CREATED   1990257    PROCESSED 1990-09-14 12:52:53
   FILL MIN FR:    45  MISS MAST FR:    11  TIME RANGE:   60601.151 TO   96299.616
   JPL RANGE:  61218.620 TO  80135.877    4007 RANGE:   94283.372 TO   95071.847
   FILLS:     0    DROPOUTS:      2    NEW CODES:     0    RECORDS: 1089
   READSEQ PROCESSING COMPLETED FOR ORBIT     7:  1990-09-14 13:00:47
ORBIT       8 DAY 90210  CREATED   1990260    PROCESSED 1990-09-18 09:25:11
   FILL MIN FR:    36  MISS MAST FR:     4  TIME RANGE:    9721.535 TO   45359.616
   JPL RANGE:  11080.376 TO  29997.778    4007 RANGE:   44120.582 TO   44911.106
   FILLS:     0    DROPOUTS:      1    NEW CODES:     2    RECORDS: 1088
   READSEQ PROCESSING COMPLETED FOR ORBIT     8:  1990-09-18 09:30:14
```

Each entry includes the time of the run, the date of creation of the GL 701-1A file, and data time ranges (including separate ranges for JPL and 4007 Inverter data). Time range entries of -1.000, such as for JPL data during orbit 3, indicate that no data of the particular type was received during the orbit. Statistics on anomalies such as time jumps, data fills, and data dropouts are also maintained. Note in the sample that data for orbit 4 was released nearly three months later than data from other early CRRES orbits.

READMEP also creates a number of auxiliary data files for delivery to other research facilities. The complete file production and delivery system is illustrated in Figure 1. JPL Transistor, JPL Timing, Temperature, and Dosimeter files are sent to Jet Propulsion Labs over the SPAN network each time a batch of orbits is processed. NASA Goddard receives 4007 Inverters, Temperature, Dosimeters, and other selected Total Dose data on 1.2 Mb floppy disk. Rate Meter and Pulse Height Analyzer (PHA) files are delivered to Clemson University on 1.44 Mb floppies. Both NASA Goddard and Clemson receive data as sufficient volume accumulates, generally every several hundred orbits.

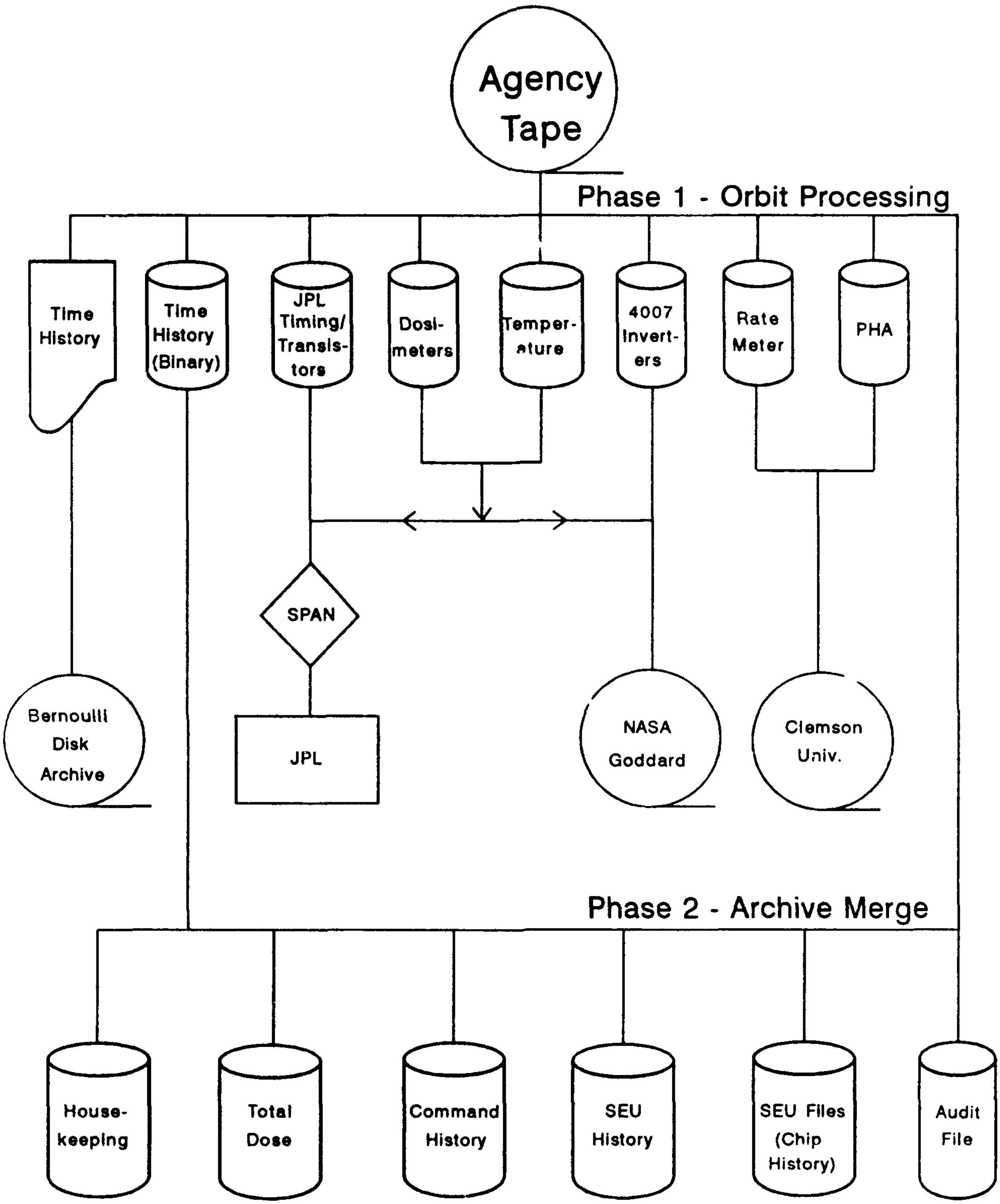

Figure 1. File production and delivery system.

READSEQ reads the READMEP output file and sorts the data packets into five categories: Commands, SEU Commands, SEU Events (separate files for sides A and B and each block), Housekeeping, and Total Dose. The files created in this stage utilize table structures where possible to facilitate data retrieval. For example, a series of DUT Power measurements, such as the one shown above, is collected and saved as one unit even though other packets may interrupt the power dump (see sample in Table 4 below). These interruptions occur because SEU information (including Rate Meter data) has the highest priority in the telemetry system. Only the initial and final times of the power dump are saved, since the exact times of the individual measurements are not critical for analysis. The output files are merged into databases that are sorted by orbit number and maintained as permanent files on NOS/VE.

3.2 DATA RETRIEVAL AND PRESENTATION

The program LOOKUP is used to unpack the binary archive files created by READSEQ. Individual packets or an entire category of data (for example, all Housekeeping data) may be extracted over any time or orbit range. Data may be presented in tables or in files suitable for plotting. Table 4 is a sample DUT Power table for orbit 700:

Table 4. Sample DUT Power Table, Orbit 700															
DUT Block Power Measurement, ICU B												UT: 7346.369 - 8390.842			
Blck	Pow	Blck	Pow	Blck	Pow	Blck	Pow	Blck	Pow	Blck	Pow	Blck	Pow	Blck	Pow
00	0.000	20	.003	40	0.000	60	0.000	80	0.000	A0	.004	C0	.022	E0	.002
01	0.000	21	.003	41	0.000	61	0.000	81	0.000	A1	.004	C1	.001	E1	.002
02	0.000	22	0.000	42	0.000	62	0.000	82	0.000	A2	.003	C2	****	E2	.003
03	0.000	23	0.000	43	0.000	63	0.000	83	0.000	A3	0.000	C3	.019	E3	0.000
04	0.000	24	0.000	44	0.000	64	0.000	84	.029	A4	.011	C4	.001	E4	.013
05	0.000	25	0.000	45	0.000	65	0.000	85	.030	A5	.006	C5	****	E5	.007
06	0.000	26	0.000	46	0.000	66	0.000	86	.001	A6	.008	C6	.016	E6	0.000
07	0.000	27	0.000	47	.009	67	.088	87	0.000	A7	0.000	C7	.002	E7	.005
08	.006	28	0.000	48	.001	68	.087	88	0.000	A8	0.000	C8	.021	E8	.002
09	.005	29	0.000	49	0.000	69	0.000	89	0.000	A9	0.000	C9	.017	E9	.002
0A	.006	2A	0.000	4A	0.000	6A	0.000	8A	0.000	AA	.026	CA	.005	EA	.003
0B	0.000	2B	.026	4B	0.000	6B	****	8B	.021	AB	.079	CB	.022	EB	0.000
0C	0.000	2C	0.000	4C	0.000	6C	****	8C	.011	AC	0.000	CC	0.000	EC	.013
0D	0.000	2D	0.000	4D	0.000	6D	****	8D	0.000	AD	****	CD	0.000	ED	.007
0E	0.000	2E	****	4E	0.000	6E	****	8E	0.000	AE	****	CE	****	EE	0.000
0F	.001	2F	****	4F	0.000	6F	****	8F	0.000	AF	****	CF	****	EF	.005
10	0.000	30	****	50	.039	70	****	90	.003	B0	****	D0	****	F0	0.000
11	0.000	31	0.000	51	.039	71	****	91	0.000	B1	****	D1	****	F1	0.000
12	0.000	32	0.000	52	.039	72	****	92	.002	B2	****	D2	****	F2	0.000
13	0.000	33	0.000	53	.033	73	****	93	.051	B3	****	D3	****	F3	0.000
14	0.000	34	0.000	54	0.000	74	****	94	0.000	B4	****	D4	****	F4	0.000
15	0.000	35	0.000	55	0.000	75	****	95	0.000	B5	****	D5	****	F5	0.000
16	0.000	36	0.000	56	0.000	76	****	96	0.000	B6	****	D6	****	F6	0.000
17	0.000	37	****	57	0.000	77	****	97	0.000	B7	****	D7	****	F7	0.000
18	0.000	38	****	58	0.000	78	****	98	****	B8	****	D8	****	F8	0.000
19	0.000	39	****	59	.060	79	****	99	****	B9	****	D9	****	F9	0.000
1A	0.000	3A	****	5A	.062	7A	****	9A	.183	BA	****	DA	****	FA	0.000
1B	0.000	3B	****	5B	.129	7B	****	9B	.271	BB	****	DB	****	FB	0.000
1C	0.000	3C	****	5C	.133	7C	****	9C	0.000	BC	****	DC	****	FC	0.000
1D	0.000	3D	****	5D	0.000	7D	****	9D	0.000	BD	****	DD	****	FD	0.000
1E	.001	3E	****	5E	0.000	7E	****	9E	0.000	BE	****	DE	****	FE	0.000
1F	0.000	3F	****	5F	0.000	7F	****	9F	****	BF	****	DF	****	FF	0.000

The asterisks indicate that a particular entry was not present in the telemetry. The time range for the power readings is shown at the top of the table (in general, specific event times are critical only for SEU's). The corresponding plot data file for DUT Power would have four columns: orbit number, Instrument Control Unit (ICU) block, and power reading.

A plotting program based on *GraphiC* (a product of Scientific Endeavors Corporation) has been written in C for use on PC's. This program allows selection of a particular ICU and device over a desired range of orbits. A typical plot of Dosimeter data is shown in Figure 2. In this case, the reading for orbit 4 is used as a "baseline", and is subtracted from subsequent readings to give accumulated dose.

LOOKUP can create spreadsheet-compatible files for selected packets, such as temperature and total dose; these files have been processed on PC's with Borland's QUATTRO. Special processing is required to print lines containing blank data fields where data is missing for an orbit. Certain capsulated event histories may also be generated - for example, Table 5 is a portion of an abbreviated command history (command parameters are not listed). Universal time in seconds is given in the right column.

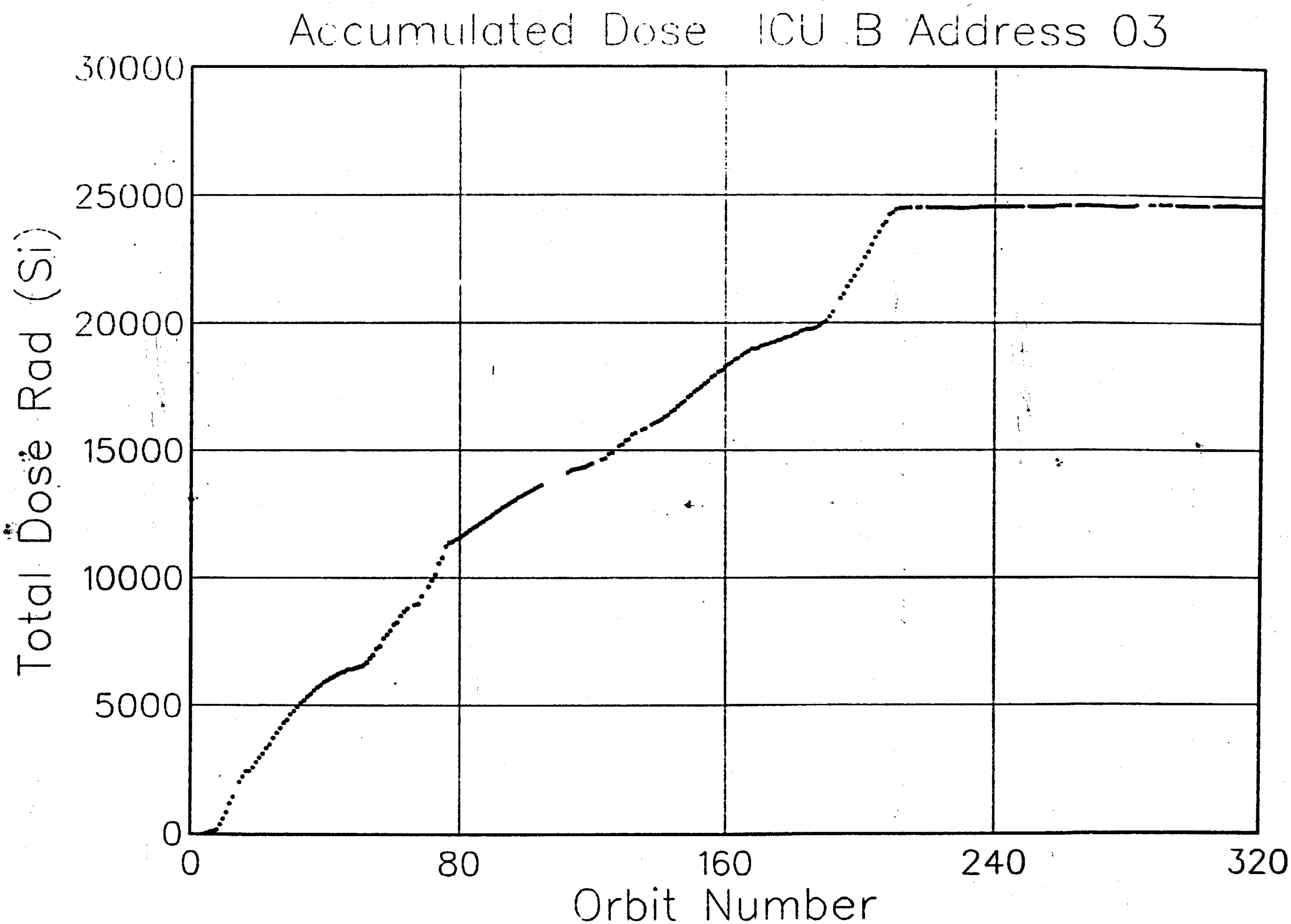

Figure 2. Accumulated dose vs. total dose.

Table 5. Portion of an Abbreviated Command History

Orbit 3 Day 208 Year 90	
ICU A Block Power Array	21417.400
ICU B Block Power Array	21417.400
Physical To Logical RAM Bank Mapping	24894.883
RAM Shadow Assignment	24894.883
Device "Map Around" Update	24894.883
ICU A Block Power Array	28626.443
ICU B Block Power Array	28626.443
ICU A Block Power Array	35835.230
ICU B Block Power Array	35835.230
Orbit 4 Day 208 Year 90	
Physical To Logical RAM Bank Mapping	42894.611
RAM Shadow Assignment	42894.611
Device "Map Around" Update	42894.611
ICU A Block Power Array	43044.242
ICU B Block Power Array	43044.242
Command Accepted - Command (624E) Orbit Segment	44180.748
Fatal Experiment Power Fault	45958.402
Fatal Experiment Power Fault	46786.814
Fatal Experiment Power Fault	47081.724
Fatal Experiment Power Fault	47409.402
Fatal Experiment Power Fault	49205.489
ICU A Block Power Array	50253.035
ICU B Block Power Array	50253.035
Fatal Experiment Power Fault	50722.024
Fatal Experiment Power Fault	50861.288
Fatal Experiment Power Fault	51594.468
Fatal Experiment Power Fault	51812.579
Fatal Experiment Power Fault	51906.786
Fatal Experiment Power Fault	51982.690
ICU A Block Power Array	57461.956
ICU B Block Power Array	57461.956
Physical To Logical RAM Bank Mapping	60894.386
RAM Shadow Assignment	60894.386
Device "Map Around" Update	60894.386
ICU A Block Power Array	64670.877
ICU B Block Power Array	64670.877
ICU A Block Power Array	71879.798
ICU B Block Power Array	71879.798

Single Event Upsets and Rate Meter Upsets are more meaningful when studied in conjunction with various ephemeris parameters such as B/B_0, L-shell, and altitude, in order to determine the conditions under which upsets are most likely to occur. The programs SEUEPH and RMTEPH read the CRRES ephemeris files and generate listings of the upsets along with the corresponding ephemeris parameters. Table 6 is a sample of output from SEUEPH:

Table 6. Sample Output from SEUEPH

SEU	ICU	BLOCK	PAT	ADR	MSK	YR	DAY	ORBIT	UT	L-SHELL	ALT
Soft	A	14	0	0209	02	90	208	5	110617.574	1.3421	2616.3566
Soft	A	14	0	0DC0	10	90	209	6	59768.674	1.4367	2430.0860
Soft	A	14	0	099C	10	90	209	7	72066.808	5.7682	29899.4435
Soft	A	14	0	0F5B	10	90	209	7	95112.807	1.5079	3044.7825
Soft	A	14	0	0889	10	90	210	8	10638.011	1.4813	2239.7298
Soft	A	14	0	09F8	04	90	210	8	10767.034	1.5827	2729.2076
Soft	A	15	0	0D9A	02	90	208	3	39181.641	1.7002	4359.8479
Soft	A	15	0	05D1	01	90	208	5	110681.062	1.3046	2374.9149
Soft	A	15	0	0CDB	04	90	210	8	10621.627	1.4687	2179.5262
Soft	A	15	0	01A4	04	90	210	9	79784.198	1.7050	2785.3600
Soft	A	16	0	0034	10	90	208	5	110617.574	1.3421	2616.3566
Soft	A	16	0	0035	10	90	208	5	110617.574	1.3421	2616.3566
Soft	A	16	0	002C	01	90	209	6	26505.148	1.6981	4115.0668
Soft	A	16	0	003C	02	90	209	7	95061.607	1.5404	3249.7413
Soft	A	19	0	0891	80	90	209	6	59705.186	1.4936	2672.9131
Soft	A	1B	0	00CE	02	90	208	3	23010.734	6.3705	33581.5760
Soft	A	1B	0	00CF	02	90	208	3	39314.760	1.5945	3808.2303
Soft	A	1B	0	00C8	40	90	208	3	39431.495	1.5023	3331.7258
Soft	A	1B	0	00C6	80	90	208	3	39449.927	1.4878	3257.3614
Soft	A	1B	0	0042	01	90	208	3	39619.910	1.3574	2587.4841
Soft	A	1B	0	00CC	20	90	208	4	41626.905	1.6169	3003.4881
Soft	A	1B	0	00FB	04	90	208	4	75570.275	1.3047	1082.0291
Soft	A	1B	0	00F6	40	90	208	5	110361.576	1.5067	3637.3913
Soft	A	1B	0	00CE	08	90	209	6	26034.109	1.3952	2242.7131
Soft	A	1B	0	00B0	01	90	209	6	26296.252	1.5591	3259.6792
Soft	A	1B	0	0086	20	90	209	6	59660.131	1.5360	2848.5385
Soft	A	1B	0	00A6	20	90	209	6	59660.131	1.5360	2848.5385
Soft	A	1B	0	0016	80	90	209	7	95157.863	1.4795	2866.5681
Soft	A	1B	0	0056	80	90	209	7	95157.863	1.4795	2866.5681
Soft	A	1B	0	001D	08	90	209	7	95458.917	1.2958	1753.1643
Soft	A	1B	0	0046	01	90	210	8	10363.580	1.2884	1312.8113
Soft	A	1B	0	0082	10	90	210	8	10441.404	1.3380	1555.5200
Soft	A	1B	0	004E	01	90	210	8	43524.617	2.0347	5905.5401
Soft	A	1B	0	0049	08	90	210	8	44519.940	1.2536	1897.2323
Soft	A	1C	0	00D4	40	90	208	3	38788.427	2.0099	6003.6122
Soft	A	1C	0	00CC	40	90	208	3	39466.311	1.4750	3191.4982
Soft	A	1C	0	0037	20	90	208	3	39581.126	1.3866	2737.3805
Soft	A	1C	0	000F	40	90	208	3	39777.605	1.2446	2002.4706
Soft	A	1C	0	0031	40	90	208	3	39804.229	1.2268	1908.3973
Soft	A	1C	0	0071	40	90	208	3	39804.229	1.2268	1908.3973
Soft	A	1C	0	0026	01	90	208	5	110453.735	1.4455	3262.9412
Soft	A	1C	0	002D	40	90	208	5	110668.774	1.3117	2421.1626
Soft	A	1C	0	0042	20	90	209	7	95350.373	1.3603	2135.5702
Soft	A	1C	0	00DB	80	90	209	7	95399.525	1.3307	1959.1852
Soft	A	1C	0	00FD	80	90	210	8	10306.236	1.2551	1146.7876
Soft	A	1C	0	0028	08	90	210	8	10459.836	1.3504	1615.6472
Soft	A	1C	0	003E	80	90	210	8	10773.178	1.5876	2753.1099
Soft	A	1C	0	00CC	10	90	210	8	10807.994	1.6151	2889.4218
Soft	A	1C	0	0056	08	90	210	8	10900.153	1.6878	3256.4670
Soft	A	1D	0	00CB	80	90	208	4	75496.547	1.3809	1291.4170
Soft	A	1D	0	01F7	04	90	208	5	110457.831	1.4428	3246.4475
Soft	A	1D	0	00B8	10	90	209	6	26062.781	1.4122	2349.2562
Soft	A	1D	0	0190	01	90	209	6	26159.037	1.4712	2716.4163
Soft	A	1D	0	00F2	02	90	209	6	59916.130	1.3191	1892.6634
Soft	A	23	0	110F	08	90	210	8	10603.195	1.4546	2112.4018

These listings have proven to be extremely useful in eliminating SEU's that are a result of ground commands and telemetry errors. SEU's of this type have been removed from the SEU database in order to maintain the validity of the statistics. The RMTEPH output has the same general format, and does not include Rate Meter packets where both counters are zero.

Similar files containing some different ephemeris parameters are also created for plotting purposes. Scatter plots have been generated from this data showing B/B_0 versus L-shell at the time of SEU occurrence. Typically, these plots are produced for individual chips, though scatter plots for an entire ICU and the entire device have also been generated. The sample shown in Figure 3 shows a fairly typical concentration of SEU's at low values of L and B/B_0. At higher L values, we see three "tracks", a result of extremely high solar flare activity during three orbits.

The satellite does not spend an equal amount of time at the various L-shell levels. Therefore, the scatter plots do not reflect the true frequency of occurrence of upsets in the various L bins. The amount of time that the satellite has spent at each L-shell level is determined from the ephemeris files. Periods of missing data are listed in the CRRES Agency Tape Anomaly bulletins released for each set of orbits; these intervals are not included in the statistics, since the receipt of upsets is not possible under such circumstances. The upsets are then binned by L-shell to produce a file of the type shown in Table 7:

Table 7. Table of Upsets

Average L-shell	Combined Frequency	SEU Frequency	Rt Mtr Frequency	Total Upsets	SEU's	Rt Mtr Upsets	Time (Sec)
1.025	.94125E-04	.94125E-04	0.0000	12	12	0	127490
1.075	.56984E-04	.56984E-04	0.0000	9	9	0	157940
1.125	.60709E-03	.59680E-03	.10290E-04	118	116	2	194370
1.175	.71875E-03	.60817E-03	.11058E-03	130	110	20	180870
1.225	.27341E-02	.19422E-02	.79191E-03	473	336	137	173000
1.275	.73944E-02	.48205E-02	.25740E-02	1287	839	448	174050
1.325	.13244E-01	.83288E-02	.49156E-02	2204	1386	818	166410
1.375	.18249E-01	.11550E-01	.66987E-02	2776	1757	1019	152120
1.425	.22349E-01	.14419E-01	.79306E-02	3052	1969	1083	136560
1.475	.24353E-01	.16561E-01	.77916E-02	3113	2117	996	127830
1.525	.23165E-01	.16612E-01	.65528E-02	2821	2023	798	121780
			.				
			.				
			.				
8.275	.20896E-03	.14925E-03	.59701E-04	7	5	2	33500
8.325	.54001E-03	.54001E-03	0.0000	11	11	0	20370
8.375	.15936E-03	.15936E-03	0.0000	4	4	0	25100
8.425	0.0000	0.0000	0.0000	0	0	0	21140
8.475	0.0000	0.0000	0.0000	0	0	0	18520
8.525	.50302E-04	.50302E-04	0.0000	1	1	0	19880
8.575	.71582E-04	.71582E-04	0.0000	1	1	0	13970
8.625	0.0000	0.0000	0.0000	0	0	0	11790
8.675	0.0000	0.0000	0.0000	0	0	0	5830
8.725	0.0000	0.0000	0.0000	0	0	0	6010
8.775	0.0000	0.0000	0.0000	0	0	0	3160

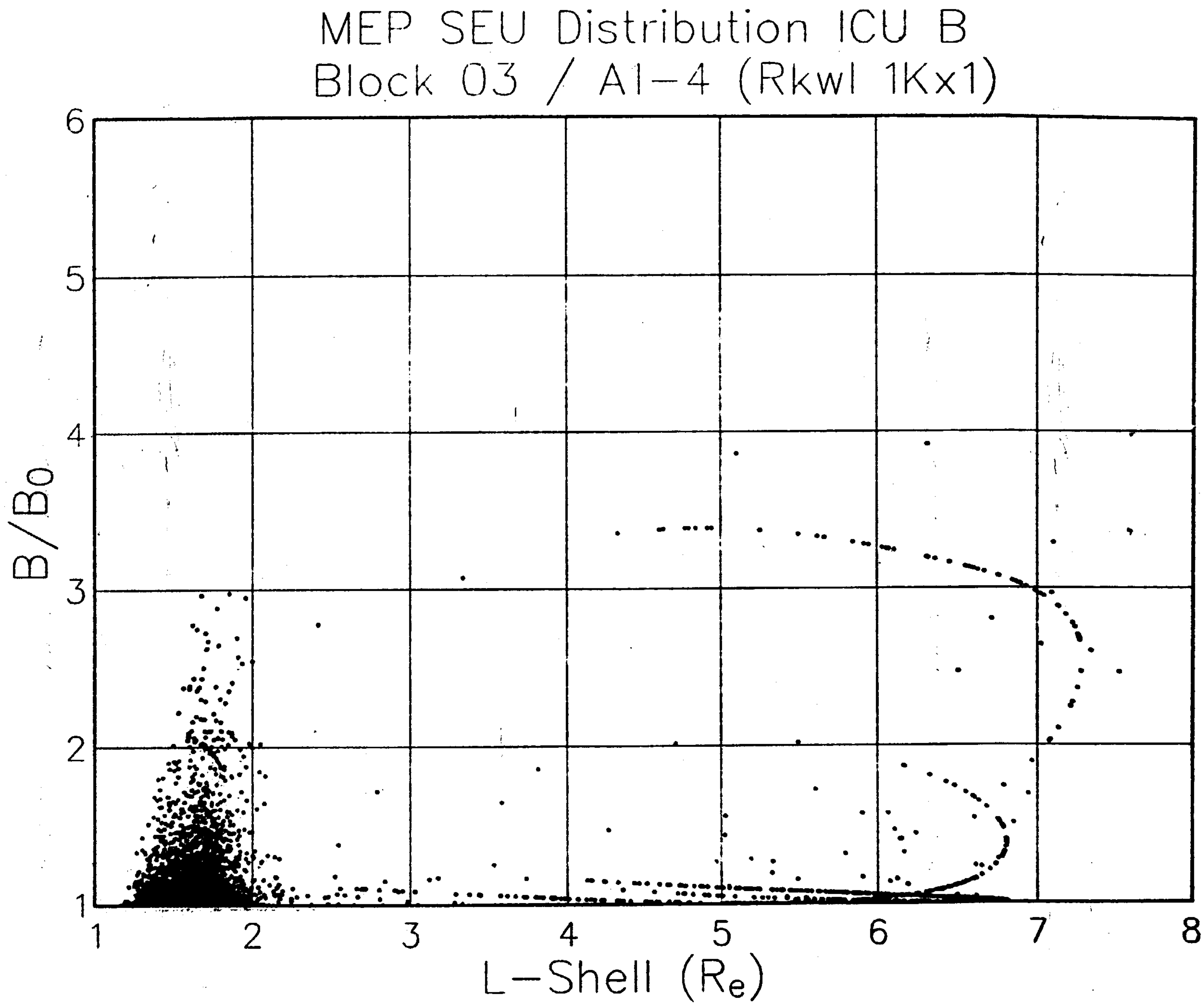

Figure 3. Scatter plot of MEP SEU distribution ICU B vs. B_0.

L-Shell is in R_e, with the number given being the center of a bin (for example, 1.025 is the center of bin from 1.0 to 1.05); frequency is the number of upset events per second. Upsets have also been binned based on the satellite's position in R_e; an SEU distribution plot of this type is shown in Figure 4. Similar studies have been made for individual blocks and for particular orbit ranges.

3.3 SOFTWARE ARCHITECTURE AND DEVELOPMENT

The CRRES Microelectronics Package Serial Telemetry Manual [*NRL*, 1989] defines six categories of data packets:

- System Configuration
- System Data
- System Information
- Experiment Configuration
- Experiment Data
- Experiment Housekeeping / Error

The READMEP and READSEQ programs were designed around these six categories, which allows for functional association of related packets. For example, the fifteen System Data packets were broken down as follows:

- Memory Dump
- Task functions (Cancelled, Scheduled, Definition Update)
- ICU SEU testing (A Offline, A Online, B Offline, B Online)
- ICU Total Dose testing (A Offline, A Online, B Offline, B Online)
- ICU Swapping (Disabled; Enabled, ICU A Active; Enabled, ICU B Active)

This type of grouping resulted in much less code than would have been required if each individual packet was handled separately.

The objective of the initial software development was to simulate the output of the Real Time Data Acquisition System (RTDS) package, which was developed in C [***Assurance Technology Corporation***, 1989]. NOS/VE was chosen as the development environment, since this was the site of most related CRRES work. A number of discrepancies were discovered between the CRRES Microelectronics Package Serial Telemetry Manual [*NRL*, 1989] and the RTDS code. These were a combination of typographical errors in the manual and undocumented changes in the telemetry format; appropriate corrections were determined through communications with ATC.

Several GL 701-1A files were available for testing prior to the actual CRRES flight. These files were a product of ground "test chamber" operation of the MEP. READMEP was run using these files as input, and program output was verified against output from the RTDS. A number of modifications to READMEP were required during this phase, in order to handle the various time anomalies present in the sample files.

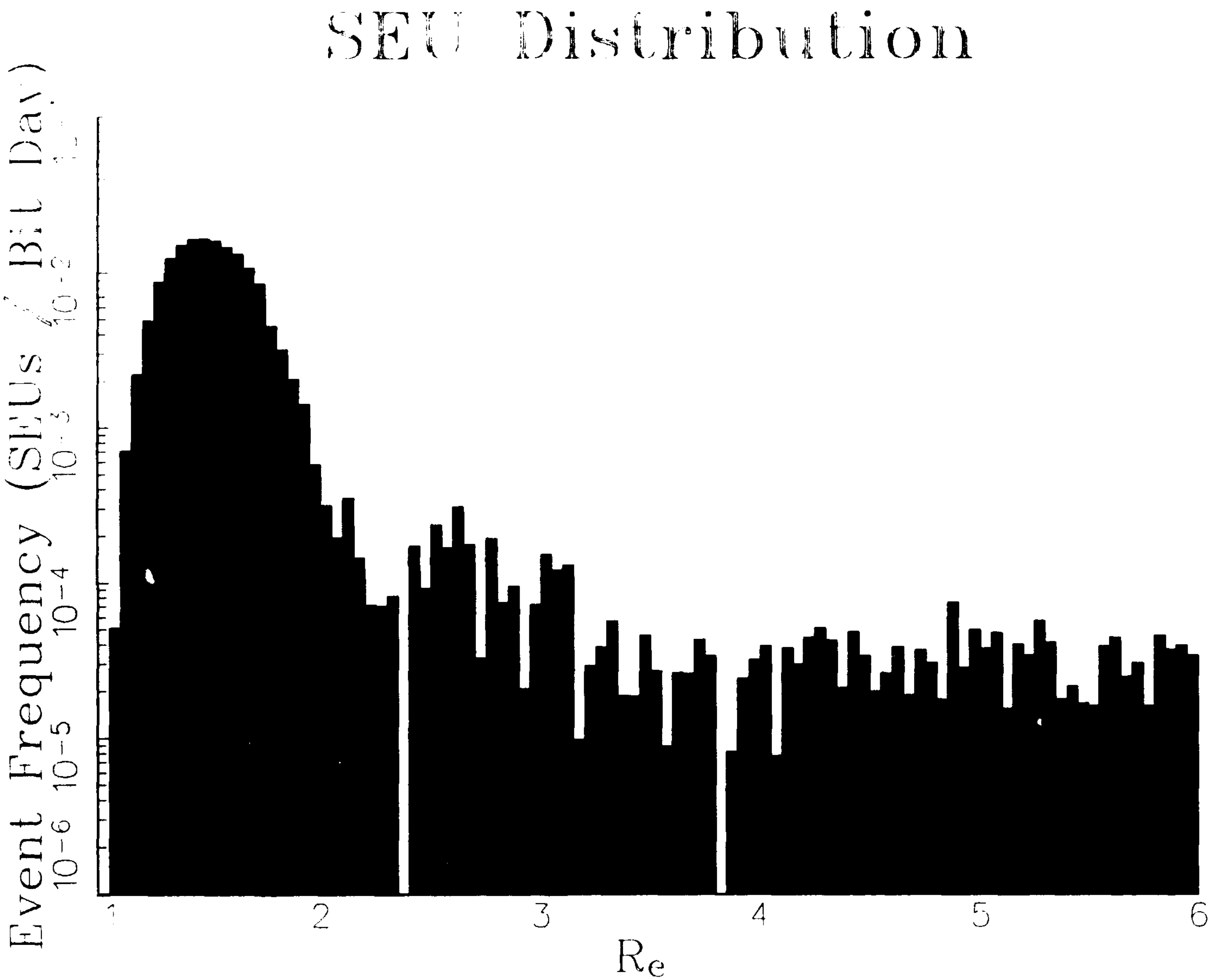

Figure 4. SEU distribution, ICU B.

Upon completion, READMEP runs the READSEQ program, which maintains all permanent MEP databases on NOS/VE. Output data organization was determined in conjunction with PL personnel, and was designed to facilitate the data retrieval tasks performed by LOOKUP. Streams of a given packet type are collected and stored in one large data structure, the size of which is known by LOOKUP. All disk I/O operations are performed using 9600 byte buffers, in order to minimize the amount of disk access. Since most retrieval requests are for one specific packet type, LOOKUP can advance quickly through the input buffer and skip data that is not of interest simply by incrementing a pointer.

Software for data presentation was developed primarily in the PC environment, using Microsoft C and ***GraphiC 6.0***, a library of high-level graphics subroutines. This approach allowed for the production of high quality output with a minimal amount of effort. ***GraphiC*** can generate high resolution images on many different hardware devices, including full support of the HP Laserjet III printers used to produce the figures in this document [***Scientific Endeavors Corporation***, 1991]. Data transfer from NOS/VE to the PC can be accomplished quickly using the high speed Ethernet link available at PL.

4.0 MEP DATABASE

4.1 FILE STORAGE

In order to minimize the volume of data stored on-line on the Cyber, the MEP data processing software was revised to maintain separate databases for every 1000 orbits. Older databases were to be backed up on tape and remain accessible through the Central File Storage System (CFS). Unfortunately, CRRES data transmission ceased shortly after completion of these code modifications (during orbit 1067).

Due to the plan to phase out the Cyber, the MEP databases were migrated to PC's and stored on Bernoulli disk (approximately 25 Mb of storage space is required). The LOOKUP program was adapted to run under MS-DOS (using the Microsoft FORTRAN compiler), and output was verified against NOS/VE results. There are several major differences between the two environments of significance to LOOKUP:

- Microsoft FORTRAN requires NOS/VE "UNFORMATTED" files to be opened as "BINARY" files (no modifications to the data files are necessary, unless floating point variables are used).

- The Microsoft FORTRAN default storage size for floating point variables is four bytes (compared to eight on NOS/VE).

- MS-DOS limits the number of open files to a maximum of 255 (compared to 1000 on NOS/VE).

A number of minor differences between the NOS/VE and Microsoft FORTRAN compilers also exist (for example, the method of appending files) [*Control Data Corporation*, 1988; *Microsoft Corporation*, 1991].

4.2 PERMANENT DATABASE FILE FORMATS

The MEP permanent database files are standard FORTRAN unformatted files, consisting of a series of 3200 byte records. The first seven bytes of each record are reserved:

Bytes 1-4	Orbit number (low order byte first)
Byte 5	Year (2 digit)
Bytes 6-7	Day number (low order byte first)

The remainder of each record consists of a packetized stream, with a format similar to the telemetry; packets may cross record boundaries if necessary. The unused portion of the last record for an orbit is "1's filled". Table 8 summarizes the data packets stored in the four permanent MEP data files:

Table 8. Archived Data Packets

Packet ID	Length	NRL Group	LOOKUP File	Name
32-33	13	1	3	EXPERIMENT BLOCK POWER ARRAY
34	6	1	3	RAM POWER
35	7	1	3	RELAY STROBED
36	8	1	3	RAM BANK MAPPING
38	8	1	3	RAM SHADOW ASSIGNMENT
40-41	6	1	3	REGISTER UPDATE
42-43	5	1	3	MMU INTERRUPT
46-47	7	1	3	COMMAND REJECTED / ACCEPTED
48,50,52,53	8	1	3	RESTART
64	-1	2	1	MEMORY DUMP
66-67	6	2	3	TASK CANCELLED / SCHEDULED
68	9	2	3	TASK DEFINITION UPDATE
72-75	5	2	4	ICU SEU OFFLINE / ONLINE
76-79	5	2	2	TOTAL DOSE OFFLINE / ONLINE
80-82	5	2	3	ICU SWAPPING
96,98,100	5	3	3	PROM CHECKSUM, NO ERROR
97,99,101	6	3	3	PROM CHECKSUM, ERROR BANK
102	7	3	3	COMMAND COULD NOT BE EXECUTED
103	6	3	3	WRITE PROTECT VIOLATION
104	5	3	3	RAM DIAGNOSTIC SUCCESS
105	9	3	3	RAM DIAGNOSTIC ERROR
106	5	3	3	WRITE PROTECT DIAGNOSTIC SUCCESS
107	7	3	3	WRITE PROTECT DIAGNOSTIC ERROR
108-111	5	3	3	WATCHDOG TIMER
112,113,116,118,119	9	3	3	PARITY ERROR
120-121	7	3	3	PARITY ERROR
124-127	9	3	3	PARITY ERROR
158	83	4	3	MAP AROUND UPDATE
159	7	4	3	MAP AROUND INITIATED
160-161	6	4	3	BLOCK POWER
162	5	4	3	EXPERIMENT ABORTED
164-165	6	4	4	SEU BLOCK DISABLED / ENABLED
166-167	6	4	2	TD BLOCK DISABLED / ENABLED
168-169	7	4	4	SEU DEVICE DECOMPRESSED / COMPRESSED
176	37	4	1	EXPERIMENT CONFIGURATION
177	-1	4	3	PERMANENT FAULT LIST UPDATE
184	7	4	3	*MEP MAXIMUM POWER UPDATE
186	5	4	3	PERMANENT FAULT LIST CLEARED
188	7	4	4	SEU TEST PATTERN UPDATE
195	6	5	4	PHA THRESHOLD UPDATE
196-197	777	5	4	*PHA SPECTRAL DATA
198-199	7	5	4	RATE METER DATA
200-203	9	5	2	ROCKWELL DATA
204-205	7	5	2	LOCKHEED DATA
206-207	49	5	2	*TOTAL DOSE REFERENCE
208-209	145	5	2	*TOTAL DOSE DOSIMETERS
210-211	41	5	2	*TOTAL DOSE HEXFETS
212-213	273	5	2	*TOTAL DOSE SEU VTR
214-215	777	5	2	*TOTAL DOSE OP-AMPS
216	65	5	2	*TOTAL DOSE CMOS OCTAL LATCH
217	89	5	2	*TOTAL DOSE ALS OCTAL LATCH
219	3281	5	2	*TOTAL DOSE 4007 INVERTERS
220	1037	5	2	*TOTAL DOSE ADC
221	97	5	2	*TOTAL DOSE ACCESS TIME
224-225	7	6	3	EXPERIMENT COMMAND UNKNOWN / REJECTED
226-227	29	6	1	*MEP PRIMARY CURRENT
228-229	8	6	3	EXPERIMENT POWER MONITOR FAULT
230-231	521	6	1	*DUT BLOCK POWER
232-233	57	6	1	*TEMPERATURE
234-235	6	6	3	INTERRUPT ERROR
236-239	153	6	1	*ANALOG TESTER CALIBRATION SYSDAC
240	7	6	4	SEU TIMEOUT
241-242	6	6	2	TOTAL DOSE TIMEOUT
243	7	6	4	RATE METER TIMEOUT
244	7	6	2	ROCKWELL TIMEOUT
245	7	6	2	LOCKHEED TIMEOUT
246	7	6	4	PHA TIMEOUT
247	6	6	3	ICU SWAP ERROR
251	5	6	3	FATAL EXPERIMENT POWER FAULT

The "packet ID" numbers are the hexadecimal codes used to identify each packet in the telemetry stream. Length is the packet size in bytes (-1 indicates variable length). The NRL group numbers refer to the six categories of data packets defined in the CRRES Microelectronics Package Serial Telemetry Manual [*NRL*, 1989] (refer to section 3.3). "LOOKUP file" indicates the file in which each packet may be found: 1 - Housekeeping, 2 - Total Dose, 3 - Command History, and 4 - SEU History. Packet names preceded by an asterisk are those for which the database format differs from the telemetry format.

All packets headers are followed by a time tag, which is stored to three decimal places, and requires four bytes. Otherwise, most of the packet storage formats are identical to that of the telemetry; refer to the CRRES Microelectronics Package Serial Telemetry Manual [*NRL*, 1989] for descriptions. Exceptions are marked in the table with an asterisk, and described below in section 4.3. Values stored in multi-byte integer or floating point format may be read with the functions INTREAD and READFLT:

```
      INTEGER FUNCTION INTREAD (NBYTE)
      COMMON /TAPEIN/ BINDAT, NBIN
      CHARACTER*3200 BINDAT
      IVAL = 0
      DO 10 I=1,NBYTE
        IVAL = IVAL + ICHAR(BINDAT(NBIN+1:NBIN+1)) * 256**(I-1)
        NBIN = NBIN + 1
        IF (NBIN.GE.3200) CALL BINREAD
   10 CONTINUE
      INTREAD = IVAL
      RETURN
      END

      FUNCTION READFLT (NDEC, NBYTE)
      READFLT = INTREAD(NBYTE) / 10.**NDEC
      RETURN
      END
```

NBYTE indicates the number of bytes used to store the value, and NDEC indicates the number of places to the right of the decimal point for floating point values. NBIN is the location at which the BINDAT array should be read, and is incremented automatically by these routines. The call to BINREAD in INTREAD will read in the next 3200 byte record into BINDAT, if necessary.

4.3 PERMANENT DATABASE PACKET FORMATS

The first five bytes of all packets contain the header byte and the universal time of the data transmission. The descriptions in this section indicate the content of all subsequent bytes. Note that some packets contain additional universal time values. In this case, each successive pair of time values constitutes the time range for a series of measurements, such as shown in Table 4 in section 3.2.

The storage format for an individual variable is indicated in square brackets as follows:
[N] - integer requiring N bytes (call INTREAD (N))
[N, D] - floating point requiring N bytes, stored with D decimal places (call READFLT (D, N))

MEP Maximum Power Update: Power [3,2].

PHA Spectral Data: Time 2 [3,4], 32 packets x 8 channel counts [3]. Orbit segment and channel zero number are determined from the packet number (0-31), as in the telemetry.

Total Dose - Reference: ICU A - time 2 [3,4], 8 reference measurements [3,2]; ICU B - time 1 [3,4], time 2 [3,4], 8 reference measurements [3,2].

Total Dose - Dosimeters: ICU A - time 2 [3,4], 32 dosimeters [3,2]; ICU B - time 1 [3,4], time 2 [3,4], 32 dosimeters [3,2].

Total Dose - Hexfets: ICU A - time 2 [3,4], 6 hexfets [3,2]; ICU B - time 1 [3,4], time 2 [3,4], 6 hexfets [3,2].

Total Dose - SEU Vtr: ICU A - time 2 [3,4], 16 devices x 4 measurements [3,2]; ICU B - time 1 [3,4], time 2 [3,4], 16 devices x 4 measurements [3,2]. Measurements 1 through 3 are VTR data readings 0, 1, and 2; measurement 4 is the 1.2 volt reference measurement.

Total Dose - Op-Amps: ICU A - time 2 [3,4], 19 devices x 10 tests [3,2]; ICU B - time 1 [3,4], time 2 [3,4], 19 devices x 10 tests [3,2].

Total Dose - CMOS Octal Latch: ICU A - time 2 [3,4], 2 blocks x 6 measurements [3,2]; ICU B time 1 [3,4], time 2 [3,4], 2 blocks x 6 measurements [3,2]. Measurements 1-3 are VTR data readings; measurements 4-6 are IOZH data readings.

Total Dose - ALS Octal Latch: ICU A - time 2 [3,4], 2 blocks x 9 measurements [3,2]; ICU B - time 1 [3,4], time 2 [3,4], 2 blocks x 9 measurements [3,2]. Measurements 1-3 are IIH data readings; measurements 4-6 are Function +5V readings; measurements 7-9 are Function +0V readings.

Total Dose - 4007 Inverters: ICU A - time 2 [3,4], 6 blocks x 16 devices x {device address [1], 8 currents [3,2]}; ICU B - time 1 [3,4], time 2 [3,4], 6 blocks x 16 devices x {device address [1], 8 currents [3,2]}.

Total Dose - ADC: ICU A - time 2 [3,4], 17 codes x 6 devices x {block number [1], current [3,4]}; ICU B - time 1 [3,4], time 2 [3,4], 17 codes x 6 devices x {block number [1], current [3,4]}.

Total Dose - Access Time: ICU A - time 2 [3,4], 5 blocks x 2 devices x {reference measurement [3,2], access time [1,2]}; ICU B - time 1 [3,4], time 2 [3,4], 5 blocks x 2 devices x {reference measurement [3,2], access time [1,2]}.

MEP Primary Current: Time 2 [3,4], 2 ICU's x 5 currents [3,2].

DUT Block Power: Time 2 [3,4], 256 power readings [3,2]. ICU is determined by the header byte (230 for A, 231 for B).

Temperature: Time 2 [3,4], 24 temperature readings [2,2]. ICU is determined by the header byte (232 for A, 233 for B).

Analog Tester Calibration SYSDAC: Time 2 [3,4], 9 inputs x 2 SYSDAC's x 2 ICU's x {reading [3,2], convert time [1,2]}.

4.4 SEU CHIP HISTORY FILE FORMAT

The SEU chip history files are standard FORTRAN unformatted files, consisting of a series of 80 byte records. Each record contains data for one Single Event Upset, and may be read with the following statement:

```
READ(1) ICU, NUMBL, IYR, IDAY, IUT IORB, ICODE, INT1, INT2, IPAT
```

The parameters are:

ICU	0 for ICU A, or 1 for ICU B
NUMBL	The block number
IYR	The last two digits of the year
IDAY	The day of the year
IUT	Universal time (milliseconds)
IORB	The orbit number
ICODE	192 for Soft SEU, 193 for Hard SEU, or 194 for SEU Compressed Data
INT1	Address for a Soft or Hard SEU, or device for SEU Compressed Data
INT2	Mask for a Soft or Hard SEU, or error count for SEU Compressed Data
IPAT	The pattern stored in the DUT block

4.5 JPL FILE FORMATS

JPL Timing and JPL Transistor data files are standard FORTRAN unformatted files, consisting of a series of 10000 byte records. The last record in a file may not be completely filled with data; the vacant bytes are "1's filled". All integer variables requiring more than one byte are written low byte to high byte. Tables 9 and 10 summarize the two file structures.

Table 9. JPL Timing File Format	
Bytes 1-2	Packet identifier, DA_{16} (218_{10})
Bytes 3-4	The number of 9-byte packets that follow in this record
Bytes 5-8	Universal time in milliseconds
Byte 9	ICU and Block Number
	Bit 7 (highest order bit) gives the ICU (0 for ICU A, 1 for ICU B)
	Bits 0-5 give the Block Number
Byte 10	Device 0, rising edge
Byte 11	Device 0, falling edge
Byte 12	Device 1, rising edge
Byte 13	Device 1, falling edge
Bytes 14-22	Repeat order of bytes 5-13
.	
.	
Bytes 9986-9994	Repeat order of bytes 5-13
Bytes 9995-10000	Vacant (1's filled)

Table 10. JPL Transistor File Format	
Bytes 1-2	Packet identifier, DE_{16} (222_{10})
Bytes 3-4	The number of 68-byte packets that follow in this record
Bytes 5-8	Universal time in milliseconds
Byte 9	ICU and Block Number
	Bit 7 (highest order bit) gives the ICU (0 for ICU A, 1 for ICU B).
	Bits 0-5 give the Block Number.
Byte 10	Device Number and Transistor Number
	Bits 5-7 give the device number; bits 0-4 give the transistor number.
Bytes 11-12	Vdd measurement results (mV)
Bytes 13-14	Vg 0 measurement results (mV)
Bytes 15-16	Vd 0 measurement results (mV)
Bytes 17-18	Id 0 measurement results (see below)
.	
Bytes 67-68	Vg 9 measurement results (mV)
Bytes 69-70	Vd 9 measurement results (mV)
Bytes 71-72	Id 9 measurement results (see below)
Bytes 73-140	Repeat order of bytes 5-72
.	
.	
Bytes 9933-10000	Repeat order of bytes 5-72

To obtain the Id measurement value in mA:

```
I.    Itemp = Idval (2 byte integer read above)
II.   If <High Byte> > 127 Then
          Itemp = Itemp .AND. '3FFF'X  (discard the 2 highest order bits)
          Id = Itemp * .0002
      Else
          Id = Itemp * .000002
```

4.6 4007 INVERTER FILE FORMAT

4007 Inverter data files are standard FORTRAN unformatted files, consisting of a series of 9200 byte records. The last record in a file may not be completely filled with data; the vacant bytes are "1's filled". All variables requiring more than one byte are written low byte to high byte. Table 11 summarizes the file structure.

Table 11. 4007 Inverter File Format

Bytes 1-2	Packet identifier, DB_{16} (219_{10})
Bytes 3-4	The number of 22-byte packets that follow in this record
Bytes 5-8	Universal time in milliseconds
Byte 9	ICU and Block Number Bit 7 (highest order bit) gives the ICU (0 for ICU A, 1 for ICU B). Bits 0-5 give the Block Number.
Byte 10	Device Address
Bytes 11-12	Current 0 (10 mA)
Bytes 13-14	Current 1 (3 mA)
Bytes 15-16	Current 2 (1 mA)
Bytes 17-18	Current 3 (300 uA)
Bytes 19-20	Current 4 (100 uA)
Bytes 21-22	Current 5 (30 uA)
Bytes 23-24	Current 6 (10 uA)
Bytes 25-26	Current 7 (1 uA)
Bytes 27-48	Repeat order of bytes 5-26
.	
.	
Bytes 9179-9200	Repeat order of bytes 5-26
Divide all current values by 1000 to obtain the actual measurement values.	

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