SAN MARCO

DISTRIBUTED DATA

88-026A-00D

THIS DATA SET CONSISTS 28 9 TK ORIGINAL 19 DD# AND NO DC# OF 9-TK TAPES, CONTAINING THE SAN MARCO DATA THAT WAS RECORDED AT THE SAN MARCO EQUATORLIA RANGE (SMER) LAUNCH FACILITY IN KENYA AND THAN POST-PROCESSED AT THE OPERATIONS CONTROL CENTER (OCC) IN ROME, ITALY AND AT THE NSSDC IN MARYLAND. THE DATA FORMAT REMAINED UNCHANGED AS THE DATA WERE DISTRIBUTED FROM THE (SMER) TO OCC TO NSSDC. DD# AND DC# WILL FOLLOW WITH TIME SPAN.

DD#	DC#	TIME SPAN
DD103905	DC031167	09/13/88 – 09/20/88
DD103906	DC031168	09/21/88 – 09/27/88
DD103907	DC031169	09/28/88 – 10/04/88
DD103908	DC031170	10/05/88 – 10/10/88
DD103909	DC031171	10/11/88 – 10/16/88
DD103910	DC031172	10/17/88 – 10/22/88
DD103911	DC031173	10/23/88 – 10/28/88
DD103912	DC031174	10/29/88 – 11/02/88
DD103913	DC031175	11/03/88 – 11/08/88
DD103914	DC031176	11/09/88 – 11/15/88
DD103915	DC031177	11/16/88 – 11/21/88
DD103916	DC031178	11/22/88 – 11/26/88
DD103917	DC031179	11/27/88 – 11/30/88
DD103918	DC031180	12/01/88 – 12/03/88
DD103886		05/20/88 – 05/27/88
DD103887		05/28/88 – 06/01/88
DD103888		06/02/88 – 06/05/88
DD103889		06/06/88 – 06/09/88
DD103890		06//10/88 – 06/17/88
DD103891		06/18/88 – 06/24/88
DD103892		06/25/88 – 06/29/88
DD103893		06/30/88 – 07/08/88
DD103894		07/09/88 – 07/14/88
DD103895		07/15/88 – 07/20/88
DD103896		07/21/88 – 07/26/88
DD103897		07/29/88 – 08/03/88
DD103898		08/04/88 – 08/08/88
DD103899		08/09/88 – 08/31/88
DD103900		08/14/88 – 08/18/88
DD103901		08/19/88 – 08/22/88
DD103902		08/23/88 – 08/27/88
DD103903		08/28/88 – 09/03/88
DD103904		09/04/88 – 09/12/88

SAN MARCO D
DISTRIBUTED DATA FORMAT

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1. OVERVIEW

This document describes the data format that will be used to distribute the San Marco data from the San Marco Equatorial Range (SMER) in Kenya by the LSI-11 system known as KENYA to the Rome Operations Control Center (OCC) IBM called IRMCRA, from the OCC to the National Space Science Data Center (NSSDC) at Goddard Space Flight Center, and from NSSDC to all of the Principal Investigators (PIs). All 'fill bits' will be binary zeros. This data format is called the Distributed Data Format (DDF) and remains unchanged as the data flows from SMER to the PIs except for the replacement of 'fill bits' by the appropriate values by IRMCRA or the NSSDC VAX known as NSSDCA. The information contained in this document specifies the DDF and is based on the final agreements of all concerned parties.

There has been a succession of San Marco papers on the DDF as it has evolved. The last previous document was entitled "Distributed Data Format" by John Maurer and Jim Vette dated April 27, 1987. The basic format is also specified in Section 15 of the Test Plan. However both of these documents are out of date relative to the precise details of the DDF and are superceded by the present document.

The format described here is the only data format that will be used for the distribution outside of SMER. There is a significant difference between the DDF and the serial spacecraft data formats, PCM decoms, LSI-11 recording systems, etc. The data transferred to the Science GSE located at SMER will be in DDF; of course the orbit and attitude fields will not be valid data at that time. The first orbit and attitude fields are written by IRMCRA and the final orbit and attitude parameters are entered by NSSDCA. The first fields for which valid values are entered are by KENYA. All fields for which KENYA does not write valid data or appropriate header information will be filled with binary zeros by KENYA. In that way the IRMCRA and NSSDCA processing centers have a way to determine if valid data or 'fill bits' have been supplied and then the valid values can be written into the appropriate fields.

2. GENERAL STRUCTURE OF A PASS FILE

A pass file will consist of a file header and all of the contiguous major frames associated with a single turn-on of the spacecraft. No distinction is made between a real time pass over SMER or a tape recorder playback from a remote turn-on. The latter are expected to more prevalent for San Marco. A broad view of the file structure is given in Figure 1 and a detailed view of the pass file header is shown in Figure 2. The pass file header is at the beginning of the pass file and always consists of 512 bytes, which in DEC terminology is called a block. The physical record size of the pass file on magnetic tape will also be one block. A major frame consists of a header and a trailer with 64 minor frames of data in between. A major frame is 6144 bytes (12 blocks) in length. The pass file will always consist of 12*N + 1 full blocks, where N is an integer.

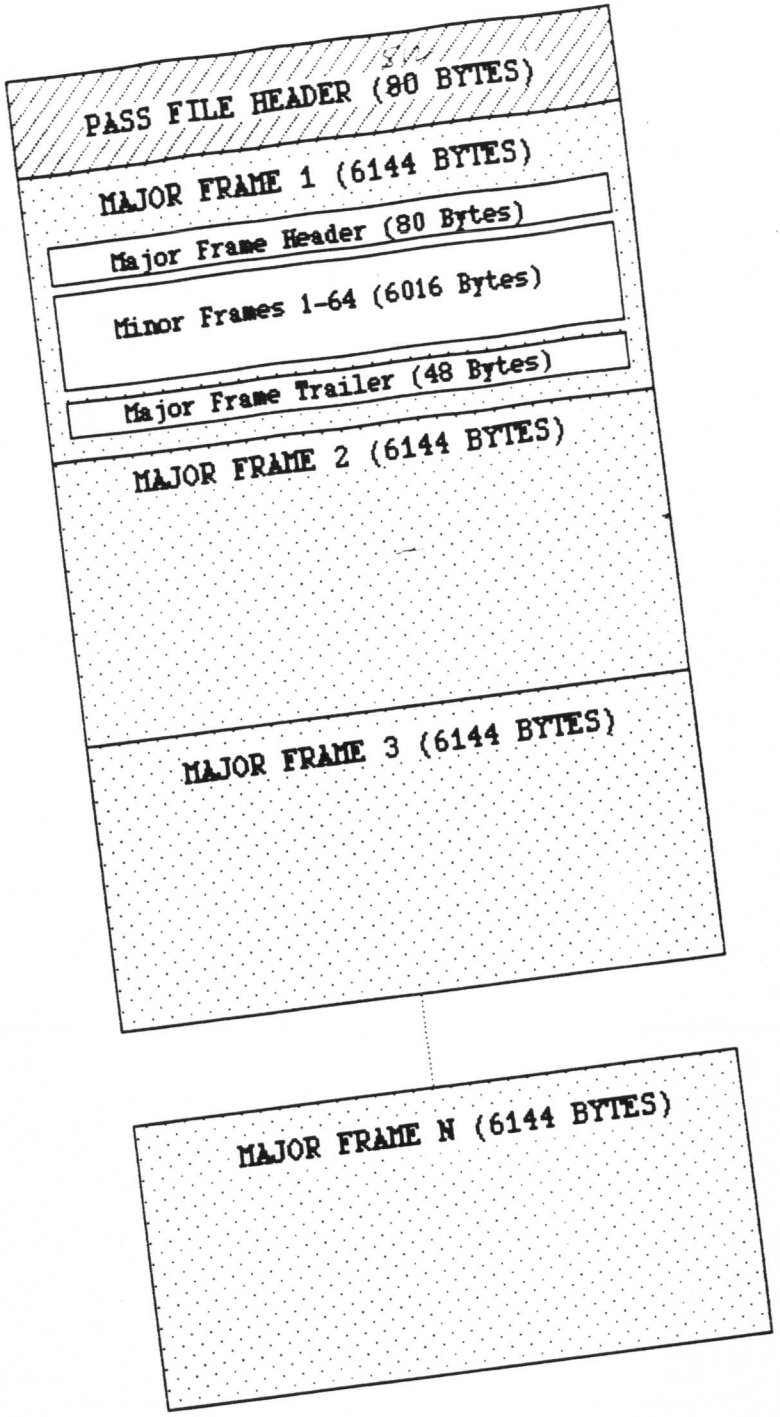

Figure 1: Structure of the Pass File

The first and the last block of the pass file will usually contain some invalid (fill) values, since data taken from the tape recorder or in real time will not start or end at major frame bound in general. Thus KENYA will supply 'fill bits' for minor frames from the time of the first frame until the beginning of the pass file turn-on and 'fill bits' for the minor frames from the of the pass file turn-off to the end of the last (Nth) major frame.

001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020
C	C	S	D	1	Z	0	0	0	0	0	1	0	0	8	9	7	5	1	6
021	022	023	024	025	026	027	028	029	030	031	032	033	034	035	036	037	038	039	040
N	S	S	D	1	I	0	0	0	0	0	1	0	0	8	9	7	4	9	6
041	042	043	044	045	046	047	048	049	050	051	052	053	054	055	056	057	058	059	060
SPARES				T	R	P	L	A	Y	.	D	A	T	T	0	0	1	0	5
061	062	063	064	065	066	067	068	069	070	071	072	073	074	075	076	077	078	079	080
.	D	T	T	T	0	0	1	0	5	.	R	O	M	T	0	0	1	0	5
081	082	083	084	085	086	087	088	089	090	091	092	093	094	095	096	097	098	099	100
.	N	S	S	SPARES						EPOCH UT-BINARY-YYDDDHHMMSSmmm								SMA	
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
in km		ECC unitless				INC in deg				AOP in deg				RAAN in deg				MA	
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
in deg		SPARES																	
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
SPARES																			
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
	Q	1st ATTITUDE EPOCH UT-BINARY								RASZA in deg				DECSZA in deg				RASXA	
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
in deg		DECSXA in deg				SR in deg/s				PAMA in deg				AAMA in deg				SPARES	
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
SPARES											Q	2nd ATTITUDE EPOCH UT-BINARY							
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
RASZA in deg				DECSZA in deg				RASXA in deg				DECSXA in deg				SR in deg/s			
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
PAMA in deg				AAMA in deg				SPARES											
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
	Q	3rd ATTITUDE EPOCH UT-BINARY								RASZA in deg				DECSZA in deg				RASXA	
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
in deg		DECSXA in deg				SR in deg/s				PAMA in deg				AAMA in deg				SPARES	
301	302	303	304	305	306	301	308	309	310	311	312	313	314	315	316	317	318	319	320
SPARES											Q	4th ATTITUDE EPOCH UT-BINARY							
321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
RASZA in deg				DECSXA in deg				RASXA in deg				DECSXA in deg				SR in deg/s			
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
PAMA in deg				AAMA in deg				SPARES											

BYTE #S 361 THROUGH 420 - SPARES

421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
NORAD EPOCH UT-BINARY								MM in rev/day				ECC unitless				INC in deg			
441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
AOP in deg				RAAN in deg				MA in deg				P	R	E	T	R	N	V	4
461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
.	2	A	T	T	I	N	P	V	3			A	T	T	O	U	T		V
481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
2		S	C	C	L	K		V	3	.	7	S	T	A	R		V	3	.
501	502	503	504	505	506	507	508	509	510	511	512								
4		D	I	S	T	.	V	0	1										

Figure 2: Pass File Header Structure.

2.1 PASS FILE HEADER

The first 40 bytes comprise two labels that conform to the Standard Formatted Data Unit (SFDU) labels of the Consultative Committee for Space Data Systems (CCSDS). The next four bytes are the first of a number of spare, or unassigned at this time, bytes embedded in the header for future use. In fact an inspection of Figure 2 shows that the spare bytes are #s

41-44, 85-90, 123-161, 199-211, 249-261, 299-311, and 349-420

The type of pass, tape recorder or real time, is given in the next item of the header, followed by the pass file names. The orbit elements are next, followed by fields that hold four different attitude solutions (different epochs). Then there is a place for the NORAD orbit elements from which the elements given previously in the header were derived. The header ends with a series of six fields which are used to provide an audit trace of the processing programs that have been used on the data and header information in the pass file. Each of these header items are specified below.

2.1.1 SFDU Labels

Each label is 20 bytes in length and only ASCII characters are used. The leading label has the following value (commonly called <u>instance</u>)

CCSD1Z000001nnnnnnnn

where the last 8 bytes give the total length of the pass file minus 20 bytes. The first four characters, CCSD, make the pass file immediately recognizable within the CCSDS community and this label can be interpreted by appropriate software. The second CCSDS label is similar to the first and has the following instance

NSSD1I000001mmmmmmmm

where the last 8 bytes give the total length in bytes of the pass file minus 40 bytes. The 20 and 40 bytes are subtracted since the CCSDS label gives the length of the labeled object that follows the label without including the length of the label itself. The second label here is considered part of the object of the first label. The instances for these labels are entered by program PRETRN running on KENYA and the label fields keep their same instances as the processing is done at the OCC and at NSSDC.

The specific details of the SFDU and its labels for general use can be found in Reference 1

2.1.2 Pass Type

Byte #s 45-54 are used to distinguish real time from tape recorder passes. The examp

Figure 2 depicts a tape recorder pass. ASCII characters are the only valid entries in this field.

2.1.3 Pass File Name.Type

Each pass file will be given a name.type. The name will consist of six ASCII characters with the first one being the capital letter , T, followed by five numeric characters. These numbers will go from 0 to 65535 and will be assigned sequentially. If there are more than 65535 turn-ons for San Marco (practically impossible), then T is replaced by the capital letter, A, and a new numeric sequence is started. Since the pass file will have some fields written by each processing center (KENYA, IRMCRA, NSSDCA), it is useful to have the file name include the processing center that produced the present version of the pass file. This is done by a file name extension, or type. The type is specified by using a period after the name and then three ASCII characters (DDT for KENYA, ROM for IRMCRA, and NSS for NSSDCA) to denote the processing center that produced the file. Since there are separate name.type fields for each processing center and each center does not blank out the previous name.type(s), a pass file produced by NSSDCA will have all three name.type fields with proper instances. A KENYA produced pass file will only have a valid instance in the first of these three fields and binary zeros in the rest. The example in Figure 2 has the name T00105 and the 30 bytes # 55-84 are used for the three entries. The programs PRETRN on KENYA, ATTOUT on IRMCRA, and DIST on NSSDCA put the proper values in these fields, respectively. The 10-byte assignments are as shown in Figure 2.

2.1.4 Classical Orbit Elements

Classical orbit elements are obtained for any desired time by program GTDS running on IRMCRA with input elements provided by NORAD, based on their tracking data. The specific epoch of these elements is not critical but should be prior to and close to the time of the first major frame of the pass file. These elements are assigned to byte #s 91-122 in the following way:

EPOCH UT: Last two digits of the year (Byte 91); Day of Year (92-93); UT hours of the day (94); Minutes of the hour (95); Seconds of the minute (96); Milliseconds of the second (97-98). These numbers will be written as binary integers (I*1 or I*2) by IRMCRA. Note that Day of Year = 1 for Jan. 1.

SEMIMAJOR AXIS (SMA): (99-102) Units are kilometers and the data type number representation is IBM Real*4

ECCENTRICITY (ECC): (103-106) No units and data type is IBM Real*4

INCLINATION (INC): (107-110) Units` are degrees and data type is IBM Real*4

ARGUMENT OF PERIGEE (AOP): (111-114) Units are degrees and data type is IBM Real*4

RIGHT ASCENSION OF ASCENDING NODE (RAAN): (115-118) Units are degrees and data type is IBM Real*4

MEAN ANOMALY (MA): (119-122) Units are degrees and data type is IBM Real*4

The elements are written by IRMCRA into the pass file header. The NORAD elements are assigned to higher byte #s and will be discussed later.

2.1.5 Attitude Solutions

The attitude solution is conveyed by giving the spin rate, the position of the Spin Z and X axes in the Vernal coordinate system, and in the case of a misaligned spin vector relative to the spacecraft axes, the polar and azimuthal misalignment angles are given. The misalignment angles are expected to be zero except for the case where the long wire antennas could not be properly deployed. The following instruments can contribute to the determination of the spacecraft attitude: (1) Star Mapper, (2) Sun sensor, (3) Horizon sensors, (4) Magnetometer, and (5) Drag Balance Instrument (DBI). A code has been developed to denote which data were used to obtain the attitude solution; this code is given in Table 2.1 and its value is denoted by the character, Q. This 5-bit code has the following algorithm. Each of the five sensor systems given above are assigned a bit in the 5-bit code. The assignment from least significant bit to most significant bit are in the order given above. If the data from a sensor system is used, then the assigned bit is set to 1, otherwise it remains a binary 0. Q is the value of the 5-bit counter. The values of 4, 8, or 16 are not possible since the attitude cannot be determined from these sensors alone.

Table 2.1 Attitude Code

Star Mapper	x		x	x		x	x			x			x			x	x			x			x			x			x	
Sun Sensors		x	x		x	x			x	x				x	x			x	x					x	x			x	x	
Horizon Sensors				x	x	x					x	x	x	x						x	x	x	x				x	x	x	x
Magnetometers							x	x	x	x	x	x	x	x										x	x	x	x	x	x	x
Drag Balance Inst															x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Code Value Q	0	1	2	3	5	6	7	9	10	11	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	

There are fields in the pass file header for four different epochs of the attitude solution. One should expect to find this many only if the pass file is 50 or more minutes in length. Short pass files of 5 minutes or less will usually have only one epoch for the attitude solution. If some of the fields are not used they will contain the binary zeros originally entered by KENYA.

The attitude code Q is assigned to byte #s 162, 212, 262, and 312 and its data type is IBM I*1 Q equal 0 means that no attitude solution could be found for the turn-on. In the case of Q equ to 2 the attitude is determined from more than one turn-on, since it is not possible to obtain attitude solution using the sun sensor alone for a single turn-on. In this case the epoch wo be near the midpoint of the two turn-ons.

The EPOCH UT is in the same format and has the same data type as that used for the EPOCH UT of Section 2.1.4. It is assigned to byte #s 163-170, 213-220, 263-270, and 313-320.

The RIGHT ASCENSION OF THE SPIN Z AXIS (RASZA) is in units of degrees and the data type is IBM Real*4. This parameter is assigned to byte #s 171-174, 221-224, 271-274, and 321-324.

The DECLINATION OF THE SPIN Z AXIS (DECSZA) is in units of degrees and the data type is IBM Real*4. This parameter is assigned to byte #s 175-178, 225-228, 275-278, and 325-328.

The RIGHT ASCENSION OF THE SPIN X AXIS (RASXA) has the same units and data type as RASZA and is assigned to byte #s 179-182, 229-232, 279-282, and 329-332.

The DECLINATION OF THE SPIN X AXIS (DECXA) has the same units and data type as DECZA and is assigned to byte #s 183-186, 233-236, 283-286, and 333-336.

The SPIN RATE (SR) has units of degrees per second and the data type is IBM Real*4. This parameter is assigned to byte #s 187-190, 237-240, 287-290, and 337-340.

The POLAR ANGLE OF MISALIGNMENT (PAMA) is the angle between the Spin Z axis and the Spacecraft Z axis and is given in degrees. The data type is IBM Real*4. This parameter is assigned to bytes 191-194, 241-244, 291-294, and 341-344. It is quite likely that this angle will always be zero.

The AZIMUTHAL ANGLE OF MISALIGNMENT (AAMA) is the acute angle between the Spacecraft Z-X plane and the plane containing the Spacecraft Z axis and the Spin Z axis. The positive direction of this angle is from the Spacecraft Z-X plane to the other plane. This parameter is also given in degrees and the data type is IBM Real*4. It is assigned to byte #s 195-198, 245-248, 295-298, and 345-348. It is quite likely that this angle will always be zero.

2.1.6 NORAD Orbit Elements

San Marco D will be tracked only by NORAD and the elements will be supplied to the project through Goddard Space Flight Center. These elements will be telexed daily to CRA in the NORAD format. The NORAD elements are similar to the classical elements described i Section 2.1.4 except that the semimajor axis is replaced by a parameter called the MEA MOTION (MM) which has units of $(\text{days})^{-1}$, meaning revolutions per day. The data type is IB Real*4. These elements are written into the pass file header for the epoch that was used t input to GTDS to provide the classical elements that are in byte #s 91-122. The specific byte assignments for these parameters are:

EPOCH UT: 421-428; MM: 429-432; ECC: 433-436; INC: 437- 440
AOP: 441-444; RAAN: 445-448; MA: 449-452

The NORAD elements are an average element set, averaged over the revolution beginnin epoch. The classical elements are an osculating set that defines the Keplerian ellipse

passes through the instantaneous position of the satellite at epoch and implies the proper velocity.

2.1.7 Program Trace

The final 60 bytes (#s 453-512) of the pass file header are used for the name and version number, or date, or some other qualifier of the programs that were used to process the pass file data and write entries into its headers and trailers fields. Ten bytes are used for each program, thus six such programs can be accommodated. These bytes must be ASCII characters. Examples are given in Figure 2.

2.2 MAJOR FRAME

The major frame header consists of an 80-byte header, 64 minor frames (numbered 1-64) with each being 94 bytes long, and a 48-byte trailer The actual 6-bit counter registers from 0 to 63, but it is more convenient. to add 1 to this value for identification purposes. The format for each of these elements of the major frame will be discussed below in detail. A major frame is always 6144 bytes in length. With a nominal spacecraft clock rate, data are recorded or telemetered in real time at 6,000 bits/s. This means that a minor frame is 128 ms in time length and a major frame starts every 8.192 s If the clock rate is not nominal, then the major and minor frames will have time lengths different than the above values.

2.2.1 Major Frame Header

The structure of this header is shown in Figure 3. The first 28 bytes serve as a label or title for the frame and their instance is written by program PRETRN on KENYA as ASCII characters. The LSI-11 (KENYA) system date occupies byte #s 29-38 and is written as ASCII characters with the format DD-MMM-YY_, where DD is the day of the month, MMM is a 3-letter abbreviation for the month, YY is the last two digits of the year, and '_ 'represents a blank space. This is illustrated in Figure 3 by the instance 15-JUL-88_.

Byte #s 39-46 are used to give the time the data were recorded at SMER during the downlink telemetry pass. This time is also written as ASCII characters with the format HH:MM:SS. The instance shown in Figure 3 is 10:32:15. The next 18 bytes of the major frame header contain various times written in the binary coded decimal (BCD) format. For BCD four binary bits are used to represent a decimal digit. A byte is used for two decimal digits with the most significant four bits (half byte) of the byte used for the most significant (MS) of the two decimal digits. Six bytes are used for each BCD time to give DDDHHMMSSmsmsms, where DDD is the Day of the Year, HH is the UT hour of the day, MM is the minute of the hour, SS is the second of the minute, and msmsms is the millisecond of the second. Consider the six bytes as 12 half bytes which are ordered from the most significant half byte (the most signicant half of the highest byte # assigned) to the least significant half byte (the least significant half byte of the lowest byte assigned). The DDD uses the three highest (or most significant) half bytes, the HH uses the ne

two half bytes, the MM uses the next two half bytes, the SS uses the next two half bytes, and finally the msmsms uses the last three half bytes. Thus each of the quantities DDD, HH, etc.

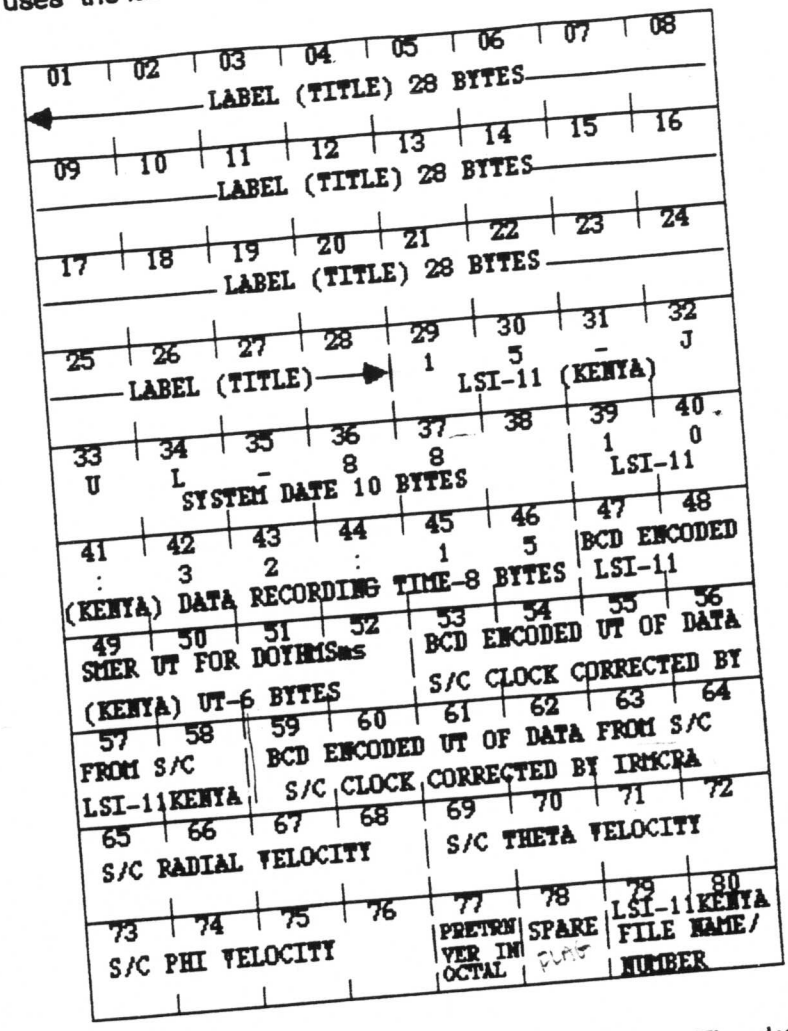

Figure 3: Major Frame Header Structure. The details of the format are given in the text.

crosses byte boundaries. As an example, consider

DDD = 365 , HH = 18, MM = 35, SS = 23, and msmsms = 465

where all numbers above are base 10 or decimal. The binary representation of the bytes would then be

MSB: 00110110, MS-1B: 01010001, MS-2B: 10000011,

MS-3B: 01010010, MS-4B: 00110100, LSB: 01100101

where MSB is the most significant byte, MS-1B is the next most significant byte, etc., and LSB is the least significant byte. The leftmost bit is the most significant bit of the bytes shown above.

Byte #s 47-52 are used to give the UT, encoded as BCD, when the major frame is processed at SMER by KENYA. The spacecraft clock time, which is part of the data in the minor frames, is corrected by program PRETRN using outputs from program SCCLK and this corrected time is encoded as BCD and written into byte #s 53-58. Byte #s 59-64 are written by IRMCRA running program ATTOUT to give the corrected UT of the major frame as determined at the OCC.

The next 12 bytes of the major frame header are written by NSSDCA. These are polar spherical velocity components of the spacecraft using the final orbit elements and computed in the geographic coordinate system in units of km/s and written in VAX Real*4 number representation (data type). The radial component is assigned to byte #s 65-68; the theta component is assigned to #s 69-72; and the phi component is assigned to #s 73-76.

Byte 77 is used for the PRETRN version number written as a two digit octal number, with each half byte being a digit. For the example shown in Figure 2 byte #s 453-462, where the PRETRN version is 4.2 , byte 77 would have the instance 52 octal (= 42 decimal).

Byte 78 is a spare.

Byte #s 79 and 80 are used by PRETRN to write a 6-digit octal number starting with 0 that has a maximum value of 177777 octal; the actual instance written comes from a parameter called DUMP. This is the number in its decimal representation that is used to form the pass file name. Thus for the example shown in Figure 2 byte #s 56-60, the 6-digit octal number would be 000151 (=105 decimal).

2.2.2 Minor Frame

The structure of the DDF minor frame is shown in Figure 4. It consists of 94 bytes and is broken up into 56 different fields. Six fields are three bytes long, 26 fields are two bytes long, and 24 fields are one byte long, including two contiguous digital spares. The minor frame that is telemetered from the spacecraft (TM minor frame) is very similar to the DDF minor frame. The TM minor frame consists of 96 bytes, the two extra bytes being sync words that are not recorded at SMER, since their function is no longer needed after the downlink . The ** in Figure 4 represents these two bytes. The field segmentation of the first 94 bytes of the TM minor frame is the same as that for the DDF minor frame. However, the TM minor frame always has the MSB transmitted first in a field and the LSB last; of course for a one byte field this is not applicable. For the 32 fields greater than one byte in length the position of MSB and LSB of the DDF minor frame are shown in Figure 4. Twenty-two of these fields have the reverse byte sequence compared to the TM minor frame. Those with reverse sequence are marked with an * in Figure 4 to call attention to this reverse sequencing. These changes are made by PRETRN based on specifications supplied by the PIs for level 0 processing.

It is not appropriate in this document to provide all the information necessary to be able t

01 LSB*	02	03 MSB*	04 6-BIT SUB-COM CTR	05 LSB*	06 MSB*	07 MSB	08	09 LSB	10 IVI ANA-LOG	11 LSB*	12 MSB*
FRAME COUNTER				WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 1 A/B				DBI DIGITAL X-AXIS	
13 LSB*	14 MSB*	15 MSB	16 LSB	17 LSB*	18 MSB*	19 SUN SENS XING TIME SBCM	20 HORZ SENS XING TIME SBCM	21 SPARE DIGI -TAL	22 SPARE DIGI -TAL	23 LSB*	24 MSB*
EFI DIGITAL DIFFERENTIAL Y-AXIS		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE						DBI DIGITAL Y-AXIS	
25 LSB*	26 MSB*	27 LSB*	28 MSB*	29 LSB*	30 MSB*	31 MSB	32	33 LSB	34 S/C ANALG SBCM	35 ATTI-TUDE EVENTS SBCM	36 EFI ANT TIMED CMD MON
DBI DIGITAL X SUM		DBI DIGITAL Y SUM		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 2 A/B					
37 LSB*	38 MSB*	39 MSB	40 LSB	41 LSB*	42 MSB*	43 LSB*	44 MSB*	45 STAR MAJOR FRAME CTR	46 ATTIT MAG X SUN1/2 CCA SBCM1	47 ATTIT MAG Y SUN1/2 -SIN SBCM2	48 ATTIT MAG Z SUN1/2 COS SBCM3
EFI DIGITAL DIFFERENTIAL Z-AXIS		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		STAR MAPPER DIGITAL 16-BIT TIME					
49 EFI ANA-LOG CH 4	50 EFI ANA-LOG CH 5	51 MSB	52 LSB	53 LSB*	54 MSB*	55 MSB	56	57 LSB	58 IVI DIGI-TAL	59 LSB*	60 MSB*
		DIGITAL SUBCOM		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 3 A/B				DBI DIGITAL X-AXIS	
61 LSB*	62 MSB*	63 MSB	64 LSB	65 LSB*	66 MSB*	67 MSB	68	69 LSB	70 EXPT ANALG SBCM	71 LSB*	72 MSB*
EFI DIGITAL		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 4 A/B				DBI DIGITAL Y-AXIS	
73 LSB*	74 MSB*	75 LSB*	76 MSB*	77 LSB*	78 MSB*	79 EFI ANA-LOG CH 1	80 EFI ANA-LOG CH 2	81 EFI ANA-LOG CH 3	82 EFI ANA-LOG CH 6	83 WATI DIGI -TAL SBCM	84 WATI ANAL -LOG SBCM
DBI DIGITAL X SUM		DBI DIGITAL Y SUM		WATI DIGITAL 16-BIT SCIENCE							
85 LSB*	86 MSB*	87 MSB	88 LSB	89 LSB*	90 MSB*	91 MSB	92	93 LSB	94 FRAME SYNC HEXFA OCT 372 DBC 250		**
EFI DIGITAL DIFFERENTIAL X-AXIS		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 5 A/B					

Figure 4: Structure of the Minor Frame. The details are given in the text including the meanings of the * and the **.

interpret the values of each field. What will be given to complete the specification of each field will be the association with an instrument or spacecraft sensor or function and a name that indicates the information content that is carried by the data. This should allow a user to successfully parse the pass file. Fields that are assigned to an individual instrument will be organized by instrument. Subcommutator fields that handle multi instrument or spacecraft sensor data will be presented individually in their own separate sections. If the byte sequence is reversed from the TM minor frame field, this will be noted as 'reversed'; the other case will be denoted by 'transmitted'. The fields will be identified by forming an ID from the byte #s using ascending order. For example the first field of the minor frame will have ID = 010203.

2.2.2.1 ASSI Fields

Field ID	Short Descriptive Name	Byte Sequence
070809	Digital Channel 1 A/B	Transmitted
313233	Digital Channel 2 A/B	Transmitted
555657	Digital Channel 3 A/B	Transmitted
676869	Digital Channel 4 A/B	Transmitted
919293	Digital Channel 5 A/B	Transmitted

2.2.2.2 DBI Fields

Field ID	Short Descriptive Name	Byte Sequence
1112	Digital X-axis	Reversed
2324	Digital Y-axis	Reversed
2526	Digital X Sum	Reversed
2728	Digital Y Sum	Reversed
5960	Digital X-axis	Reversed
7173	Digital Y-axis	Reversed
7374	Digital X Sum	Reversed
7576	Digital Y Sum	Reversed

2.2.2.3 EFI Fields

Field ID	Short Descriptive Name	Byte Sequence
1314	Digital Differential Y-axis	Reversed
36	Antenna Timed Command Monitor	N/A
3738	Digital Differential Z-axis	Reversed
49	Analog Channel 4	N/A
50	Analog Channel 5	N/A
6162	Digital	Reversed

Field ID	Short Descriptive Name	Byte Sequence
79	Analog Channel 1	N/A
80	Analog Channel 2	N/A
81	Analog Channel 3	N/A
82	Analog Channel 6	N/A
8586	Digital Differential X-axis	Reversed

2.2.2.4 IVI Fields

Field ID	Short Descriptive Name	Byte Sequence
10	Analog	N/A
1516	Digital	Transmitted
3940	Digital	Transmitted
58	Digital	N/A
6364	Digital	Transmitted
8788	Digital	Transmitted

2.2.2.5 WATI Fields

Field ID	Short Descriptive Name	Byte Sequence
0506	Digital 16-Bit Science	Reversed
1718	Digital 16-Bit Science	Reversed
2930	Digital 16-Bit Science	Reversed
4142	Digital 16-Bit Science	Reversed
5354	Digital 16-Bit Science	Reversed
6566	Digital 16-Bit Science	Reversed
7778	Digital 16-Bit Science	Reversed
83	Digital Subcommutator	N/A
84	Analog Subcommutator	N/A
8990	Digital 16-Bit Science	Reversed

2.2.2.6 Spacecraft Fields

Field ID	Short Descriptive Name	Byte Sequence
010203	Frame Counter	Reversed
04	6-Bit Subcommutator	N/A
21	Spare Digital	N/A
22	Spare Digital	N/A

Field ID	Short Descriptive Name	Byte Sequence
4344	Star Mapper Digital 16-Bit Time	Reversed
45	Star Mapper Frame Counter	N/A
94	Minor Frame Sync	N/A

2.2.2.7 Sun Sensor Crossing Time Subcommutator Field 19

The counter that generates the crossing times starts at the event (sensor 'sees' the Sun)) and stops at the first minor frame boundary. Each count is equal to 2/3 ms. Counters will not reset at times; in this case the count will be higher than the maximum of 192 counts. By subtracting 192 from the counts, in this case, the correct answer will be obtained. This counter cannot be read out until the next minor frame. The non-reset situation does not alter the readout frame #

Consequently, the sun pulse occurs one or two frames earlier than its detection and readout. Sun Sensor 1 crossing times occur on odd numbered frames. Sun Sensor 2 crossing times occur on even numbered frames.

2.2.2.8 Horizon Sensor Crossing Time Subcommutator Field 20

There are two horizon sensors and two types of events. The first type of event is the sky-to-Earth (HSE) event, where the sensor first sees cold then heat. The second type of event is Earth-to-sky (HES) event, where the sensor first sees heat then cold. The HSE 1 event crossing times appear in this field for frames #s 1,5,9,....J*4 + 1,... The HES2 1 event crossing times appear in this field for frame #s 2,6,10,....,J*4 + 2 ,.... The HSE2 event crossing times appear in this field for frame #s 3, 7, 11,.....J*4 + 3, ...The HES2 crossing times appear in this field for frame #s 4, 8, 12,.....J*4,..... The crossing time counter is very similar to the sun sensor crossing time counter.

2.2.2.9 Spacecraft Analog Subcommutator Field 34

The minor frame #, using 1-64 , is given by the value of 1 + the 6-bit Subcom Counter. For clarity we show both the frame # in parentheses and the value of the 6-bit counter.

6-BIT SUBCOM CTR(+1)	USE
00(01)	S/C Command Receiver 1 AGC 3.5V = -85dbm
01(02)	S/C Command Receiver 2 AGC 3.5V = -85dbm
02(03)	TEMPERATURE 1 DBI
03(04)	TEMPERATURE 2 DBI
04(05)	TEMPERATURE 3 CONTINUOUS CONVERTER A
05(06)	TEMPERATURE 4 CONTINUOUS CONVERTER B
06(07)	TAPE RECORDER 1 PRESSURE 3V=18psi 4V=9psi
07(08)	TAPE RECORDER 1 MOTOR CURRENT 4.17ma/count
08(09)	S/C Command Receiver 1 AGC 3.5V = -85dbm
09(10)	S/C Command Receiver 2 AGC 3.5V = -85dbm
10(11)	TEMPERATURE 5 TRANSMITTER 1
11(12)	TEMPERATURE 6 TRANSMITTER 2
12(13)	TEMPERATURE 7 BATTERY 1 142 = 20 DBG
13(14)	TEMPERATURE 8 BATTERY 2 142 = 20 DBG
14(15)	BATTERY 1 CURRENT 0.01667ma/COUNT 35 = 0
15(16)	BATTERY 2 CURRENT 0.01667ma/COUNT 35 = 0
16(17)	S/C Command Receiver 1 AGC 3.5V = -85dbm
17(18)	S/C Command Receiver 2 AGC 3.5V = -85dbm
18(19)	TEMPERATURE 9 SINGLE GaAs PANEL
19(20)	TEMPERATURE 10 K7 PANEL WITH ABOVE
20(21)	SOLAR ARRAY 2 CURRENT 2.174 ma/COUNT
21(22)	SOLAR ARRAY 1 CURRENT 2.174 ma/COUNT
22(23)	TRANSMITTER 1 RF POWER MONITOR
23(24)	TRANSMITTER 2 RF POWER MONITOR
24(25)	S/C Command Receiver 1 AGC 3.5V = -85dbm
25(26)	S/C Command Receiver 2 AGC 3.5V = -85dbm
26(27)	TEMPERATURE 11 TX 1 207 COUNTS = 20 DBG
27(28)	TEMPERATURE 12 TX 1 OVERLOAD TEMPERATURE
28(29)	TEMPERATURE 11 TX 2 207 COUNTS = 20 DBG
29(30)	TEMPERATURE 12 TX 1 OVERLOAD TEMPERATURE
30(31)	TAPE RECORDER 2 PRESSURE 3V=18psi 4V=9psi
31(32)	TAPE RECORDER 2 MOTOR CURRENT 4.17ma/count

6-BIT SUBCOM CTR(+1)	USE
32(33)	S/C Command Receiver 1 AGC 3.5V = -85dbm
33(34)	S/C Command Receiver 2 AGC 3.5V = -85dbm
34(35)	SUN SENSOR 1 BIAS VOLTAGE 2.5V = NORMAL
35(36)	SUN SENSOR 2 BIAS VOLTAGE 2.5V = NORMAL
36(37)	MAGNETOMETER/VECTOR
37(38)	UNREGULATED BUS VOLTAGE 0.099V/COUNT
38(39)	SOLAR ARRAY 1 VOLTAGE 0.099V/COUNT
39(40)	BATTERY 1 VOLTAGE 0.099V/COUNT
40(41)	S/C Command Receiver 1 AGC 3.5V = -85dbm
41(42)	S/C Command Receiver 2 AGC 3.5V = -85dbm
42(43)	SOLAR ARRAY 2 VOLTAGE 0.1V/COUNT
43(44)	BATTERY 2 VOLTAGE 0.099V/COUNT
44(45)	+10 CONTINUOUS CONVERTER "A" 0.0524V/COUNT
45(46)	+10 LOW POWER "A" VOLTAGE 0.0544/COUNT
46(47)	+10 Switched Converter V/Count: 1=.0561; 2=.0547
47(48)	DBI TEST.....
48(49)	S/C Command Receiver 1 AGC 3.5V = -85dbm
49(50)	S/C Command Receiver 2 AGC 3.5V = -85dbm0
50(51)	TEMPERATURE 9 SINGLE GaAs PANEL
51(52)	TEMPERATURE 10 K7 PANEL WITH ABOVE
52(53)	+10 LOW POWER "B" VOLTAGE 0.0527V/COUNT
53(54)	+10 CONTINUOUS "B" VOLTAGE 0.0526V/COUNT
54(55)	NOT USED
55(56)	TEMPERATURE 15 SWITCH +10 CONV. BOX
56(57)	S/C Command Receiver 1 AGC 3.5V = -85dbm
57(58)	S/C Command Receiver 2 AGC 3.5V = -85dbm0
58(59)	NOT USED
59(60)	-10 CONTINUOUS CONVERTER "A" 0.0509V/COUNT
60(61)	-10 CONTINUOUS CONVERTER "B" 0.0511V/COUNT
61(62)	-10 Switched Converter V/Count: 1=.0571; 2=.0554
62(63)	0 VOLT CALIBRATION
63(64)	5 VOLT CALIBRATION

2.2.2.10 Attitude Events Field 35

The six least significant bits of this field are assigned to the horizon sensor and sun sensor events. Calling the least significant bit (lsb) Bit 1, the assignments are

STATUS: ATTITUDE EVENTS

BIT # (1-8)	USE
1	HORIZON SENSOR 1 SKY-TO-EARTH (HSE1)EVENT
2	HORIZON SENSOR 1 EARTH-TO-SKY (HES1)EVENT
3	HORIZON SENSOR 2 SKY-TO-EARTH (HSE2)EVENT

BIT # (1-8)	USE
4	HORIZON SENSOR 2 EARTH-TO-SKY (HES2)EVENT
5	SUN SENSOR 1 (SS1) EVENT
6	SUN SENSOR 2 (SS2) EVENT
7	NOT USED
8	NOT USED

The assigned bit is set to 1 when an event occurs. Since the spin period is about 10 seconds and the length of a major frame is 8.192 s, there will be at most one event of each type per major frame.

2.2.2.11 EFI Antenna Timed Antenna Deployment Field 36

STATUS: EFI TIMED ANTENNA DEPLOYMENT

BIT # (1-8)	USE
1	0.512 SEC ON TIME
2	2.04 SEC ON TIME
3	10.97 SEC ON TIME
4	60 SEC ON TIME
5	305 SEC ON TIME
6	NOT USED
7	NOT USED
8	EFI ANTENNA TIMER ENABLED

2.2.2.12 Attitude Sensors Subcommutator1 Field 46

The X-axis magnetometer and the coded coarse angle data (CCAD) from SS1 and SS2 appear in this field. The CCAD for SS1 appear in this field for frame #s 2,6,10,....J*4 + 2. The CCAD for SS2 appear in this field for frame #s 4,8,12,....J*4. The magnetometer output appears for the other frames.

2.2.2.13 Attitude Sensors Subcommutator2 Field 47

The Y-axis magnetometer and the fine angle cos data (FACD) from SS1 and SS2 appear in this field. The FACD for SS1 appears in this field for frame #s 2,6,10,....J*4 + 2. The FACD for SS2 appears in this field for frame #s 4,8,12,...J*4,..... The Y-axis magnetometer output appears for the other frames.

2.2.2.14 Attitude Sensors Subcommutator3 Field 48

The Z-axis magnetometer and the fine angle sin data (FASD) from SS1 and SS2 appear in this

field. The negative of FASD for SS1 appears in this field for frame #s 2,6,10,....J*4 + 2. The negative of FASD for SS2 appears in this field for frame #s 4,8,12,...J*4,..... The Z-axis magnetometer output appears for the other frames. It was discovered during the S/C Sun Test in October 1986 that the negative of FASD instead of FASD appeared in this field, with the wiring error being in the sun sensor unit , not in the telemetry system.

2.2.2.14 Digital Subcommutator Field 5152

6-BIT SUBCOM CTR(+1)	6-BIT SUBCOM CTR(+1)	USE
00(01)	32(33)	ASSI AUXILIARY A
01(02)	33(34)	ASSI AUXILIARY B
02(03)	34(35)	ASSI AUXILIARY A
03(04)	35(36)	ASSI AUXILIARY B
04(05)	36(37)	ASSI AUXILIARY A
05(06)	37(38)	ASSI AUXILIARY B
06(07)	38(39)	ASSI AUXILIARY A
07(08)	39(40)	ASSI AUXILIARY B
08(09)	40(41)	ASSI AUXILIARY A
09(10)	41(42)	ASSI AUXILIARY B
10(11)	42(43)	ASSI AUXILIARY A
11(12)	43(44)	ASSI AUXILIARY B
12(13)	44(45)	ASSI AUXILIARY A
13(14)	45(46)	ASSI AUXILIARY B
14(15)	46(47)	ASSI AUXILIARY A
15(16)	47(48)	ASSI AUXILIARY B
16(17)	48(49)	COMMAND VERIFY* W51 = CMND BYTE # 4** (1st byte) W52 = CMND BYTE # 5 (2nd byte)
17(18)	49(50)	COMMAND VERIFY* W51 = CMND BYTE # 6 (3rd byte) W52 = CMND BYTE # 7 (4th byte)
18(19)	50(51)	DBI STATUS
19(20)	51(52)	DBI STATUS
20(21)	52(53)	EFI MAIN BODY STATUS
21(22)	53(54)	EFI ANTENNA STATUS
22(23)	54(55)	S/C DIGITAL STATUS A SEE TABLE 2.2 ON NEXT PAGE
23(24)	55(56)	S/C DIGITAL STATUS B SEE TABLE 2.2 ON NEXT PAGE
24(25)	56(57)	S/C DIGITAL STATUS C SEE TABLE 2.2 ON NEXT PAGE
25(26)	57(58)	S/C DIGITAL STATUS D SEE TABLE 2.2 ON NEXT PAGE
26(27)	58(59)	S/C DIGITAL STATUS E NOT USED
27(28)	59(60)	S/C DIGITAL STATUS F NOT USED
28(29)	60(61)	IVI AUXILIARY DATA
29(30)	61(62)	ORC STATUS WD51/BIT 1-4 = -EXEC /BIT 5-8 = -SET WD52/BIT 1-4 = +EXEC /BIT 5-8 = +SET
30(31)	62(63)	COMMAND VERIFY* W51 = CMND BYTE # 4** (1st byte) W52 = CMND BYTE # 5 (2nd byte)
31(32)	63(64)	COMMAND VERIFY* W51 = CMND BYTE # 6 (3rd byte) W52 = CMND BYTE # 7 (4th byte)

* THE FIRST TWO AND THE LAST TWO BYTES OF THE COMMAND WORD ARE FIXED AND ARE NOT IN THE TELEMETRY FOR VERIFICATION

** BYTE 4 COMMAND VERIFY DECIMAL DECODE

		DEC 1	DEC 2			DEC 1	DEC 2
DBI	=	65	193	EFI ANTENNA	=	70	198
TEST D 2	=	66	194	ASSI 1	=	71	199
ORC PLUS	=	67	195	ASSI 2	=	73	200
ORC MINUS	=	68	196	IVI	=	74	201
EFI	=	69	197	WATI	=	75	202
				TEST D 3	=	76	203

2.2.2.15 Experiment Analog Subcommutator Field 70

6-BIT SUBCOM CTR(+1)	USE
00(01)	ASSI A IDENTIFICATION = 0.00
01(02)	ASSI B IDENTIFICATION = 5.00
02(03)	ASSI A TEMPERATURE ANALOG BOX (TAB)
03(04)	ASSI B TEMPERATURE ANALOG BOX (TAB)
04(05)	ASSI A TEMPERATURE AMPLIFIER (TV)
05(06)	ASSI B TEMPERATURE AMPLIFIER (TV)
06(07)	ASSI A TEMPERATURE (LEV)
07(08)	ASSI B TEMPERATURE (LEV)
08(09)	ASSI A HIGH VOLTAGE 1
09(10)	ASSI B HIGH VOLTAGE 1
10(11)	ASSI A HIGH VOLTAGE 2
11(12)	ASSI B HIGH VOLTAGE 2
12(13)	ASSI A +12 VOLT MONITOR
13(14)	ASSI B +12 VOLT MONITOR
14(15)	ASSI A -12 VOLT MONITOR
15(16)	ASSI B -12 VOLT MONITOR
16(17)	ASSI A +30 VOLT MONITOR
17(18)	ASSI B +30 VOLT MONITOR
18(19)	ASSI A -30 VOLT MONITOR
19(20)	ASSI B -30 VOLT MONITOR
20(21)	ASSI A TEMPERATURE TF
21(22)	ASSI B TEMPERATURE TF
22(23)	ASSI A SPARE (OPEN)
23(24)	ASSI B SPARE (OPEN)
24(25)	EFI +30 VOLT MONITOR
25(26)	EFI -30 VOLT MONITOR
26(27)	EFI +13 VOLT MONITOR
27(28)	EFI -13 VOLT MONITOR
28(29)	EFI +18 VOLT MONITOR
29(30)	EFI S/C CONTINUOUS +10 VOLT MONITOR
30(31)	EFI +10 VOLT MONITOR
31(32)	EFI MAIN BODY TEMPERATURE
32(33)	EFI PULSE AMPLIFIER TEMPERATURE
33(34)	EFI -X PULSE AMPLIFIER (10)
34(35)	EFI +Y PULSE AMPLIFIER (11)
35(36)	EFI -Y PULSE AMPLIFIER (12)
36(37)	EFI +Z PULSE AMPLIFIER (13)
37(38)	EFI -Z PULSE AMPLIFIER (14)
38(39)	EFI 28 VOLT POWER (15)
39(40)	EFI Z ANTENNA LIMIT (16)
40(41)	EFI +X DEPLOY (17)
41(42)	EFI -X DEPLOY (18)
42(43)	EFI +Y DEPLOY (19)
43(44)	EFI -Y DEPLOY (20)
44(45)	EFI +Z DEPLOY (21)
45(46)	EFI -Z DEPLOY (22)
46(47)	EFI +Z ANTENNA TEMPERATURE (23)
47(48)	EFI -Z ANTENNA TEMPERATURE (24)
48(49)	EFI +X ANTENNA TEMPERATURE (25)
49(50)	IVI SENSOR TEMPERATURE
50(51)	IVI IDM REFERENCE CURRENT
51(52)	IVI SFE TEMPERATURE
52(53)	S/C GaAs 2 CURRENT 0.647 ma/COUNT
53(54)	S/C K7 2 CURRENT 0.647 ma/COUNT
54(55)	S/C Temperature Single Solar Array K7 Panel
55(56)	STAR MAPPER +10 VOLT MONITOR
56(57)	STAR MAPPER +12 VOLT MONITOR
57(58)	STAR MAPPER -12 VOLT MONITOR
58(59)	Star Mapper High Voltage On>41 Counts = On
59(60)	Star Mapper Temperature >>Only Encoder 1<<
60(61)	Star Mapper Temperature >>Only Encoder 2<<
61(62)	DBI TEST OSCILLATOR Y
62(63)	0 VOLT CALIBRATION
63(64)	5 VOLT CALIBRATION

Within the subcommutator for certain frames the information is status information and is conveyed at the bit level. The code for these status bits is given in Table 2.2.

Table 2.2
Digital Subcom Byte #s 51/52 Status Bits

STATUS A FRAME 23, BYTE # 51

BIT # (1-8)	USE
1	TRANSMITTER 1 ON
2	TRANSMITTER 2 ON
3	TAPE RECORDER 1 ON
4	TAPE RECORDER 2 ON
5	ORC ON
6	BUS 1 CONNECT "A" (FOR "B", BIT = 0)
7	ORC SENSE "+" (FOR "-" ,BIT = 0)
8	ORC MANEUVER DISABLE

STATUS A FRAME 23, BYTE # 52

BIT # (1-8)	USE
1	PYRO 1 ENABLE
2	UVD 1 NOT ACTIVE
3	PYRO 2 ENABLE
4	UVD 2 NOT ACTIVE
5	BATTERY 1 NOT CONNECTED
6	BATTERY 2 NOT CONNECTED
7	Solar Array 1 on Battery 1 (if on Battery 2, Bit = 0)
8	Solar Array 2 on Battery 2 (if on Battery 1, Bit = 0)

STATUS B FRAME 24, BYTE # 51

BIT # (1-8)	USE
1	PREMOD FILTER 1 ON (6K)
2	PREMOD FILTER 2 ON (6K)
3	TRANSMITTER HIGHPOWER
4	TAPE RECORDER RECORD MODE ON
5	TAPE RECORDER PLAY MODE ON
6	TAPE RECORDER FAST FORWARD MODE ON
7	TAPE RECORDER 2 AT BEGINNING OF TAPE
8	TAPE RECORDER 2 AT END OF TAPE

STATUS B FRAME 24, BYTE # 52

BIT # (1-8)	USE
1	ENCODER 1 ON
2	ENCODER 2 ON
3	MAGNETOMETER ON (VIA TELEMETRY)
4	SUN SENSOR 1 ON
5	SUN SENSOR 2 ON
6	HORIZON SENSOR 1 ON
7	HORIZON SENSOR 2 ON
8	BUS 2 "B" (IF "A" ,BIT = 0)

STATUS C FRAME 25, BYTE # 51

BIT # (1-8)	USE
1	DELAY COMMAND 1 LOADED
2	DELAY COMMAND 2 LOADED
3	DELAY COMMAND 3 LOADED
4	DELAY COMMAND 2 LOADED
5	TAPE RECORDER 1 AT BEGINNING OF TAPE
6	TAPE RECORDER 1 AT END OF TAPE
7	PYRO 1 ENABLE
8	PYRO 2 ENABLE

STATUS C FRAME 25, BYTE # 52

BIT # (1-8)	USE
1	STAR MAPPER 10 VOLT SWITCH ON
2	EFI 10 VOLT SWITCH ON
3	IVI 10 VOLT SWITCH ON
4	ASSI 10 VOLT SWITCH ON
5	WATI 10 VOLT SWITCH ON
6	DECODER 1 10 VOLT SWITCH ON
7	DECODER 2 10 VOLT SWITCH ON
8	SPARE

STATUS D FRAME 26, BYTE # 51

BIT # (1-8)	USE
1	SRC ON
2	MAGNETOMETER ON (VIA SRC)
3	SRC SWITCHING "DIRECT"(IF "REV", BIT = 0)
4	SRC COIL "DIRECT" (IF "REV", BIT = 0)
5	STAR MAPPER LEAST SIGNIFICANT BYTE
6	STAR MAPPER MOST SIGNIFICANT BYTE
7	SPARE
8	STAR MAPPER POWER ON

STATUS D FRAME 26, BYTE # 52

BIT # (1-8)	USE
1	EFI MAIN BODY ON
2	EFI ANTENNA ON
3	IVI ON
4	WATI ON
5	ASSI ON
6	DBI ON
7	BUS 3 "B" (IF "A", BIT = 0)
8	EXPERIMENT POWER ON (ENABLE)

2.2.3 Major Frame Trailer

The structure of the major frame trailer is shown in Figure 5. It consists of 48 bytes broken up into twelve 4-byte fields. Values are written into all these fields by NSSDCA running program DIST. The fields all have VAX Real*4 data type. The parameters and their physical units are

6097 6098 6099 6100 S/C GEOCENTRIC ALTITUDE IN KM VAX REAL*4	6101 6102 6103 6104 S/C GEOGRAPHIC EAST LONGITUDE IN DEG VAX REAL*4
6105 6106 6107 6108 S/C GEOCENTRIC LATITUDE IN DEG VAX REAL*4	6109 6110 6111 6112 S/C LOCAL SOLAR TIME IN HRS (MEAN SUN) VAX REAL*4
6113 6114 6115 6116 S/C SOLAR ZENITH ANGLE IN DEG VAX REAL*4	6117 6118 6119 6120 MAGNETIC FIELD MAG IN GAUSS VAX REAL*4
6121 6122 6123 6124 MAGNETIC DIP EQUATOR IN DEG VAX REAL*4	6125 6126 6127 6128 S/C SPIN RATE IN DEG/SEC VAX REAL*4
6129 6130 6131 6132 S/C Z-AXIS GEOGRAPHIC LONG-TUDE IN DEG VAX REAL*4	6133 6134 6135 6136 S/C Z-AXIS GEOCENTRIC LAT-TUDE IN DEG VAX REAL*4
6137 6138 6139 6140 S/C X-AXIS GEOGRAPHIC LONG-TUDE IN DEG VAX REAL*4	6141 6142 6143 6144 END OF FILE FIELDS OUT OF KENYA TO IRMCRA OCT 371 OCT 363 OCT 040 OCT 373 HEX F9 HEX F3 HEX 20 HEX FB S/C X-AXIS GEOCENTRIC LATITUDE IN DEG OUT OF NSSDCA WITH DATA TYPE=VAX REAL*4

Figure 5: Structure of the Major Frame Trailer. The details are given in the text.

are explicitly given in Figure 5 and will not be repeated here. The two magnetic field parameters will be computed using the IGRF 1985 model extrapolated to 1988.5 as recommended by R. A Langel of Goddard Space Flight Center. The last field (6141-6144) in the major frame is unique one because it is given a value by KENYA that is changed by NSSDCA. In order t transfer the major frames from KENYA to IRMCRA without incidence end-of-file markers ar

Satellite Name	NSSDC ID	AGT	RAND Code	Identification	Launch Date	Contact	Form	Qnty	Timespan of Data		Avail
	92-038A-04B	ASCO-00018	R P 5E	SAMPEX 30s Resolution Fluxes		Mazur	DL	2	1992-07-05	2003-06-18	S
	92-038A-04B	ASCO-00018	R P 5E	SAMPEX 30s Resolution Fluxes		Mazur	KO		1992-07-05	2003-06-18	S
	92-038A-04C	ASCO-00001	R P 5E	SAMPEX 30s Fluxes, CDF		Mazur	KO		1992-07-05	2003-06-18	S
	92-038A-04D	ASCO-00002	R P 5E	SAMPEX 30s Rates,ASCII		Mazur	KO		1992-07-05	2003-05-31	S
	92-038A-04E	ASCO-00005	R P 5E	SAMPEX Polarcap Flux,ASCII		Mazur	KO		1992-07-05	2003-05-31	S
	92-038A-04F	ASCO-00003	R P 5E	SAMPEX Polarcap Flux, CDF		Mazur	KO		1992-07-05	2003-05-31	S
	92-038A-04G	ASCO-00009	R P 5E	SAMPEX Polarcap Rates, ASCII		Mazur	KO				
San Marco 1		1964-084A	DKB	San Marco 1	1964-12-15	ITALY					
	64-084A-00A	XXNO-00360	NAA 6A	Predicted World Maps		Unknown	MP	1	1964-12-15	1964-12-29	A
	64-084A-00B	XXNO-00470	NAA 6A	Refined World Maps		Unknown	MP	1	1964-12-29	1965-01-05	A
		1964-084A-01	NAA 14	San Marco 1,Atmosphere		Broglio					
		1964-084A-02	NAA 12	San Marco 1,RF Beacon		Carrara					
San Marco 2		1967-038A	DKB	San Marco 2	1967-04-26	ITALY					
	67-038A-00A	XXNO-00117	NAA 6A	Predicted World Maps		Unknown	MP	1	1967-08-11	1967-08-23	A
	67-038A-00B	XXNO-00016	NAA 6A	Refined World Maps		Unknown	MP	2	1967-04-26	1967-08-14	A
		1967-038A-01	NAA 14	San Marco 2,Radio Beacon		Broglio					
		1967-038A-02	NAA 14	San Marco 2,Air Density		Broglio					
		1967-038A-03	NAA 12	San Marco 3,20MC Beacon		Carrara					
San Marco 3		1971-036A	DKB	San Marco 3	1971-04-24	NASA-ITAL					
	71-036A-00A	XXNO-00258	NAA 6A	Predicted World Maps		Pritchett	MP	1	1971-11-23	1971-11-28	A
	71-036A-00B	XXNO-00525	NAA 6A	Refined World Maps		Pritchett	MP	6	1971-04-24	1971-11-29	A
		1971-036A-01	NAA 14	San Marco 3,Drag Balance Exp		Broglio					
		1971-036A-02	NAA 14	San Marco 3,Neut Atm Comp Spect		Newton					
		1971-036A-03	NAA 14	San Marco 3,Atm Nitrogen Density		Spencer					
San Marco 4		1974-009A	DKB	San Marco 4	1974-02-18	CRA-OAST					
	74-009A-00A	XXNO-00310	NAA 6A	Predicted World Maps		Pritchett	MP	2	1975-10-13	1976-05-06	A
	74-009A-00B	XXNO-00067	NAA 6A	Refined World Maps		Pritchett	MP	12	1974-04-14	1975-10-27	A
		1974-009A-01	NAA 14	San Marco 4,Drag Balance Exper		Broglio					
		1974-009A-02	NAA 14	San Marco 4,Neutral Atmos Comp		Newton					
		1974-009A-03	NAA 14	San Marco 4,Neutral Atmos Temp		Spencer					
San Marco-A		1964-084A	DKB	See San Marco 1	1964-12-15	ITALY					
San Marco-B		1967-038A	DKB	See San Marco 2	1967-04-26	ITALY					
San Marco-C		1971-036A	DKB	See San Marco 3	1971-04-24	NASA-ITAL					
San Marco-C-2		1974-009A	DKB	See San Marco 4	1974-02-18	CRA-OAST					
San Marco-D/L		1988-026A	DKB	San Marco-D/L	1988-03-25	NASA-CRA					
	88-026A-00D	SPIO-00238	DKB 5B	San Marco Distributed Data		Vette	DD	34			A
		1988-026A-01	DKB 14	San Marco-D/L,Drag Balance		Broglio					
	88-026A-01A	SPTH-00005	DKB 5L	DBI,1-s,Neut Dens,Bin		Arduini	DD	9			A
	88-026A-01B	SPTH-00009	DKB 5L	SM D/L,DBI, N, ASCII, online		Arduini	KF	13			A
	88-026A-01C	SPTH-00006	DKB 5L	DBI,21-s,Neut Dens,ASCII		Arduini					A
		1988-026A-02	DKB 14	San Marco-D/L,Airglow-Solar		Schmidtke					
	88-026A-02A	SOUV-00027	DKB 5H	Solar Data		Spencer	DD	1			A
	88-026A-02B	SOUV-00026	DKB 5H	SanMarco,ASSI,Flux Data,ASCII		Enninghors	DE	1	1988-03-25	1988-12-06	A
		1988-026A-03	DKB 12	San Marco-D/L,Ion Veloc Inst(IVI)		Hanson					
	88-026A-03A	SPIO-00131	NAA 5L	SM D/L,IVI, Ni,Ti,vi, ASCII, onli		Coley	DL	1	1988-04-20	1988-12-04	A
	88-026A-03A	SPIO-00131	NAA 5L	SM D/L,IVI, Ni,Ti,vi, ASCII, onli		Coley	KO		1988-04-20	1988-12-04	A
		1988-026A-04	DKB 14	San Marco-D/L,Neutral Wind		Spencer					
		1988-026A-05	DKB 12	San Marco-D/L,Electric Field		Aggson					
	88-026A-05A	SPIO-00145	DKB 5B	SM D/L,EFI AC/DC, online		Johnson	DD	12	1988-04-20	1988-12-01	A
San Marco-D/M		SANM-DM	NAA	San Marco-D/M	1983-07-01	CRA-GSFC					
Sapphire		2001-043D	NAA	Sapphire	2001-09-30	DOD					
SARA		1991-050E	NAA	SARA	1991-07-17	ESA					
SARI		SARI	CYN	SARI	FRANCE						
SAS 1		1970-107A	HKH	See Uhuru	1970-12-12	NASA-GSFC					
SAS 2		1972-091A	HKH	See SAS-B	1972-11-15	NASA-GSFC					
SAS 3		1975-037A	NAA	See SAS-C	1975-05-07	NASA-GSFC					

INFORMATION SHEET FOR INCOMING DATA

DATE DATA RECEIVED: 11/2/93

NSSDC ID: (AIM / NSDF) 88-026A-00D

SOURCE:	MATERIAL RECEIVED: (NUMBER OF SHEETS OF HARDCOPY, NUMBER 100' REELS MICROFILM, NUMBER OF MAGNETIC TAPES, NUMBER OF CD-ROMS,ETC.)
PI AND AFFILIATION:	34 mag tapes (14 C #'s)

SATELLITE NAME./NSDF NAME: SAN MARCO

EXPERIMENT NAME:

DATA SET SHORT NAME: DISTRIBUTED DATA TAPES

CONTACT: ACQUISITION SCIENTIST: DKB

FORM CODE DATA TO BE ANNOUNCED IN AIM / NSDF: DD

THESE ARE : ✓ A NEW DATA SET ___ ADDITIONS ___ REPLACEMENTS ___ OTHER

ACCESSION UNIT NUMBERS: DD-103886-919
C-031167-80

REMARKS:

DSC #871

DATA RECEIPT NOTIFICATION SENT?

Ralph Post

DATA TECHNICIAN

UNIT RECORD FILE

933.0 (1/91)

A POST PROCESSOR FOR THE LEVEL 0 FILES OF SAN MARCO D

JAMES I. VETTE AND HOWARD A. LECKNER
NSSDC, GODDARD SPACE FLIGHT CENTER

SEPTEMBER 1988

1. INTRODUCTION

It has been observed that the Level 0 processing done by machine KENYA using Program PRETRN produces some pass files that have many differences compared to that specified in the "San Marco D Distributed Data Format" document dated March 1988. Although the major difficulties occur with the real-time passes, denoted as PS files, there are some difficulties with other types of pass files. The statistics on bad files is given in Table 1, which was produced by running a diagnostic program that computed the major frame (MF) time (MFT) difference between adjacent MFs. If a file is without difficulty, it is likely that this time difference will be a constant denoted as the MF period (MFP). This constant will lie in the range 8.189 and 8.192 s for a 'good' file. Any other behavior of the MFP is a signal that something is wrong and that the file needs restructuring in almost all cases. This test cannot reveal all the MFs that may have problems, since the MFT comes from the first, or possibly the first few, minor frames (mFs). The errors in the first and second MFs as shown in Table 1 are caused by starting the pass file before the telemetry noise has diminished to the point where the bit synchronization can be established. The errors in the last MF are also caused by telemetry noise and the resulting lack of bit sync as the pass is extended to include the portion where the S/C is going over the radio horizon.

The purpose of this paper is to: (a) present a summary of all the difficulties observed to date through the illustration of PS 1101.DTT, (b) show a restuctured file to be used in place of PS 1101.DTT, and (c) recommend a post processor algorithm that should clean up the problem files, except for a few mFs.

2. BRIEF SUMMARY OF LEVEL 0 PROCESSING IN KENYA

PRETRN builds the pass file from the telemetered 64 mFs that constitute a MF of telemetry. The pass file consists of a file header of 512 bytes followed by a set of pass file MFs. These MFs consist of a 80- byte MF header, 64 mFs reduced from 96 bytes of the telemetered data to 94 bytes, by dropping the last two sync bytes of the mF, and a 48-byte MF trailer. The formats for these various structures are given in the Distributed Data Format (DDF) document referred to earlier.

PRETRN uses two buffers, one for the 32 odd and one for the32 even numbered mFs that g into building a MF. For reasons that were felt to minimize the effects of the loss of l synchronization during Level 0 processing, the buffers are not zeroed out prior to successiv filling. This results in the repetition of mFs in the next (odd or even) MF if there are not curr mFs to be read into the buffer for whatever reason (usually loss of bit sync). Some 'earlier m have been noted to migrate as far as 6 MFs, when conditions are noisy. Since the associated with a mF is inferred to be

$$UT(mF\#) = MFT + (mF\# - 1)*0.015625*MFP \qquad (1)$$

where the second term on the right hand side is in units of s and the numeric is the qu

0.128 / 8.192. As part of the Level 0 processing each MF is assigned a UT and by inference the UT at the beginning of each mF is obtained by equation (1). As such, an 'earlier mF' will have an erroneous time assignment each time it is repeated in the pass file. We do not refer to this data as noise when it has the wrong time assignment, since we reserve the term noise to mean that which is present to produce out of range values for the some of the bytes in the mF in question. Unfortunately, PRETRN does not produce a flag to indicate the repetition of a mF in a MF. To describe the exact functioning of PRETRN using its source code is not the approach of this paper. Instead a study of the output will be used to identify the important characteristics of the program and to flag its deficiencies so that the requirements for a post

Table 1. Statistics on Time Assignment Errors in San Marco Pass Files (Data Time Period: May 3 - June 24, 1988)

Item	Real Time	Tape Recorder	Totals
Number of Pass Files:			
Tested	298		172
With Error in 1st MF	291	14	305
With Error in 2nd MF	46	4	50
With Error in Last MF	23		42
With Errors in Other MFs	207		32
With No Errors			65
			239
			<137 (29.1%)

processor become clear.

3. ELEMENTS OF THE PASS FILE USED FOR DIAGNOSTICS AND POST PROCESSING

The MFT, mentioned above, is found in Bytes 53-58 of the MF header and is the most common way used to determine if a pass file is correct or needs to be reconstructed by a post processor. Although this does not detect when the last 60 or so mFs of a major frame have problems, it is not too likely that these alone would be the only ones affected. As soon as one error is found, the whole pass is subject to reconstruction. Since an abnormal change in the MFP almost always signals that bit synchronization has been lost (such as by noise causing a change in the S/C clock), it is necessary to examine the S/C clock in Bytes 1-3 of the mF to ensure that a regula monotonic counting of the clock has in fact occurred. (The numbering of the mFs will be fro 1-64, not 0-63.) If the clock shows a jump in value, then some data with predictable values mu be examined to verify whether the clock has jumped to a new state or that the data in the buff comes from a different time sequence than the surrounding mF data. The routine data to use this purpose are the magnetometer readings, which are in Bytes 46-48 of the odd mFs. A discontinuity of any of these signals (denoted by MagD) means that a new sequence of data noisy data has been put in the buffer. Usually this means that a series of 'earlier mFs' has b placed in the current MF. If the data show no discontinuity but the S/C clock has a sequence of values then a S/C clock jump has occurred. Of course the magnetometer

cannot address even mFs. Since the spin period of the S/C is around 10 s and the MFP is around 8.192 s, the only way a time jump would not produce a MagD would be if the following condition obtained

$$I = J*MFP/SP \qquad (2)$$

where SP is the spin period, J is an integer and I is within +/- 0.016 of an integer Using the values MFP = 8.1905 and SP = 10.165 the smallest values of I and J are I = 29.00718 and J = 36. The Sun crossing times, ST1 and ST2, are also useful data when high precision is desired. These data are only used for special purpose diagnostics as they do not occur often enough to address most mFs. Use of the sun sensor data requires the processing of Bytes 19 and 35 to obtain ST1 and ST2. Using these data the I in equation (2) must be within +/- 0.004 (this is limited by the SP change that occurs between daylight and dark due to the thermal expansion or contraction of the long antennas and wires). Using this precision moves the smallest values of I and J to I = 223.9999 and J = 278. This means that only for the longest tape recorder pass files (longer than 37 min.) would such a condition possibly be satisfied within the file.

There is one problem with the sun sensor crossing time counters that should be mentioned. The counts will be in error about 15% of the time due to some random electronic conditions. In about two-thirds of such cases (10% of the total) the counts are short by 64 resulting in a ST being 0.0427 s earlier than the correct time. The other 5% of the time the error is random within the limits of the mF in which the pulse occurs. For either ST1 or ST2, if the time is off from that expected by the SP by more than +/- 0.128 s, then the ST was derived from a misplaced or repeated 'earlier mF'.

The magnetometer times cannot be determined as precisely as the sun sensor times but have the advantage of operating in the dark and being available for all odd mFs. The horizon sensors could be used for high precision during the dark passes, but so far this data has not been studied for this purpose. The best way to flag repeated mFs, however, is by using the S/C clock. The S/C clock count (cc) forms the basis for nearly all of the reconstruction discussed here. The results of the test case show that the use of test data, such as the magnetometer, is only a second order contributor in identifying valid mFs. Since the use of this test data introduces a major complexity into a post processor, the data test is not recommended.

4. TERMINOLOGY USED IN STUDYING PASS FILE RECONSTRUCTION

Before presenting the case study of PS 1101.DTT, it is necessary to put down the terminolog used in the next section. The orientation will be on the mFs since a MF may consist of both goo and bad mFs. n Some of the terms are only used in the case study when the file was examine by hand. Other terms are valid both for the proposed post processor and for the case study.

DATA: Consist of the magnetometer or sun sensor data.

FNTEICC: An acronym standing for Flagged, Non-tested, Embedded, Invalid Clock Count. . T

even embedded mFs which have an invalid S/C cc have no means of being tested to see if the data are valid. Consequently, these must be flagged in a unique way. The flag that is chosen for Byte 94 is decimal 204=hexidecimal CC. The values in Bytes 4-93 remain the same as in the OPF. In the recommended post processor this category will also include the odd embedded mFs. For the case study the odd embedded mF is usually tested, so the three acronyms FTEICCI, FTEICCV, and FTEICC? are used in connection with the odd mFs.

FPICC: An acronym standing for Flagged, Padded, Invalid Clock Counter. This is used in Table 4 to denote those entries in the Gap Set when an invalid cc is present. There is no testing for data validity in the Gap Set. Since it is difficult to determine what might be the correct time for such a mF, there is no direct way to check for data validity. The flag instance in Byte 94 is decimal 255=hexadecimal FF. The data is padded so that no misuse of the original values can occur.

FPNDF: An acronym that stands for Flagged, Padded, No Data Found. This is used to distinguish those entries in Table 4 where there is no clear tie between the OPF and the RCF. In this case the bytes 4-93 must be padded. The flag instance is decimal 255=hexadecimal FF.

FPNS: An acronym that stands for Flagged, Padded, Not in a Sequence. This is used to distinguish those entries in Table 4 which have valid S/C ccs that are not in a sequence and so are part of the Gap Set. These are quite likely valid entries, but the complexity of the algorithm to retrieve them does not warrant the effort. Consequently these entries are padded and flagged in the same manner as the rest of the Gap Set, i.e., Byte 94 is set to decimal 255=hexadecimal FF.

FPNT: An acronym that stands for Flagged, Padded, Not Tested. This is used to distinguish those entries in Table 4 which are in the Gap Set and have an invalid S/C cc. Since it is not clear what the correct time for these mFs are, it is impossible to test for data validity. The flag instance of Byte 94 is the same as all other Gap Set entries; Byte 94 is set to decimal 255=hexadecimal FF.

FPXID: An acronym that stands for Flagged, Padded, Repeated Invalid or Indeterminate Data. This is used to distinguish those entries in Table 4 which are repeated data, which were invali or indeterminate in the first place,. These mFs must be part of the Gap Set and are padded s that false use will not be made of the values. The flag in Byte 94 is the same as for the rest of th Gap Set, i.e., Byte 94 is set to decimal 225=hexadecimal FF.

FPXVD: An acronym that stands for Flagged, Padded, Repeated Valid Data. This is used distinguish those entries in Table 4 which are repeated data and which were valid in the fi place. These mFs must be part of the Gap Set and are padded so that false use will not be ma of the values. The flag in Byte 94 is the same as for the rest of the Gap Set, i.e., Byte 94 is se decimal 225=hexadecimal FF.

FTEICCI: An acronym that stands for Flagged, Tested, Embedded Invalid Clock Counter, (fo to be) Invalid. This is used to distinguish those entries in Table 3 that are embedded sequence, have been tested using the test data, and have been found to contain invalid Since this category does not appear in the post processor, no flag value is assigned.

FTEICCV: An acronym that stands for Flagged, Tested, Embedded Invalid Clock Counter, to be) Valid. This is used to distinguish those entries in Table 4 that are embedde

sequence, have been tested using the test data, and have been found to contain valid data. Since this category does not appear in the post processor, no flag value is assigned.

FTEICC?: An acronym that stands for Flagged, Tested, Embedded Invalid Clock Counter, with questionable validity. This is used to distinguish those entries in Table 4 that are embedded in a sequence, have been tested using the test data, but the visual test, as opposed to the proposed analytical one, cannot determine the validity. Since this category does not appear in the post processor, no flag value is assigned.

FPXVD: An acronym that stands for Flagged Padded Repeated Valid Data. The padding occurs because there are no data available in the original pass file for the mF occupying the given time slot. What appears in the original pass file is repeated data which was valid for the original mF in which it appeared. Since it is confusing to have a previous instance in the data fields, padding (with binary zeros) is done and the flag byte is assigned the value decimal 255=hexadecimal FF.

INVALID: The data are comprised by noise and/or the correct time of the data cannot be ascertained.

OPF: An acronym that stands for original pass file. This is the file that is produced by machine KENYA in operating the program PRETRN to effect level 0 processing.

PADDED: When no valid data can be found for the time of the mF, binary zeros, appear in Bytes 4-93. The S/C clock count (cc) (Bytes 1-3) will contain its proper ordering value and the sync byte (94) will be given the value decimal 255=hexadecimal FF to denote a padded mF.

RECONSTRUCTED FILE (RCF): A pass file that contains complete MFs covering the whole time period of the pass file. Each MF consists of valid mFs and possibly some flagged frames, and/or some flagged and padded frames. The MFTs will be monotonic and the MFP will be within the acceptable limits. The S/C cc serves as a monotonic ordering and logical location number. There is a one-to-one mapping between the S/C cc and the MF#;mF#. This one-to-one mapping is not true in any pass file that needs to be restructured.

ROMO: An acronym standing for Received Out of Monotonic Order. Two sequences are monotonic order if the values of the ordering variable of the sequence that occupies the earl position in the OPF are less than the values of the second sequence. Since the S/C clo returns to 0 after the value 16777215, this modulo must be used every 24.85 days to keep correct monotonic count.

ROO: An acronym that stands for Received Out of Order. A mF is out of order in the OPF if not in the same position as in the RCF. If an mF is in the in-order position and has the same cc, it could still not be a valid mF. This case arises when the MFT is not correct.

SEQUENCE: Defined by the S/C cc which must be incremented by +1 for atleast successive mFs. The sequence is terminated when two successive values of the S/C cc are not in the sequence. Once a sequence has been established by moving to larger values sequence is extended backwards, if possible, until it is ended by two sucessive values S/C cc that are not in the sequence. Literally this is a sequence of mFs. The two mFs

break or terminate the sequence at both ends are not part of the sequence.

VALID: The data in the mF is essentially free of noise and the implicit UT assigned to this mF is correct. For the OPF this means that the mF must be in order with the RCF and the time assignment must be correct. The flag value in Byte 94 is set to decimal 250=hexadecimal FA by KENYA and is not changed for valid mFs.

VALID DATA: The data readings of the magnetometer and the sun sensor crossing times are not affected by noise and give values within the acceptable limits dependent on the time assignment. Repeated valid data might be within the acceptable limits, but usually it is known that the time of this data is incorrect and so the mF could not be labeled as 'valid'.

WRONG TIME: When the UT associated with the data in the mF using the assigned MFT is incorrect, the term 'Wrong Time' is used. This is always the case for 'earlier mFs' which appear as repeated mFs in later MFs.

5. RECONSTRUCTION OF PASS FILE PS1101.DTT

After examining this pass file using the S/C clock and the data from the magnetometers, the following approach was taken. The results of the MFP analysis for PS 1101.DTT are shown in Table 2. It can be seen there that the first MFT was absurd, and starting with MF9 and continuing through MF 16, there were some weird things occurring. From the looks of things one could suspect that the MFTs for MF2 and MF27 are correct. If this is the case, then the average MFP is 8.190478 s, which is consistent with the good MFPs in Table 2, as they are only given to an accuracy of 0.001 s. Considering the first MF as having some valid data (which will be shown to be the case later), the time interval for the whole pass file is 196.571 s, which corresponds to 25 MFs instead of the 27 shown. As a result of the procedures described in this section, one will be able to see just how altered this file is from the nominal. None of the discrepancies were flagged in the OPF.

Table 2. Major Frame Times and Periods for Pass File PS 1101.DTT

MF#	MFT(sec)*	MFT − t_o(sec)	MFP(sec)
1	31449600.000	12.743	13977612.743
2	45427212.743	20.934	8.191
3	45427220.934	29.124	8.190
4	45427229.124	37.315	8.191
5	45427237.315	45.505	8.190
6	45427245.505	53.695	8.190
7	45427253.695	70.077	16.382
8	45427270.077	53.695	-16.382
9	45427253.695	70.077	16.382
10	45427270.077	94.648	24.571
11	45427294.648	70.077	-24.571
12	45427270.077	102.838	32.761
13	45427302.838		

Table 2. Major Frame Times and Periods for Pass File PS 1101.DTT (continued)

MF#	MFT(sec)*	MFT - t_o(sec)	MFP(sec)
14	45427270.077	70.077	-32.761
15	45427311.029	111.029	40.952
16	45427270.077	70.077	-40.952
17	45427319.219	119.219	49.142
18	45427327.410	127.410	8.191
19	45427335.600	135.600	8.190
20	45427343.791	143.791	8.191
21	45427351.981	151.981	8.190
22	45427360.171	160.171	8.190
23	45427368.362	168.362	8.191
24	45427376.552	176.552	8.190
25	45427384.743	184.743	8.191
26	45427392.933	192.933	8.190
27	45427401.124	201.124	8.191

*Time in s since 0000 UT on 1 Jan 87
t_o = 45427200 s corresponding to 1840 UT on 9 Jun 88

Sequences of mFs were determined (and extended backwards), as defined in the previous section. The sequences were then merged using end point S/C cc values. Repeated values of any S/C cc were eliminated and a monotonic ordering of the sequences was done. The results of these operations on PS1101.DTT are shown in Table 3 where the Reduced Sequence Set (RSS) is identified. The next step was to examine the RSS to identify the embedded invalid S/C cc mFs and test them for data validity under the assumption that the time of the mF is midway between the time of its two adjacent mFs. The S/C cc was then converted to the proper monotonic value and the mF was flagged based on the test data. In this case study only visua comparisons were made and the recommendation is made here to ignore this test for routin reconstruction. For important situations, for example,if some of the sequential data is suspec the magnetometer data from valid regions could be used to establish what are the expecte values in the region of interest. Standard statistical methods could be employed to decide whi data are valid. Sun sensor crossing time data could also be used for validity checks where t S/C cc is invalid or additional confirmation is needed. The results of this operation are a shown in Table 3. In only one visual data case was it impossible to establish data validity invalidity. In three cases data validity was found and 10 cases showed invalid Consequentially, in about 75% of the cases tested the data had been comprised by noise al with the S/C cc. The summary statistics at the bottom of Table 3 will be discussed later after T 4 has been presented and discussed.

Using the 25 MFs that are needed for the RCF, the whole set of monotonic S/C ccs cou written down. The values start at 1549056 and run to 1550655. For all the S/C cc where data do not exist the mFs are padded. This operation results in left half of Table 4 where C A contains the mF number, Column B is the MFT-t_o (t_o is given in the legend of the table MFP is in Column C (this column is also used, where possible, to indicate the sequence number for the RCF mF in order to follow these entities better in the table), the adjusted S/

Table 3. Case Study PS 1101.DTT Statistics

	A	B	C	D
1	Non-overlapping	Sequences	Number of Minor Frames	Embedded Invalid S/C cc Minor
2	in Monotonic Order		Contained in the Sequence	Frames in the Sequence
3	**********		**********	**********
4	Adjusted S/C Clock Counts		Adjusted S/C Clock Counts	Adjusted S/C Clock Counts
5	Starting	Ending		
6	73	197	125	83;87;100;168;189
7	200	211	12	202;206;208;210
8	234	259	26	235;237;243;246;251;256
9	267	275	9	269;273
10	278	290	13	280;289
11	305	316	12	309;315
12	321	326	6	323;
13	336	443	108	337;342;348
14	458	470	13	
15	508	521	14	516;
16	535	552	18	544;551
17	555	568	14	
18	571	574	4	
19	600	612	13	602;608
20	620	623	4	
21	659	682	24	668;
22	701	732	32	715;717;728
23	746	780	35	769;
24	785	811	27	787;792;806
25	819	860	42	821;826;833;846;849;853;858
26	869	892	24	881;885
27	900	920	21	915;
28	928	1655	728	
29				1324
30	mFs in Reduced Sequences Set			1276
31	Definitely Valid mFs in Reduced Sequences Set			32
32	Invalid mFs in Embedded mFs by Visual Inspection			13
33	Embedded mFs with no Validity Resolution			3
34	Embedded mFs with Valid Data determined visually			276
35	mFs in Gap Set; these require Padding			327
36	mFs that are Repeated Data in the OPF			32
37	Non-embedded mFs with Invalid S/C cc			11
38	Valid mFs in the Gap Set, therefore not in a Sequence			1600
39	Total mFs in Reconstructed File (~ 80% are valid)			1728
40	Total mFs in Original Pass File (~ 75% have valid data;			
41	but only ~ 57 % have the proper time associated with them)			

(obtained by subtracting 154900 from the S/C cc) is in Column D, and Column E contains comments. This latter column is used to indicate whether the mFs listed on a line are valid, flagged and padded, or just flagged . The mFs within a MF are grouped into the categories used in Column E and matched in number with mFs of other categories used in the OPF , which constitutes the right half of Table 4.

The Columns F-I correspond to Columns B-E but are for the OPF. Since the S/C cc does not order the OPF, the MF;mF position is used to bring the RCF and the OPF into a mF-by-mF comparison. The OPF is ordered exactly as it was received from KENYA. For those S/C cc in Column H which are preceded by an asterick or exceed four digits no adjustment has been made; these are the actual values received.

Using the data it was determined what the properties of each sequence were. These are listed in column I. Since the latter part of the OPF beginning with MF17 was correct, it was possible to assign a time to the first MF that was consistent with the rest of the file. The RCF was then laid out in column D starting the adjusted S/C clock at 56 so that as it counted correctly through to 1655, it would order the RCF correctly. All mFs of the RCF are either valid , flagged and padded, or flagged. In reality the valid entries are flagged with the original value of decimal 250=hexadecimal FA for Byte 94. The comments in column E give some additional information but this does not alter the three basic categories. All six type of comments in Column E pertaining to flagged and padded begin with FP and carry the same flag value. The flagged comments are three in number, i.e., FNTEICC, FTECCI, and FTEICCV. The comment FTEICC? becomes either FTEICCI or FTEICCV when the test is performed. If the data tests are not performed, all of these fold into the FNTEICC category. If the data tests are not performed, all of these fold into the FNTEICC category. The table is laid out so that by looking on the same line of the table the S/C-clock- numbered mF in the OPF and the correctly ordered mF for the RCF are seen together. Later in Table 5 the mapping function from the RCF location to the OPF location will be presented and discussed.

6. DISCUSSION OF THE PASS FILE

Obviously, the first 17 mFs of the OPF were received before bit sync had been established a form Gap Set 1. In the RCF these are padded without testing and the comment FPNT appears Column E. The partial sequence 73-119 had the wrong time since the MFT was erroneou Starting with MF2 the correct MFT was assigned up through MF7 but MFTs for MF8-12 w incorrect. It becomes confusing to continue in this way much further because eventually two M from the OPF are not needed. By studying the MFs that have erroneous MFTs one comes t possible hypothesis that PRETRN determined the MFT by using only the S/C cc of mF1. If value is very far off (say by hours), then PRETRN does not change the MFT, leaving the bu unchanged. This is the hypothetical reason that one sees a repeat of the 70.077-s MFT in T 2 for 4 alternate frames after it first appears. This suggests that the MF header shoul considered as a part of mF1, particularly as concerns the MFT. Thus if a MF in the RCF starts other than a valid mF, the MF header should be padded. Otherwise, the MF header found i OPF associated with an mF1 must be used for the header. Whether or not the header is pa the UT assigned to the RCF MF must be written in Bytes 59-64. IRMCRA may wish to chang entry for a tape recorded OPF, if their S/C clock correction differs from that of KENYA.

Table 4. Reconstructed File PS 1101.DTT

	A	B	C	D	E	F	G	H	I
469		******* RECONSTRUCTED FILE**********					AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF#	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
1	1	4.553	GAP1	56-72	FPNT	Dec31,87		*0	17 mFs of invalid data @ 0000 UT
2	1		SEQ1	73-82	Valid			73-82	Valid
3	1		SEQ1	83	FNTEICC			1548827	Invalid S/C cc; Even mF ; can't test
4	1		SEQ1	84-86	Valid			84-86	Valid
5	1		SEQ1	87	FNTEICC			1418015	Invalid S/C cc; Even mF ; can't test
6	1		SEQ1	88-99	Valid			88-99	Valid
7	1		SEQ1	100	FTEICCV			1418028	Invalid S/C cc; data tested valid
8	1		SEQ1	101-119	Valid			101-119	Valid
9	2	12.743	8.190	120-167	Valid	12.743	8.190	120-167	Valid
10	2		SEQ1	168	FTEICC?			1517424	Invalid S/C cc; Inconclusive data tes
11	2		SEQ1	169-183	Valid			169-183	Valid
12	3	20.933	8.190	184-188	Valid	20.934	8.191	184-188	Valid
13	3		SEQ1	189	FNTEICC			70277	Invalid S/C cc; Even mF ; can't test
14	3		SEQ1	190-197	Valid			190-197	Valid
15	3		GAP2	198	FPNT			1371022	Invalid S/C cc; Test data not tested
16	3		GAP2	199	FPNT			15442821	Invalid S/C cc; Even mF ; can't tes
17	3		SEQ2	200-201	Valid			200-201	Valid
18	3		SEQ2	202	FTEICCI			1548818	Invalid after data test
19	3		SEQ2	203-205	Valid			203-205	Valid
20	3		SEQ2	206	FTEICCI			3098454	Invalid after data test
21	3		SEQ2	207	Valid			207	Valid
22	3		SEQ2	208	FTEICCI			3098456	Invalid after data test
23	3		SEQ2	209	Valid			209	Valid
24	3		SEQ2	210	FTEICCI			3098458	Invalid after data test
25	3		SEQ2	211	Valid			211	Valid
26	3		GAP3	212-213	FPXVD			84-85	Repeated valid data from MF 1
27	3		GAP3	214	FPNS			214	Valid
28	3		GAP3	215	FPICC			3580575	Invalid S/C cc; Even mF ; can't
29	3		GAP3	216-217	FPNS			216-217	Valid
30	3		GAP3	218-224	FPXVD			90-96	Repeated valid data from MF 1
31	3		GAP3	225-226	FPNS			225-226	Valid
32	3		GAP3	227	FPXVD			99	Repeated valid data from MF
33	3		GAP3	228	FPXID			1418028	Repeated valid data from MF
34	3		GAP3	229-233	FPXVD			101-105	Repeated valid data from MF
35	3		SEQ3	234	Valid			234	Valid
36	3		SEQ3	235	FTEICCI			107	Repeated valid data from MF
37	3		SEQ3	236	Valid			236	Valid
38	3		SEQ3	237	FNTEICC			1188533	Invalid S/C cc; Even mF ; ca
39	3		SEQ3	238-242	Valid			238-242	Valid
40	3		SEQ3	243	FNTEICC			15222715	Invalid S/C cc; Even mF ; c
41	3		SEQ3	244-245	Valid			244-245	Valid
42	3		SEQ3	246	FTEICCI			1418174	Invalid after data test
43	3		SEQ3	247	Valid			247	Valid
44	4	29.124	8.191	248-250	Valid	29.124	8.190	248-250	Valid
45	4		SEQ3	251	FTEICCI			187	Repeated valid data from

Table 4. Reconstructed File PS 1101.DTT (cont. 1)

	A	B	C	D	E	F	G	H	I
469		******* RECONSTRUCTED FILE********					AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF#	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
46	4		SEQ3	252-255	Valid			252-255	Valid
47	4		SEQ3	256	FTEICCI			1757640	Invalid after data test
48	4		SEQ3	257-259	Valid			257-259	Valid
49	4		GAP4	260-266	FPXVD			132-138	Repeated valid data from MF2
50	4		SEQ4	267-268	Valid			267-268	Valid
51	4		SEQ4	269	FNTEICC			5743573	Invalid S/C cc; Even mF ; can't test
52	4		SEQ4	270-272	Valid			270-272	Valid
53	4		SEQ4	273	FNTEICC			1417561	Invalid S/C cc; Even mF ; can't test
54	4		SEQ4	274-275	Valid			274-275	Valid
55	4		GAP5	276-277	FPXVD			148-149	Repeated valid data from MF2
56	4		SEQ5	278-279	Valid			278-279	Valid
57	4		SEQ5	280	FTEICCV			3515360	Invalid S/C cc; data tested valid
58	4		SEQ5	281-288	Valid			281-288	Valid
59	4		SEQ5	289	FNTEICC			9937833	Invalid S/C cc; Even mF ; can't tes
60	4		SEQ5	290	Valid			290	Valid
61	4		GAP6	291	FPICC			1418155	Invalid S/C cc; Even mF ; can't te
62	4		GAP6	292-293	FPXVD			164-165	Repeated valid data from MF2
63	4		GAP6	294	FPICC			16110062	Invalid
64	4		GAP6	295	FPXVD			167	Repeated valid data from MF2
65	4		GAP6	296	FPXID			1517424	Repeated indeterminate data fro
66	4		GAP6	297-301	FPXVD			169-173	Repeated valid data from MF2
67	4		GAP6	302	FPICC			774646	Invalid
68	4		GAP6	303	FPICC			774647	Invalid S/C cc; Even mF ; can't
69	4		GAP6	304	FPXVD			176	Repeated valid data from MF2
70	4		SEQ6	305-308	Valid			305-308	Valid
71	4		SEQ6	309	FTEICCI			181	Repeated valid data from MF2
72	4		SEQ6	310-311	Valid			310-311	Valid
73	5	37.314	8.190	312-314	Valid	37.315	8.191	312-314	Valid
74	5		SEQ6	315	FNTEICC			594435	Invalid S/C cc; Even mF ; con
75	5		SEQ6	316	Valid			316	Valid
76	5		GAP7	317	FPXID			70277	Repeated indeterminate data
77	5		GAP7	318-319	FPXVD			190-191	Repeated valid data from MF
78	5		GAP7	320	FPICC			774664	Invalid
79	5		SEQ7	321-322	Valid			321-322	Valid
80	5		SEQ7	323	FNTEICC			11010507	Invalid S/C cc; Even mF ; co
81	5		SEQ7	324-326	Valid			324-326	Valid
82	5		GAP8	327	FPXID			15442831	Repeated indeterminate de
83	5		GAP8	328	FPICC			1451024	Invalid
84	5		GAP8	329	FPICC			1483793	Invalid S/C cc; Even mF ;
85	5		GAP8	330	FPICC			1548818	Invalid
86	5		GAP8	331-333	FPXVD			203-205	Repeated valid data from
87	5		GAP8	334	FPXID			3098454	Repeated invalid data fro
88	5		GAP8	335	FPXVD			207	Repeated valid data from
89	5		SEQ8	336	Valid			336	Valid
90	5		SEQ8	337	FTEICCI			209	Repeated valid data from

Table 4. Reconstructed File PS 1101.DTT (cont. 2)

	A	B	C	D	E	F	G	H	I
469		*******	RECONSTRUCTED FILE*******			******* AS RECEIVED FROM KENYA**********			
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF#	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
91	5		SEQ8	338-341	Valid			338-341	Valid
92	5		SEQ8	342	FTEICCI			214	Repeated valid data from MF3
93	5		SEQ8	343-347	Valid			343-347	Valid
94	5		SEQ8	348	FTEICCI			92	Repeated valid data from MF1
95	5		SEQ8	349-375	Valid			349-375	Valid
96	6	45.505	8.191	376-439	Valid	45.505	8.190	376-439	Valid
97	7	53.695	8.190	440-443	Valid	53.695	8.190	440-443	Valid
98	7		GAP9	444-451	FPNDF			508-515	Valid data out of order; ROM0
99	7		GAP9	452	FPNDF			1377356	Invalid
100	7		GAP9	453-457	FPNDF			517-21	Valid data out of order; ROM0
101	7		SEQ9	458-470	Valid			458-470	Valid
102	7		GAP10	471-479	FPNDF			535-543	Valid data out of order ;ROM0
103	7		GAP10	480	FPNS			480	Valid
104	7		GAP10	481-486	FPNDF			545-550	Valid data out of order-wrong T,
105	7		GAP10	487	FPXYD			359	Repeated valid data from MF5
106	7		GAP10	488	FPNDF			552	Valid data out of order-wrong T,
107	7		GAP10	489	FPNDF			3253489	Invalid S/C cc; Even mF ; can't te
108	7		GAP10	490	FPNDF			1516786	Invalid S/C cc; Test data not test
109	7		GAP10	491-503	FPNDF			555-567	Valid data out of order-wrong T
110	8	61.886	8.191	504	FPNDF	70.077	16.382	568	Valid data out of order-wrong T
111	8		GAP10	505	FPNDF			262145	Invalid S/C cc; Even mF ; can't t
112	8		GAP10	506	FPNDF			634	Invalid
113	8		GAP10	507	FPNDF			571	Valid data out of order-wrong T
114	8		SEQ10	508-510	Valid,R00			572-574	Valid data out of order-wrong T
115	8		SEQ10	511	Valid,R00			774791	Invalid S/C cc; Even mF ; can't
116	8		SEQ10	512	Valid,R00			3099272	Invalid
117	8		SEQ10	513	Valid,R00			577	Valid data out of order ;not in a
118	8		SEQ10	514-515	Valid,R00			642-643	Valid data out of order ;not in a
119	8		SEQ10	516 IS/Ccc	FTEICCI			774796	Invalid after data test
120	8		SEQ10	is1377356					
121	8		SEQ10	517	Valid,R00			774797	Invalid S/C cc; Even mF ; can't
122	8		SEQ10	518-521	Valid,R00			390-393	Repeated valid data from MF6
123	8		GAP11	522-524	FPNDF			394-396	Repeated valid data from MF6
124	8		GAP11	525-526	FPNDF			589-590	Valid data out of order ;not in
125	8		GAP11	527	FPNDF			774807	Invalid S/C cc; Even mF ; can'
126	8		GAP11	528	FPNDF			592	Valid data out of order ;not in
127	8		GAP11	529-531	FPNDF			401-403	Repeated valid data from MF6
128	8		GAP11	532	FPNDF			774812	Invalid
129	8		GAP11	533	FPNDF			774813	Invalid S/C cc; Even mF ; can
130	8		GAP11	534	FPNDF			406	Repeated valid data from MF
131	8		SEQ11	535	Valid,R00			407	Repeated valid data from MF
132	8		SEQ11	536-537	Valid,R00			600-601	Valid data out of order-wron
133	8		SEQ11	538	Valid,R00			16002402	Invalid after data test
134	8		SEQ11	539-543	Valid,R00			603-07	Valid data out of order-wron
135	8		SEQ11	544 IS/Ccc	FTEICCI			416	Repeated valid data from MF

Table 4. Reconstructed File PS 1101.DTT (cont. 3)

	A	B	C	D	E	F	G	H	I
469		*******	RECONSTRUCTED FILE*******			********	AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF*	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
136	8		SEQ11	is 480				609-612	Valid data out of order-wrong T,MF
137	8		SEQ11	545-548	Valid,R00			421-422	Repeated valid data from MF6
138	8		SEQ11	549-550	Valid,R00			423	Repeated valid data from MF6
139	8		SEQ11	551 IS/Ccc	FTEICCI				
140	8		SEQ11	is 359				424	Repeated valid data from MF6
141	8		SEQ11	552	Valid,R00			425-426	Repeated valid data from MF6
142	8		GAP12	553-554	FPNDF			427	Repeated valid data from MF6
143	8		SEQ12	555	Valid,R00			620-623	Valid data out of order-wrong T,MF
144	8		SEQ12	556-559	Valid,R00			432-439	Repeated valid data from MF6
145	8		SEQ12	560-567	Valid,R00			*0	Invalid
146	9	70.076	8.190	568	Valid,R00	53.695	-16.382	697	Invalid S/C cc; Even MF; can't test
147	9		GAP13	569	FPNDF			442	Repeated valid data MF7
148	9		GAP13	570	FPNDF			443	Repeated valid data MF7
149	9		SEQ13	571	Valid,R00			1385796	Invalid S/C cc; Test data not tested
150	9		SEQ13	572	Valid,R00			509-510	Repeated valid data MF7
151	9		SEQ13	573-574	Valid,R00			511-512	Repeated valid data MF7
152	9		GAP14	575-576	FPNDF			513	Repeated valid data MF7
153	9		GAP14	577	FPNS			514-515	Repeated valid data MF7
154	9		GAP14	578-579	FPNDF			1377356	Repeated invalid data MF7
155	9		GAP14	580	FPNDF			517-521	Repeated valid data MF7
156	9		GAP14	581-585	FPNDF			458	Repeated valid data MF7
157	9		GAP14	586	FPNDF			651	Wrong time; valid data not in a sec
158	9		GAP14	587	FPNDF			460-461	Repeated valid data MF7
159	9		GAP14	588-589	FPNS			462	Repeated valid data MF7
160	9		GAP14	590	FPNS			463	Repeated valid data MF7
161	9		GAP14	591	FPXYD			464	Repeated valid data MF7
162	9		GAP14	592	FPNS			465-466	Repeated valid data MF7
163	9		GAP14	593-594	PDNDF			659-663	Wrong time;valid data out of orde
164	9		GAP14	595-599	PDNDF			664-665	Wrong time;valid data out of orde
165	9		SEQ14	600-601	Valid,R00			666	Wrong time;valid data out of orde
166	9		SEQ14	602 IS/Ccc	FTEICCI				
167	9		SEQ14	16002402				667	Wrong time;valid data out of ord
168	9		SEQ14	603	Valid,R00			540	Repeated valid data MF7
169	9		SEQ14	604	Valid,R00			669-671	Wrong time;valid data out of ord
170	9		SEQ14	605-607	Valid,R00			672	Wrong time;valid data out of ord
171	9		SEQ14	608	FTEICCI			673-676	Wrong time;valid data out of ord
172	9		SEQ14	609-612	Valid,R00			677-682	Wrong time;valid data out of ord
173	9		GAP15	613-618	FPNDF			555	Repeated valid data MF7
174	9		GAP15	619	FPNDF			556-559	Repeated valid data MF7
175	9		SEQ15	620-623	Valid,R00			560	Repeated valid data MF7
176	9		GAP16	624	FPNDF			774841	Invalid S/C cc; Even mF; can't t
177	9		GAP16	625	FPNDF			774842	Invalid after data test
178	9		GAP16	626	FPNDF			563-567	Repeated valid data MF7
179	9		GAP16	627-631	FPNDF			*0	Invalid S/C cc; Test data not tes
180	10	78.267	8.191	632	FPNDF	70.077	16.382		

Table 4. Reconstructed File PS 1101.DTT (cont. 4)

	A	B	C	D	E	F	G	H	I
469		*******	RECONSTRUCTED FILE******			********	AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF*	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
181	10		GAP16	633	FPXID			262145	Repeated indeterminate data from MF
182	10		GAP16	634	FPXID			634	Repeated invalid data from MF8
183	10		GAP16	635-36	FPNDF			571-572	Repeated valid data from MF8
184	10		GAP16	637-50	FPNDF			701-714	Wrong time;valid data out of order
185	10		GAP16	651	FPNS			774867	Invalid S/C cc; Even mF; can't test
186	10		GAP16	652	FPNDF			716	Wrong time;valid data out of order
187	10		GAP16	653	FPNDF			1483029	Invalid S/C cc; Even mF; can't test
188	10		GAP16	654-658	FPNDF			718-722	Wrong time;valid data out of order
189	10		SEQ16	659-663	Valid,R00			723-727	Wrong time;valid data out of order
190	10		SEQ16	664	Valid,R00			600	Repeated valid data from MF 8
191	10		SEQ16	665-667	Valid,R00			729-731	Wrong time;valid data out of order
192	10		SEQ16	668	FTEICCI			732	Wrong time;valid data out of order
193	10		SEQ16	669-671	Valid,R00			605-607	Repeated valid data from MF6
194	10		SEQ16	672	Valid,R00			416	Repeated valid data from MF8
195	10		SEQ16	673-674	Valid,R00			609-610	Repeated valid data from MF8
196	10		SEQ16	675	Valid,R00			761579	Invalid S/C cc; Even mF; can't test
197	10		SEQ16	676	Valid,R00			612	Repeated valid data from MF8
198	10		SEQ16	677-681	Valid,R00			421-425	Repeated valid data MF6
199	10		SEQ16	682	Valid,R00			426	Repeated valid data MF6
200	10		GAP17	683-695	FPDNF			747-759	Wrong time;valid data out of order
201	11	86.457	8.190	696-700	FPDNF	94.648	24.571	760-764	Wrong time;valid data out of order
202	11		SEQ17	701-704	Valid,R00			765-768	Wrong time;valid data out of order
203	11		SEQ17	705	Valid,R00			705	Invalid S/C cc; Even mF; can't test
204	11		SEQ17	706-714	Valid,R00			770-778	Wrong time;valid data out of order
205	11		SEQ17	715 IS/Ccc	FNTEICC			779	Wrong time;valid data out of order
206	11		SEQ17	is774867					
207	11		SEQ17	716	Valid,R00			780	Wrong time;valid data out of order
208	11		SEQ17	717 IS/Ccc	FNTEICC			461	Repeated valid data from MF7
209	11		SEQ17	is1483029					
210	11		SEQ17	718-722	Valid,R00			462-466	Repeated valid data from MF7
211	11		SEQ17	723-727	Valid,R00			659-663	Repeated valid data from MF9
212	11		SEQ17	728	FTEICCI			664	Repeated valid data from MF9
213	11		SEQ17	729-731	Valid,R00			665-667	Repeated valid data from MF9
214	11		SEQ17	732	Valid,R00			540	Repeated valid data from MF7
215	11		GAP18	733-745	FPNDF			669-681	Repeated valid data from MF9
216	11		SEQ18	746	Valid,R00			682	Repeated valid data from MF9
217	11		SEQ18	747-752	Valid,R00			555-560	Repeated valid data from MF7
218	11		SEQ18	753-754	Valid,R00			7741841-42	Repeated indeterminate data from
219	11		SEQ18	755-759	Valid,R00			563-567	Repeated valid data from MF7
220	12	94.648	8.191	760	Valid,R00	70.077	-24.571	1442816	Invalid
221	12		SEQ18	761	Valid,R00			262145	Repeated indeterminate data from
222	12		SEQ18	762	Valid,R00			634	Repeated invalid data from MF8
223	12		SEQ18	763	Valid,R00			571	Repeated valid data from MF8
224	12		SEQ18	764	Valid,R00			*4	Invalid
225	12		SEQ18	765-768	Valid,R00			701-704	Repeated valid data from MF10

Table 4. Reconstructed File PS 1101.DTT (cont. 5)

	A	B	C	D	E	F	G	H	I
469		*******	RECONSTRUCTED FILE******			********	AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF*	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
226	12		SEQ18	769 IS/Ccc	FNTEICC			705	Repeated valid data from MF10
227	12		SEQ18	is 705					
228	12		SEQ18	770-775	Valid,R00			706-711	Repeated valid data from MF10
229	12		SEQ18	776	Valid,R00			*6800	Invalid
230	12		SEQ18	777-778	Valid,R00			713-714	Wrong time;repeated valid data MF1
231	12		SEQ18	779	Valid,R00			774867	Invalid S/C cc; Even mF ; can't test
232	12		SEQ18	780	Valid,R00			716	Repeated valid data from MF10
233	12		GAP19	781	FPNDF			1483029	Invalid S/C cc; Even mF ; can't test
234	12		GAP19	782	FPNS			782	Wrong time ;valid data not in a seq.
235	12		GAP19	783	FPNDF			*9687	Invalid S/C cc; Even mF ; can't test
236	12		GAP19	784	FPNDF			500184	Invalid S/C cc; Test data not tested
237	12		SEQ19	785-786	Valid,R00			785-786	Wrong time;valid data in right MF
238	12		SEQ19	787	FTEICCI			723	Repeated valid data from MF10
239	12		SEQ19	788-791	Valid,R00			788-791	Wrong time;valid data in right MF
240	12		SEQ19	792	FTEICCI			*32	Invalid after data test
241	12		SEQ19	793-805	Valid,R00			793-805	Wrong time;valid data in right MF
242	12		SEQ19	806	FTEICCI			422	Repeated valid data from MF6
243	12		SEQ19	807-811	Valid,R00			807-811	Wrong time;valid data in right MF
244	12		GAP20	812-817	FPXVD			748-753	Repeated valid data from MF10
245	12		GAP20	818	FPICC			774906	Invalid
246	12		SEQ20	819-820	Valid			819-820	Wrong time;valid data in right MF
247	12		SEQ20	821	FNTEICC			15457661	Invalid S/C cc; Even mF ; can't test
248	12		SEQ20	822-823	Valid			822-823	Wrong time;valid data in right MF
249	13	102.838	8.190	824-825	Valid	102.838	32.761	824-825	Valid
250	13		SEQ20	826	FTEICCI			1484290	Invalid after data test
251	13		SEQ20	827-832	Valid			827-832	Valid
252	13		SEQ20	833	FTEICCI			705	Repted indeterminate data from MF
253	13		SEQ20	834-845	Valid			834-845	Valid
254	13		SEQ20	846	FTEICCI			462	Repeated valid data MF7
255	13		SEQ20	847-848	Valid			847-848	Valid
256	13		SEQ20	849	FNTEICC			1311769	Invalid S/C cc; Even mF ; can't test
257	13		SEQ20	850-852	Valid			850-852	Valid
258	13		SEQ20	853	FTEICCI			661	Repeated valid data from MF9
259	13		SEQ20	854-857	Valid			854-857	Valid
260	13		SEQ20	858	FTEICCV			14132770	Invalid S/C cc; data tested valid
261	13		SEQ20	859-860	Valid			859-60	Valid
262	13		GAP21	861-868	FPXVD			669-676	Repeated valid data from MF9
263	13		SEQ21	869-874	Valid,R00			677-682	Repeated valid data from MF9
264	13		SEQ21	875-877	Valid,R00			555-557	Repeated valid data from MF7
265	13		SEQ21	878	Valid,R00			15227382	Invalid
266	13		SEQ21	879-880	Valid,R00			559-560	Repeated valid data from MF7
267	13		SEQ21	881	FTEICCI			774841	Repeated indeterminate data from
268	13		SEQ21	882	Valid,R00			774842	Repeated invalid data from MF9
269	13		SEQ21	883-884	Valid,R00			563-564	Repeated valid data from MF7
270	13		SEQ21	885	FTEICCI			565	Repeated valid data from MF7

Table 4. Reconstructed File PS 1101.DTT (cont. 6)

	A	B	C	D	E	F	G	H	I
469		*******	RECONSTRUCTED FILE******			********	AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF#	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
271	13		SEQ21	886-887	Valid,R00			566-567	Repeated valid data from MF7
272	14	111.029	8.191	888	Valid,R00	70.077	-32.761	*1024	Invalid
273	14		SEQ21	889	Valid,R00			262145	Repeated indeterminate data from MI
274	14		SEQ21	890	Valid,R00			15227330	Invalid
275	14		SEQ21	891	Valid,R00			571	Repeated valid data from MF8
276	14		SEQ21	892	Valid,R00			*4	Repeated invalid data from MF12
277	14		GAP22	893-899	FPNDF			701-707	Repeated valid data from MF10
278	14		SEQ22	900-903	Valid,R0S			708-711	Repeated valid data from MF10
279	14		SEQ22	904	Valid,R00			*6800	Repeated invalid data from MF12
280	14		SEQ22	905-906	Valid,R00			713-714	Repeated valid data from MF10
281	14		SEQ22	907	Valid,R00			774931	Invalid S/C cc; Even mF; can't test
282	14		SEQ22	908	Valid,R00			716	Repeated valid data from MF10
283	14		SEQ22	909	Valid,R00			1483029	Repted indeterminate data from MF
284	14		SEQ22	910	Valid,R00			782	Repeated valid data from MF12
285	14		SEQ22	911	Valid,R00			*9687	Repted indeterminate data from MF
286	14		SEQ22	912	Valid,R00			500184	Repted indeterminate data from MF
287	14		SEQ22	913-914	Valid,R00			785-786	Repeated valid data from MF12
288	14		SEQ22	915	FTEICCI			723	Repeated valid data from MF10
289	14		SEQ22	916-919	Valid,R00			788-791	Repeated valid data from MF12
290	14		SEQ22	920	Valid,R00			*32	Repeated invalid data from MF12
291	14		GAP23	921-927	FPNDF			793-799	Repeated valid data from MF12
292	14		SEQ23	928-932	Valid,R00			800-804	Repeated valid data from MF12
293	14		SEQ23	933-944	Valid,R00			869-880	Wrong time;valid data
294	14		SEQ23	945	Valid,R00			753	Repeated valid data from MF10
295	14		SEQ23	946-948	Valid,R00			882-884	Wrong time;valid data
296	14		SEQ23	949	Valid,R00			15457661	Repted indeterminate data from MF
297	14		SEQ23	950-951	Valid,R00			886-887	Wrong time;valid data
298	15	119.219	8.190	952-956	Valid,R00	111.029	40.952	888-892	Wrong time;valid data
299	15		SEQ23	957-960	Valid,R00			829-832	Repeated valid data from MF13
300	15		SEQ23	961	Valid,R00			705	Repted indeterminate data from MF
301	15		SEQ23	962-973	Valid,R00			834-835	Repeated valid data from MF13
302	15		SEQ23	974	Valid,R00			462	Repeated valid data from MF7
303	15		SEQ23	975-976	Valid,R00			847-848	Repeated valid data from MF13
304	15		SEQ23	977	Valid,R00			1311769	Repted indeterminate data from MF
305	15		SEQ23	978-980	Valid,R00			850-852	Repeated valid data from MF13
306	15		SEQ23	981	Valid,R00			661	Repeated valid data from MF9
307	15		SEQ23	982-985	Valid,R00			854-857	Repeated valid data from MF13
308	15		SEQ23	986	Valid,R00			14132770	Repeated valid data from MF13
309	15		SEQ23	987-988	Valid,R00			859-860	Repeated valid data from MF13
310	15		SEQ23	989-1002	Valid,R00			669-682	Repeated valid data from MF9
311	15		SEQ23	1003-005	Valid,R00			555-557	Repeated valid data from MF7
312	15		SEQ23	1006	Valid,R00			15227382	Repeated invalid data from MF13
313	15		SEQ23	1007-008	Valid,R00			559-560	Repeated valid data from MF7
314	15		SEQ23	1009-010	Valid,R00			774841-42	Repeated data from MF13
315	15		SEQ23	1011-015	Valid,R00			563-567	Repeated valid data from MF7

Table 4. Rconstructed File PS 1101.DTT (cont. 7)

	A	B	C	D	E	F	G	H	I
469		*******	RECONSTRUCTED FILE******			********	AS RECEIVED FROM KENYA**********		
470					t0 = 6/9/88 1840				
471		Adj S/C Clock Counts = S/C cc - 1549000 ; all entries of 5 digits or more or those with an * are unchanged							
472	MF*	MFT-t0	MFP	Adj S/C cc	Comments	MFT-t0	MFP	Adj S/C cc	Comments
473		(sec)	(sec)			(sec)	(sec)		
316	16	127.410	8.191	1016	Valid,R00	70.077	-40.952	*0	Invalid
317	16		SEQ23	1017	Valid,R00			262145	Repeated indeterminate data from MF8
318	16		SEQ23	1018	Valid,R00			15227330	Repeated invalid data from MF14
319	16		SEQ23	1019	Valid,R00			571	Repeated valid data from MF8
320	16		SEQ23	1020	Valid,R00			*4	Repeated invalid data from MF12
321	16		SEQ23	1021-027	Valid,R00			701-707	Repeated valid data from MF10
322	16		SEQ23	1028-042	Valid,R00			900-914	Wrong time;valid data
323	16		SEQ23	1043	Valid,R00			723	Repeated valid data from MF10
324	16		SEQ23	1044-048	Valid,R00			916-920	Wrong time;valid data
325	16		SEQ23	1049-051	Valid,R00			793-795	Repeated valid data from MF12
326	16		SEQ23	1052	Valid,R00			22948	Invalid
327	16		SEQ23	1053-055	Valid,R00			797-799	Repeated valid data from MF12
328	16		SEQ23	1056-079	Valid,R00			928-951	Wrong time;valid data
329	17	135.600	8.190	1080-143	Valid,R00	119.219	49.142	952-1015	Valid,Wrong MF
330	18	143.791	8.191	1144-207	Valid,R00	127.410	8.191	1016-079	Valid,Wrong MF
331	19	151.981	8.190	1208-271	Valid,R00	135.600	8.190	1080-143	Valid,Wrong MF
332	20	160.172	8.191	1272-335	Valid,R00	143.791	8.191	1144-207	Valid,Wrong MF
333	21	168.362	8.190	1336-399	Valid,R00	151.981	8.190	1208-271	Valid,Wrong MF
334	22	176.553	8.191	1400-463	Valid,R00	160.171	8.190	1272-335	Valid,Wrong MF
335	23	184.743	8.190	1464-527	Valid,R00	168.362	8.191	1336-399	Valid,Wrong MF
336	24	192.934	8.191	1528-591	Valid,R00	176.552	8.190	1400-463	Valid,Wrong MF
337	25	201.124	8.190	1592-655	Valid,R00	184.743	8.191	1464-527	Valid,Wrong MF
338	26				Not Needed	192.933	8.190	1528-591	Valid,Wrong MF
339	27				Not Needed	201.124	8.191	1592-655	Valid,Wrong MF
340									
341									
342									
343									
344									
345									
346									
347									
348									
349									
350									
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356									
357									
358									
359									
360									

Examples of the different types of entries in Table 4 will now be discussed. The line number, which is given in bold face in the leftmost column of the table will be used to locate the mFs in question. Line 2 contains a case where valid data mFs with the proper inferred times appear in the OPF. An example of an embedded mF with an invalid S/C cc appears on line 3. This cannot be tested using magnetometer data since it occurs in an even mF; this appears in Column I. Sometime horizon or sun sensor pulses can be used in conjunction with the same event pulses in mFs in other MFs, but this complexity cannot be handled on a routine basis. Line 7 contains a case where the visual magnetometer data test showed a valid instance, so the comment FTEICCV appears in Column E and the comment in Column I explains the situation. The same procedure was used for line 10, but the visual test could not establish invalidity. In the case of lines 15 and 16 the two invalid S/C cc mFs are not tested since they are members of a Gap Set; note the comment columns for these two cases. Line 18 is a case where the embedded S/C cc and the data are both invalid , as determined by the visual test for data. In line 26 the first example of repeated data in the OPF occurs. Notice that the S/C cc values are 84 and 85; these instances appeared in MF1 as valid mFs. These mFs are padded in MF3 of the RCF to avoid confusion and misuse. The same instances appear in MF1 of the RCF so the padding in MF3 does not purge data from the pass file.

The reconstruction of the file is not perfect and line 27 contains an example where valid data is actually purged from the file. This valid mF, as determined by the visual data test of the OPF, is notin a sequence by the algorithm used to define a sequence. Since this mF becomes a member of a Gap Set 3, it must be padded. Line 28 is an example of an invalid S/C cc that is not tested because it is in Gap Set 3. Although the algorithm used for the RCF makes no distinction between repeated data that were originally valid, invalid, or indeterminate the exposition in Table 4 does. Line 65 is an example of an indeterminate data value and line 87 is an example of an invalid case.

The position where unusual things start to happen is on line 98. Here a sequence of valid data appears before it normally should. Up to this point the MF# for the RCF is the same as that of the OPF. But the sequence 508-521 (with one embedded invalid S/C cc) of OPF MF7 really belongs in MF8 of the RCF and bears the comment on being out of monotonic order. The same is true for line 102. Once line 103 is passed there is no more monotonic disorder. The sequences 508-521,535-552, and 555-567 were read into the wrong buffer (the one for odd MFs instead of for even). Succeeding sequences to those beginning with 440 and 508 continue in MF7 of OPF along with other types of mFs. To follow this situation more easily, the mapping function from RCF location to OPF location is introduced. In Table 4 it is easy to select a S/C cc value from the OPF and find it in the RCF. The converse is more difficult. The mapping function uses the location MF#;mF# as its argument. Symbolically the mapping function is written as

$$(MF\#;mF\#)_{opf} = F((MF\#;mF\#)_{rcf}) \qquad (3)$$

Thus for a given RCF location, an OPF location is obtained. This function is given explicitly in Table 5. Since some locations in the RCF do not map into the OPF the function merely shows a blank for these cases. Those cases that are indeterminate are shown with a '?'. Using Table 5 it is seen that the RCF location maps into the OPF location up to position 8;5 except for blanks (non-mappings). Starting with 8;5 the mapping is M;m -> M-1;m up to 12;21. Then at 12;23 the mapping mysteriously gets back to normal. This normal mapping continues up through 13;37

Table 5. RCF to OPF Mapping Function

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	RCF	OPF	*	RCF	OPF	*	RCF	OPF	*	RCF	OPF	*	RCF	OPF	*	RCF	OPF
2	LOC	LOC	*	LOC	LOC	*	LOC	LOC	*	LOC	LOC	*	LOC	LOC	*	LOC	LOC
3	1;1		*	4;13		*	7;5		*	9;23	8;23	*	11;10=?		*	13;38	
4	to		*	to		*	to		*	9;24		*	12;22		*	to	
5	1;17		*	4;19		*	7;18		*	to		*	12;23	12;23	*	13;45	
6	1;18	1;18	*	4;20	4;20	*	7;19	7;19	*	9;32		*	12;24		*	13;46	14;46
7	to		*	to	to	*	to	to	*	9;33	8;33	*	12;25		*	to	to
8	1;45	1;45	*	4;28	4;28	*	7;31	7;31	*	9;34	8;34	*	12;26	12;26	*	13;57	14;57
9	1;28,1;32=?		*	4;22=?		*	7;32		*	9;35		*	12;27	12;27	*	13;58	
10	1;46	1;46	*	4;29		*	to		*	9;36	8;36	*	12;28		*	13;59	14;59
11	to	to	*	4;30		*	8;4		*	to	to	*	12;29	12;29	*	to	to
12	3;14	3;14	*	4;31	4;31	*	8;5	7;5	*	9;40	8;40	*	to	to	*	13;61	14;61
13	2;49,3;6=?		*	to	to	*	to	to	*	9;41		*	12;32	12;32	*	13;62	
14	3;15	3;15	*	4;43	4;43	*	8;12	7;12	*	9;42	8;42	*	12;33		*	13;63	14;63
15	3;16	3;16	*	4;42=?		*	8;13		*	to	to	*	12;34	12;34	*	to	to
16	3;17	3;17	*	4;44		*	8;14	7;14	*	9;45	8;45	*	to	to	*	14;5	15;5
17	3;18	3;18	*	to		*	to	to	*	9;46		*	12;46	12;46	*	14;6	
18	3;19		*	4;57		*	8;18	7;18	*	to		*	12;47		*	to	
19	3;20	3;20	*	4;58	4;58	*	8;19		*	9;52		*	12;48	12;48	*	14;12	
20	3;21	3;21	*	to	to	*	to		*	9;53	8;53	*	to	to	*	14;13	16;13
21	3;22	3;22	*	4;61	4;61	*	8;31		*	to	to	*	12;52	12;52	*	to	
22	3;23		*	4;62		*	8;32	7;32	*	9;56	8;56	*	12;53		*	14;27	16;27
23	3;24	3;24	*	4;63	4;63	*	to	to	*	9;57		*	to		*	14;28	
24	3;25		*	to	to	*	8;40	7;40	*	to		*	12;59		*	14;29	16;29
25	3;26	3;26	*	5;5	5;5	*	8;35		*	10;19		*	12;60	12;60	*	to	to
26	3;27		*	5;4=?		*	8;41		*	10;21		*	12;61	12;61	*	14;33	16;33
27	3;28	3;28	*	5;6		*	8;42	7;42	*	to		*	12;62 =?		*	14;34	
28	3;29		*	to		*	to	to	*	10;27		*	12;63	12;63	*	to	
29	to		*	5;9		*	8;47	7;47	*	10;2	9;28	*	to	to	*	14;40	
30	3;50		*	5;10	5;10	*	8;48		*	to	to	*	13;2	13;2	*	14;41	16;41
31	3;51	3;51	*	to	to	*	8;49	7;49	*	10;3	9;36	*	13;3		*	to	to
32	3;52		*	5;15	5;15	*	8;50		*	10;37		*	13;4	13;4	*	14;64	16;64
33	3;53	3;53	*	5;12=?		*	8;51		*	10;3	9;38	*	to	to	*	15;1	17;1
34	to	to	*	5;16		*	8;52	7;52	*	to	to	*	13;9	13;9	*	to	to
35	3;62	3;62	*	to		*	to	to	*	10;5	9;51	*	13;10		*	25;64	27;64
36	3;54&60=?		*	5;24		*	9;1	8;1	*	10;52		*	13;11	13;11	*		
37	3;63		*	5;25	5;25	*	9;2		*	to		*	to	to	*		
38	3;64	3;64	*	to	to	*	9;3		*	11;5		*	13;22	13;22	*		
39	to	to	*	5;30	5;30	*	9;4	8;4	*	11;6	10;6	*	13;23		*		
40	4;3	4;3	*	5;31	5;31	*	to	to	*	to	to	*	13;24	13;24	*		
41	4;4		*	5;32	5;32	*	9;7	8;7	*	11;3	10;37	*	to	to	*		
42	4;5	4;5	*	to	to	*	9;8		*	10;20,22=?		*	13;29	13;29	*		
43	to	to	*	5;36	5;36	*	9;9		*	11;38		*	13;26=?		*		
44	4;8	4;8	*	5;37		*	9;10	8;10	*	to		*	13;30		*		
45	4;9		*	5;38	5;38	*	9;11		*	11;50		*	13;31	13;31	*		
46	4;10	4;10	*	to	to	*	to		*	11;5	10;51	*	to	to	*		
47	4;11	4;11	*	7;4	7;4	*	9;21		*	to	to	*	13;37	13;37	*		
48	4;12	4;12	*			*	9;22	8;22	*	12;2	11;21	*			*		

with a number of non-mappings interspersed. Following a non-mapping set from 13;38 through 13;45, the mapping goes to M;m -> M+1;m. This mapping continues through RCF location 14;5 and then after some non-mappings jumps to M;m -> M+2;m at 14;13. This mapping continues to the end of the file. The cause in PRETRN for these jumps in mapping is not understood.

Returning to line 98, Column E contains the FPNDF acronym because there is no evidence of the partial sequence 444-451 appearing in the OPF, thus the mapping is blank (termed a non-mapping). It appears that the partial sequence 508-515 was switched into the wrong buffer and 452-459 never got into a buffer. In line 104 the partial sequence is out of order but it is not out of monotonic order. In other words, there are no valid data that appear in the OPF that have a lower adjusted S/C cc than 550. Finally, in line 114 we have the S/C cc values 508-510, which are listed in Column C as valid, but were received out of order (the order being the location in the OPF). The data that would normally be located here have been encountered earlier as part of the first ROMO comment in line 98. As one moves on in Table 4, one sees an increasing frequency of valid, ROO comments in Column C and Repeated Data comments in Column I.

If one looks at the OPF MFTs and starts from the rear of the OPF to compare MFTs to see which ones are false, and taking into account that two MFTs must be eliminated, then one finds that the elimination of MF16 and 14 lead the following conclusion. MF2-7,13,15, and 17-27 are correct times and MF1 and 8-12 are incorrect times. The MFs that have padded headers in the RCF are MF1, 8-12, 14, and 16 since the first mF of those MFs in the OPF contain invalid or repeated data.

Now turning to the bottom of Table 3, notice that the RCF contains 1600 mFs of which 1276 are valid, resulting in a file that is about 80% correct. The OPF contained 1728 mFs and only 57% had the proper times while 75% of them had valid data but nothing was flagged. In making the RCF in the manner prescribed 11 mFs (0.69%) which were valid have been removed from the pass file. As pointed out earlier, the added complexity to find and identify such mFs was not justified. Since the total number of mFs in the OPF that contained both valid times and data was 985 , the RCF has increased this number by a factor of 1.293 and has all mFs properly flagged. As can be seen on lines 32-34, of the mFs of the Reduced Sequences Set that cannot immediately be asserted as valid only 3 of them were found to be valid by the data test and 13 could not be tested. The manual method showed that 32 were invalid. Thus in the extreme for this case study, the recommended algorithm would remove 16 more valid mFs from the pass file. This would give a total of 27 mFs out of a total of 1600, which is 1.7%. Considering that 297 mFs of the 1600 mFs are invalid anyway, the 27 mFs are not much improvement for the large effort required to find them.

1.7 CONCLUSION

Based on the case study presented here and the statisitics of Table 1 it is imperative that some type of post processing of the .DTT pass files from KENYA be done. The merging of orbit and attitude parameters at the MF level would not be practical without using the post processor program. An algorithm for doing this post processing has been presented here, that does not use a data test, since the data test does not significantly improve the identification of valid mFs. The inclusion of such a test greatly complicates the coding of the post processor program. It is further proposed that NSSDC provide this program to CRA for operation at IRMCRA. This has two

advantages. First, the processing at CRA following the post processing will greatly improve the information about the S/C, as well as the DBI from the existing situation. Second, NSSDC will be able to quality control much better the final output that is sent to the PIs. This output will contain the application of .ROM and .NSS processing on all of the valid mFs remaining in the pass file.

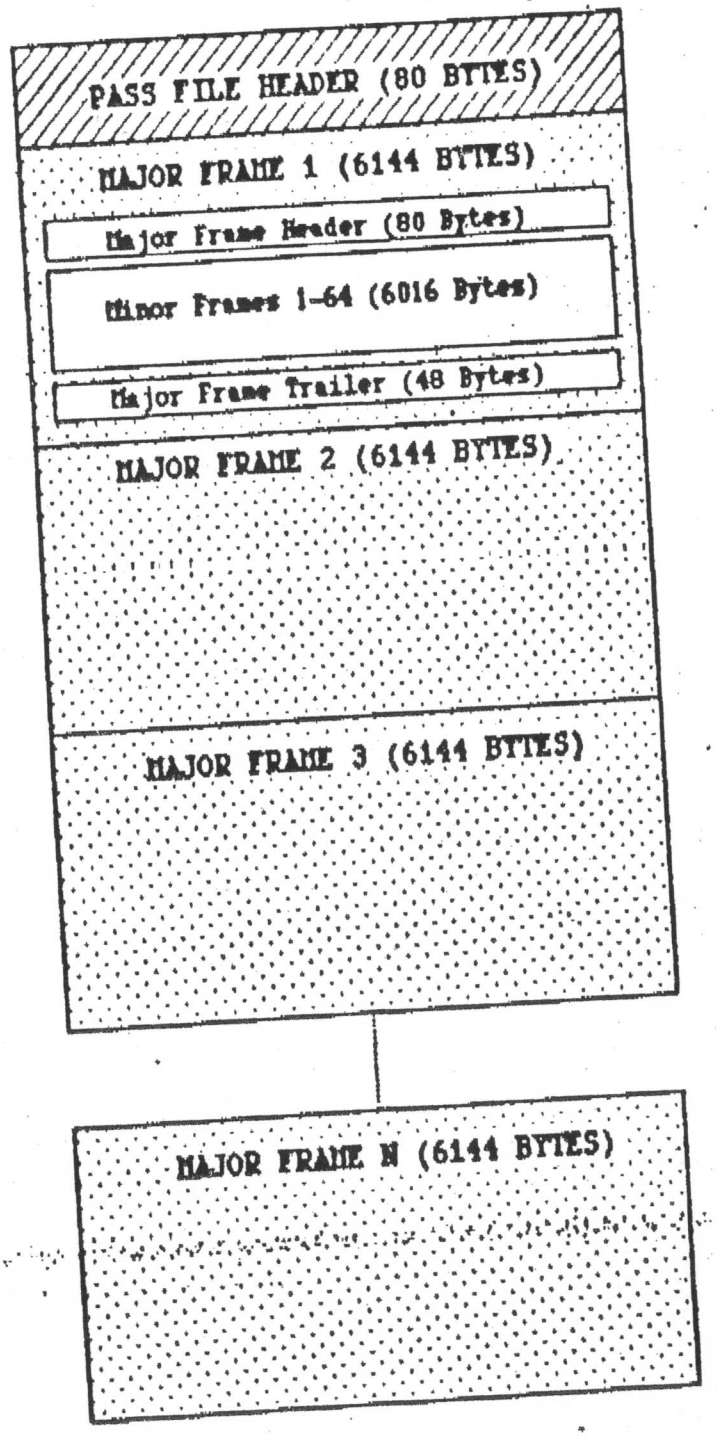

Figure 1: Structure of the Pass File

it and the last block of the pass file will usually contain some invalid (fill) values, since the ken from the tape recorder or in real time will not start or end at major frame boundaries rel. Thus KENYA will supply 'fill bits' for minor frames from the time of the first major until the beginning of the pass file turn-on and 'fill bits' for the minor frames from the time pass file turn-off to the end of the last (Nth) major frame.

001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020
C	C	S	D	1	Z	0	0	0	0	0	1	0	0	8	9	7	5	1	6
021	022	023	024	025	026	027	028	029	030	031	032	033	034	035	036	037	038	039	040
N	S	S	D	1	I	0	0	0	0	0	1	0	0	8	9	7	4	9	6
041	042	043	044	045	046	047	048	049	050	051	052	053	054	055	056	057	058	059	060
SPARES				T	R	P	L	A	Y	.	D	A	T	T	0	0	1	0	5
061	062	063	064	065	066	067	068	069	070	071	072	073	074	075	076	077	078	079	080
.	D	T	T	T	0	0	1	0	5	.	R	O	M	T	0	0	1	0	5
081	082	083	084	085	086	087	088	089	090	091	092	093	094	095	096	097	098	099	100
.	N	S	S	SPARES						EPOCH UT-BINARY-YYDDDHHMMSS								SMA	
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
in km		ECC unitless				INC in deg				AOP in deg				RAAN in deg				MA	
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
in deg		SPARES																	
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
SPARES																			
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
	Q	1st ATTITUDE EPOCH UT-BINARY								RASZA in deg				DECSZA in deg				RASIA	
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
in deg		DECSIA in deg				SR in deg/s				PAMA in deg				AAMA in deg				SPARES	
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
SPARES											Q	2nd ATTITUDE EPOCH UT-BINARY							
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
RASZA in deg				DECSZA in deg				RASIA in deg				DECSIA in deg				SR in deg/s			
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
PAMA in deg				AAMA in deg				SPARES											
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
	Q	3rd ATTITUDE EPOCH UT-BINARY								RASZA in deg				DECSZA in deg				RASIA	
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
in deg		DECSIA in deg				SR in deg/s				PAMA in deg				AAMA in deg				SPARES	
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
SPARES											Q	4th ATTITUDE EPOCH UT-BINARY							
321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
RASZA in deg				DECSZA in deg				RASIA in deg				DECSIA in deg				SR in deg/s			
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
PAMA in deg				AAMA in deg				SPARES											

BYTE #S 361 THROUGH 420 - SPARES

421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
NORAD EPOCH UT-BINARY								MM in rev/day				ECC unitless				INC in deg			
441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
AOP in deg				RAAN in deg				MA in deg				P	R	E	T	R	M	V	4
461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
.	2	A	T	T	I	E	P		V	3		A	T	T	O	U	T		V
481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
2		S	C	C	L	K		V	3	.	7	S	T	A	R	.	V	3	.
501	502	503	504	505	506	507	508	509	510	511	512								
4		D	I	S	T	.	V	0	1										

Figure 2: Pass File Header Structure.

2.1 PASS FILE HEADER

The first 40 bytes comprise two labels that conform to the Standard Formatted Data Unit (SFDU) labels of the Consultative Committee for Space Data Systems (CCSDS). The next four bytes are the first of a number of spare, or unassigned at this time, bytes embedded in the header for future use. In fact an inspection of Figure 2 shows that the spare bytes are #s

41-44, 85-90, 123-161, 199-211, 249-261, 299-311, and 349-420

The type of pass, tape recorder or real time, is given in the next item of the header, followed by the pass file names. The orbit elements are next, followed by fields that hold four different attitude solutions (different epochs). Then there is a place for the NORAD orbit elements from which the elements given previously in the header were derived. The header ends with a series of six fields which are used to provide an audit trace of the processing programs that have been used on the data and header information in the pass file. Each of these header items are specified below.

2.1.1 SFDU Labels

Each label is 20 bytes in length and only ASCII characters are used. The leading label has the following value (commonly called <u>instance</u>)

CCSD1Z000001nnnnnnnn

where the last 8 bytes give the total length of the pass file minus 20 bytes. The first four characters, CCSD, make the pass file immediately recognizable within the CCSDS community and this label can be interpreted by appropriate software. The second CCSDS label is similar to the first and has the following instance

NSSD1I000001mmmmmmmm

where the last 8 bytes give the total length in bytes of the pass file minus 40 bytes. The 20 and 40 bytes are subtracted since the CCSDS label gives the length of the labeled object that follows the label without including the length of the label itself. The second label here is considered part of the object of the first label. The instances for these labels are entered by program PRETRN running on KENYA and the label fields keep their same instances as the processing is done at the OCC and at NSSDC.

The specific details of the SFDU and its labels for general use can be found in Reference 1

2.1.2 Pass Type

Byte #s 45-54 are used to distinguish real time from tape recorder passes. The example in

Figure 2 depicts a tape recorder pass. ASCII characters are the only valid entries in this field.

2.1.3 Pass File Name.Type

Each pass file will be given a name.type. The name will consist of six ASCII characters with the first one being the capital letter , T, followed by five numeric characters. These numbers will go from 0 to 65535 and will be assigned sequentially. If there are more than 65535 turn-ons for San Marco (practically impossible), then T is replaced by the capital letter, A, and a new numeric sequence is started. Since the pass file will have some fields written by each processing center (KENYA, IRMCRA, NSSDCA), it is useful to have the file name include the processing center that produced the present version of the pass file. This is done by a file name extension, or type. The type is specified by using a period after the name and then three ASCII characters (DDT for KENYA, ROM for IRMCRA, and NSS for NSSDCA) to denote the processing center that produced the file. Since there are separate name.type fields for each processing center and each center does not blank out the previous name.type(s), a pass file produced by NSSDCA will have all three name.type fields with proper instances. A KENYA produced pass file will only have a valid instance in the first of these three fields and binary zeros in the rest. The example in Figure 2 has the name T00105 and the 30 bytes # 55-84 are used for the three entries. The programs PRETRN on KENYA, ATTOUT on IRMCRA, and DIST on NSSDCA put the proper values in these fields, respectively. The 10-byte assignments are as shown in Figure 2.

2.1.4 Classical Orbit Elements

Classical orbit elements are obtained for any desired time by program GTDS running on IRMCRA with input elements provided by NORAD, based on their tracking data. The specific epoch of these elements is not critical but should be prior to and close to the time of the first major frame of the pass file. These elements are assigned to byte #s 91-122 in the following way:

EPOCH UT: Last two digits of the year (Byte 91); Day of Year (92-93); UT hours of the day (94); Minutes of the hour (95); Seconds of the minute (96); Milliseconds of the second (97-98). These numbers will be written as binary integers (I*1 or I*2) by IRMCRA. Note that Day of Year = 1 for Jan. 1.

SEMIMAJOR AXIS (SMA): (99-102) Units are kilometers and the data type or number representation is IBM Real*4

ECCENTRICITY (ECC): (103-106) No units and data type is IBM Real*4

INCLINATION (INC): (107-110) Units are degrees and data type is IBM Real*4

ARGUMENT OF PERIGEE (AOP): (111-114) Units are degrees and data type is IBM Real*4

RIGHT ASCENSION OF ASCENDING NODE (RAAN): (115-118) Units are degrees and data type is IBM Real*4

MEAN ANOMALY (MA): (119-122) Units are degrees and data type is IBM Real*4

The elements are written by IRMCRA into the pass file header. The NORAD elements are assigned to higher byte #s and will be discussed later.

2.1.5 Attitude Solutions

The attitude solution is conveyed by giving the spin rate, the position of the Spin Z and X axes in the Vernal coordinate system, and in the case of a misaligned spin vector relative to the spacecraft axes, the polar and azimuthal misalignment angles are given. The misalignment angles are expected to be zero except for the case where the long wire antennas could not be properly deployed. The following instruments can contribute to the determination of the spacecraft attitude: (1) Star Mapper, (2) Sun sensor, (3) Horizon sensors, (4) Magnetometer, and (5) Drag Balance Instrument (DBI). A code has been developed to denote which data were used to obtain the attitude solution; this code is given in Table 2.1 and its value is denoted by the character, Q. This 5-bit code has the following algorithm. Each of the five sensor systems given above are assigned a bit in the 5-bit code. The assignment from least significant bit to most significant bit are in the order given above. If the data from a sensor system is used, then the assigned bit is set to 1, otherwise it remains a binary 0. Q is the value of the 5-bit counter. The values of 4, 8, or 16 are not possible since the attitude cannot be determined from these sensors alone.

Table 2.1 Attitude Code

Star Mapper	X		X	X		X	X			X			X			X	X			X			X			X			X		X
Sun Sensors		X	X		X	X			X					X	X			X												X	X
Horizon Sensors				X	X	X					X	X	X	X	X																
Magnetometers								X	X	X	X	X	X	X	X																
Drag Balance Inst																X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Code Value Q	0	1	2	3	5	6	7	9	10	11	12	13	14	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		

There are fields in the pass file header for four different epochs of the attitude solution. One should expect to find this many only if the pass file is 50 or more minutes in length. Short pass files of 5 minutes or less will usually have only one epoch for the attitude solution. If some of the fields are not used they will contain the binary zeros originally entered by KENYA.

The attitude code Q is assigned to byte #s 162, 212, 262, and 312 and its data type is IBM I*1. Q equal 0 means that no attitude solution could be found for the turn-on. In the case of Q equal to 2 the attitude is determined from more than one turn-on, since it is not possible to obtain an attitude solution using the sun sensor alone for a single turn-on. In this case the epoch would be near the midpoint of the two turn-ons.

The EPOCH UT is in the same format and has the same data type as that used for the EPOCH UT of Section 2.1.4. It is assigned to byte #s 163-170, 213-220, 263-270, and 313-320.

The RIGHT ASCENSION OF THE SPIN Z AXIS (RASZA) is in units of degrees and the data type is IBM Real*4. This parameter is assigned to byte #s 171-174, 221-224, 271-274, and 321-324.

The DECLINATION OF THE SPIN Z AXIS (DECSZA) is in units of degrees and the data type is IBM Real*4. This parameter is assigned to byte #s 175-178, 225-228, 275-278, and 325-328.

The RIGHT ASCENSION OF THE SPIN X AXIS (RASXA) has the same units and data type as RASZA and is assigned to byte #s 179-182, 229-232, 279-282, and 329-332.

The DECLINATION OF THE SPIN X AXIS (DECXA) has the same units and data type as DECZA and is assigned to byte #s 183-186, 233-236, 283-286, and 333-336.

The SPIN RATE (SR) has units of degrees per second and the data type is IBM Real*4. This parameter is assigned to byte #s 187-190, 237-240, 287-290, and 337-340.

The POLAR ANGLE OF MISALIGNMENT (PAMA) is the angle between the Spin Z axis and the Spacecraft Z axis and is given in degrees. The data type is IBM Real*4. This parameter is assigned to bytes 191-194, 241-244, 291-294, and 341-344. It is quite likely that this angle will always be zero.

The AZIMUTHAL ANGLE OF MISALIGNMENT (AAMA) is the acute angle between the Spacecraft Z-X plane and the plane containing the Spacecraft Z axis and the Spin Z axis. The positive direction of this angle is from the Spacecraft Z-X plane to the other plane. This parameter is also given in degrees and the data type is IBM Real*4. It is assigned to byte #s 195-198, 245-248, 295-298, and 345-348. It is quite likely that this angle will always be zero.

2.1.6 NORAD Orbit Elements

San Marco D will be tracked only by NORAD and the elements will be supplied to the project through Goddard Space Flight Center. These elements will be telexed daily to CRA in the NORAD format. The NORAD elements are similar to the classical elements described in Section 2.1.4 except that the semimajor axis is replaced by a parameter called the MEAN MOTION (MM) which has units of $(\text{days})^{-1}$, meaning revolutions per day. The data type is IBM Real*4. These elements are written into the pass file header for the epoch that was used as input to GTDS to provide the classical elements that are in byte #s 91-122. The specific byte # assignments for these parameters are:

EPOCH UT: 421-428; MM: 429-432; ECC: 433-436; INC: 437- 440
AOP: 441-444; RAAN: 445-448; MA: 449-452

The NORAD elements are an average element set, averaged over the revolution beginning at epoch. The classical elements are an osculating set that defines the Keplerian ellipse that

passes through the instantaneous position of the satellite at epoch and implies the proper velocity.

2.1.7 Program Trace

The final 60 bytes (#s 453-512) of the pass file header are used for the name and version number, or date, or some other qualifier of the programs that were used to process the pass file data and write entries into its headers and trailers fields. Ten bytes are used for each program, thus six such programs can be accommodated. These bytes must be ASCII characters. Examples are given in Figure 2.

2.2 MAJOR FRAME

The major frame header consists of an 80-byte header, 64 minor frames (numbered 1-64) with each being 94 bytes long, and a 48-byte trailer The actual 6-bit counter registers from 0 to 63, but it is more convenient. to add 1 to this value for identification purposes. The format for each of these elements of the major frame will be discussed below in detail. A major frame is always 6144 bytes in length. With a nominal spacecraft clock rate, data are recorded or telemetered in real time at 6,000 bits/s. This means that a minor frame is 128 ms in time length and a major frame starts every 8.192 s If the clock rate is not nominal, then the major and minor frames will have time lengths different than the above values.

2.2.1 Major Frame Header

The structure of this header is shown in Figure 3. The first 28 bytes serve as a label or title for the frame and their instance is written by program PRETRN on KENYA as ASCII characters. The LSI-11 (KENYA) system date occupies byte #s 29-38 and is written as ASCII characters with the format DD-MMM-YY_, where DD is the day of the month, MMM is a 3-letter abbreviation for the month, YY is the last two digits of the year, and '_' represents a blank space. This is illustrated in Figure 3 by the instance 15-JUL-88_.

Byte #s 39-46 are used to give the time the data were recorded at SMER during the downlink telemetry pass. This time is also written as ASCII characters with the format HH:MM:SS. The instance shown in Figure 3 is 10:32:15. The next 18 bytes of the major frame header contain various times written in the binary coded decimal (BCD) format. For BCD four binary bits are used to represent a decimal digit. A byte is used for two decimal digits with the most significant four bits (half byte) of the byte used for the most significant (MS) of the two decimal digits. Six bytes are used for each BCD time to give DDDHHMMSSmsmsms, where DDD is the Day of the Year, HH is the UT hour of the day, MM is the minute of the hour, SS is the second of the minute, and msmsms is the millisecond of the second. Consider the six bytes as 12 half bytes which are ordered from the most significant half byte (the most signicant half of the highest byte assigned) to the least significant half byte (the least significant half byte of the lowest byte # assigned). The DDD uses the three highest (or most significant) half bytes, the HH uses the next

two half bytes, the MM uses the next two half bytes, the SS uses the next two half bytes, and finally the mamama uses the last three half bytes. Thus each of the quantities DDD, HH, etc.

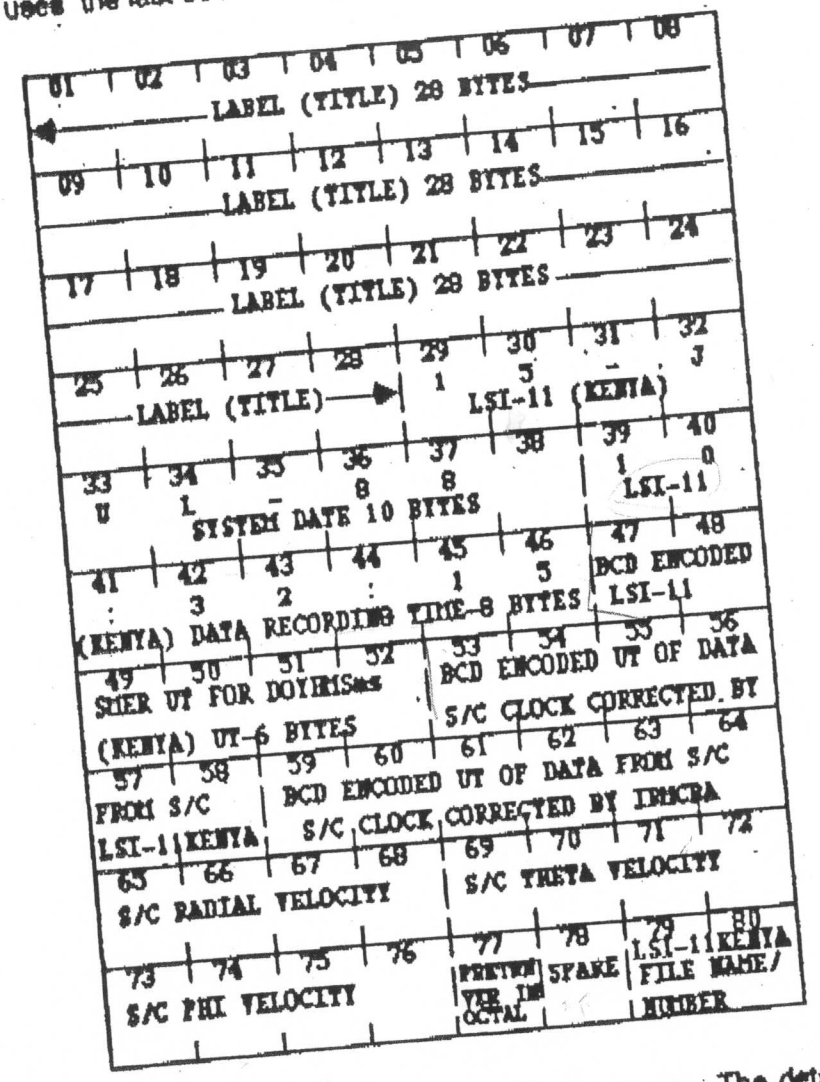

Figure 3: Major Frame Header Structure. The details of the format are given in the text.

crosses byte boundaries. As an example, consider

DDD = 365 , HH = 18, MM = 35, SS = 23, and mamama = 465

where all numbers above are base 10 or decimal. The binary representation of the bytes would then be

MSB: 00110110, MS-1B: 01010001, MS-2B: 10000011,

MS-3B: 01010010, MS-4B: 00110100, LSB: 01100101

where MSB is the most significant byte, MS-1B is the next most significant byte, etc., and LSB is the least significant byte. The leftmost bit is the most significant bit of the bytes shown above.

Byte #s 47-52 are used to give the UT, encoded as BCD, when the major frame is processed at SMER by KENYA. The spacecraft clock time, which is part of the data in the minor frames, is corrected by program PRETRN using outputs from program SCCLK and this corrected time is encoded as BCD and written into byte #s 53-58. Byte #s 59-64 are written by IRMCRA running program ATTOUT to give the corrected UT of the major frame as determined at the OCC.

The next 12 bytes of the major frame header are written by NSSDCA. These are polar spherical velocity components of the spacecraft using the final orbit elements and computed in the geographic coordinate system in units of km/s and written in VAX Real*4 number representation (data type). The radial component is assigned to byte #s 65-68; the theta component is assigned to #s 69-72; and the phi component is assigned to #s 73-76.

Byte 77 is used for the PRETRN version number written as a two digit octal number, with each half byte being a digit. For the example shown in Figure 2 byte #s 453-462, where the PRETRN version is 4.2 , byte 77 would have the instance 52 octal (= 42 decimal).

Byte 78 is a spare. 0, 1, 2

Byte #s 79 and 80 are used by PRETRN to write a 6-digit octal number starting with 0 that has a maximum value of 177777 octal; the actual instance written comes from a parameter called DUMP. This is the number in its decimal representation that is used to form the pass file name. Thus for the example shown in Figure 2 byte #s 56-60, the 6-digit octal number would be 000151 (=105 decimal).

2.2.2 Minor Frame

The structure of the DDF minor frame is shown in Figure 4. It consists of 94 bytes and is broken up into 56 different fields. Six fields are three bytes long, 26 fields are two bytes long, and 24 fields are one byte long, including two contiguous digital spares. The minor frame that is telemetered from the spacecraft (TM minor frame) is very similar to the DDF minor frame. The TM minor frame consists of 96 bytes, the two extra bytes being sync words that are not recorded at SMER, since their function is no longer needed after the downlink. The * in Figure 4 represents these two bytes. The field segmentation of the first 94 bytes of the TM minor frame is the same as that for the DDF minor frame. However, the TM minor frame always has the MSB transmitted first in a field and the LSB last; of course for a one byte field this is not applicable. For the 32 fields greater than one byte in length the position of MSB and LSB of the DDF minor frame are shown in Figure 4. Twenty-two of these fields have the reverse byte sequence compared to the TM minor frame. Those with reverse sequence are marked with an * in Figure 4 to call attention to this reverse sequencing. These changes are made by PRETRN based on specifications supplied by the PIs for level 0 processing.

It is not appropriate in this document to provide all the information necessary to be able to

0 = GOOD
1 = OA DATA GOOD INSTR BAD
2 = MAJOR FRAME

2**24-1
16777215

01 LSB+	02	03 MSB+	04	05 LSB+	06 MSB+	07 MSB	08	09 LSB	10	11 LSB+	12 MSB+
FRAME COUNTER			6-BIT SUB-COM CTR	WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 1 A/B			IVI ANA-LOG	DBI DIGITAL X-AXIS	
13 LSB+	14 MSB+	15 MSB	16 LSB	17 LSB+	18 MSB+	19	20	21	22	23 LSB+	24 MSB+
EFI DIGITAL DIFFERENTIAL Y-AXIS		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		SUN SENS XING TIME SBCM	HORZ SENS XING TIME SBCM	SPARE DIGI -TAL	SPARE DIGI -TAL	DBI DIGITAL Y-AXIS	
25 LSB+	26 MSB+	27 LSB+	28 MSB+	29 LSB+	30 MSB+	31 MSB	32	33 LSB	34	35	36
DBI DIGITAL X SUM		DBI DIGITAL Y SUM		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 2 A/B			S/C ANALG SBCM	ATTI-TUDE EVENTS SBCM	EFI ANT TIMED CMD MON
37 LSB+	38 MSB+	39 MSB	40 LSB	41 LSB+	42 MSB+	43 LSB+	44 MSB+	45	46	47	48
EFI DIGITAL DIFFERENTIAL Z-AXIS		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		STAR MAPPER DIGITAL 16-BIT TIME		STAR MAJOR FRAME CTR	ATTIT MAG X SUN1/2 CCA SBCM1	ATTIT MAG Y SUN1/2 -SIN SBCM2	ATTIT MAG Z SUN1/2 COS SBCM3
49	50	51 MSB	52 LSB	53 LSB+	54 MSB+	55 MSB	56	57 LSB	58	59 LSB+	60 MSB+
EFI ANA-LOG CH 4	EFI ANA-LOG CH 5	DIGITAL SUBCOM		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 3 A/B			IVI DIGI-TAL	DBI DIGITAL X-AXIS	
61 LSB+	62 MSB+	63 MSB	64 LSB	65 LSB+	66 MSB+	67 MSB	68	69 LSB	70	71 LSB+	72 MSB+
EFI DIGITAL		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 4 A/B			EXPT ANALG SBCM	DBI DIGITAL Y-AXIS	
73 LSB+	74 MSB+	75 LSB+	76 MSB+	77 LSB+	78 MSB+	79	80	81	82	83	84
DBI DIGITAL X SUM		DBI DIGITAL Y SUM		WATI DIGITAL 16-BIT SCIENCE		EFI ANA-LOG CH 1	EFI ANA-LOG CH 2	EFI ANA-LOG CH 3	EFI ANA-LOG CH 6	WATI DIGI -TAL SBCM	WATI ANAL -LOG SBCM
85 LSB+	86 MSB+	87 MSB	88 LSB	89 LSB+	90 MSB+	91 MSB	92	93 LSB	94		
EFI DIGITAL DIFFERENTIAL X-AXIS		IVI DIGITAL		WATI DIGITAL 16-BIT SCIENCE		ASSI DIGITAL CH 5 A/B			FRAME SYNC HEXPA OCT 372 DEC 250		

128 MS

Figure 4: Structure of the Minor Frame. The details are given in the text including the meanings of the * and the **.

Table 2.2
Digital Subcom Byte #s 51/52 Status Bits

USE A FRAME 23, BYTE # 51

(1-8)	USE
1	TRANSMITTER 1 ON
2	TRANSMITTER 2 ON
3	TAPE RECORDER 1 ON
4	TAPE RECORDER 2 ON
5	ORC ON
6	BUS 1 CONNECT "A" (FOR "B", BIT = 0)
7	ORC SENSE "+" (FOR "-" ,BIT = 0)
8	ORC MANEUVER DISABLE

STATUS A FRAME 23, BYTE # 52

BIT # (1-8)	USE
1	PYRO 1 ENABLE
2	UVD 1 NOT ACTIVE
3	PYRO 2 ENABLE
4	UVD 2 NOT ACTIVE
5	BATTERY 1 NOT CONNECTED
6	BATTERY 2 NOT CONNECTED
7	Solar Array 1 on Battery 1 (if on Battery 2, Bit = 0)
8	Solar Array 2 on Battery 2 (if on Battery 1, Bit = 0)

USE B FRAME 24, BYTE # 51

(1-8)	USE
1	FREMOD FILTER 1 ON (6K)
2	FREMOD FILTER 2 ON (6K)
3	TRANSMITTER HIGH POWER
4	TAPE RECORDER RECORD MODE ON
5	TAPE RECORDER PLAY MODE ON
6	TAPE RECORDER FAST FORWARD MODE ON
7	TAPE RECORDER 2 AT BEGINNING OF TAPE
8	TAPE RECORDER 2 AT END OF TAPE

STATUS B FRAME 24, BYTE # 52

BIT # (1-8)	USE
1	ENCODER 1 ON
2	ENCODER 2 ON
3	MAGNETOMETER ON (VIA TELEMETRY)
4	SUN SENSOR 1 ON
5	SUN SENSOR 2 ON
6	HORIZON SENSOR 1 ON
7	HORIZON SENSOR 2 ON
8	BUS 2 "B" (IF "A" ,BIT = 0)

USE C FRAME 25, BYTE # 51

(1-8)	USE
1	DELAY COMMAND 1 LOADED
2	DELAY COMMAND 2 LOADED
3	DELAY COMMAND 3 LOADED
4	DELAY COMMAND 2 LOADED
5	TAPE RECORDER 1 AT BEGINNING OF TAPE
6	TAPE RECORDER 1 AT END OF TAPE
7	PYRO 1 ENABLE
8	PYRO 2 ENABLE

STATUS C FRAME 25, BYTE # 52

BIT # (1-8)	USE
1	STAR MAPPER 10 VOLT SWITCH ON
2	EFI 10 VOLT SWITCH ON
3	IVI 10 VOLT SWITCH ON
4	ASSI 10 VOLT SWITCH ON
5	WATI 10 VOLT SWITCH ON
6	DECODER 1 10 VOLT SWITCH ON
7	DECODER 2 10 VOLT SWITCH ON
8	SPARE

USE D FRAME 26, BYTE # 51

(1-8)	USE
1	SRC ON
2	MAGNETOMETER ON (VIA SRC)
3	SRC SWITCHING "DIRECT"(IF "REV", BIT = 0)
4	SRC COIL "DIRECT" (IF "REV", BIT = 0)
5	STAR MAPPER LEAST SIGNIFICANT BYTE
6	STAR MAPPER MOST SIGNIFICANT BYTE
7	SPARE
8	STAR MAPPER POWER ON

STATUS D FRAME 26, BYTE # 52

BIT # (1-8)	USE
1	EFI MAIN BODY ON
2	EFI ANTENNA ON
3	IVI ON
4	WATI ON
5	ASSI ON
6	DBI ON
7	BUS 3 "B" (IF "A",-BIT = 0)
8	EXPERIMENT POWER ON (ENABLE)

2.2.3 Major Frame Trailer

The structure of the major frame trailer is shown in Figure 5. It consists of 48 bytes broken up into twelve, 4-byte fields. Values are written into all these fields by NSSDCA running program DIST. The fields all have VAX Real*4 data type. The parameters and their physical units are

6097 6098 6099 6100 S/C GEOCENTRIC ALTITUDE IN KM VAX REAL*4	6101 6102 6103 6104 S/C GEOGRAPHIC EAST LONGITUDE IN DEG VAX REAL*4
6105 6106 6107 6108 S/C GEOCENTRIC LATITUDE IN DEG VAX REAL*4	6109 6110 6111 6112 S/C LOCAL SOLAR TIME IN HRS (MEAN SUN) VAX REAL*4
6113 6114 6115 6116 S/C SOLAR ZENITH ANGLE IN DEG VAX REAL*4	6117 6118 6119 6120 MAGNETIC FIELD MAG IN GAUSS VAX REAL*4
6121 6122 6123 6124 MAGNETIC DIP EQUATOR IN DEG VAX REAL*4	6125 6126 6127 6128 S/C SPIN RATE IN DEG/SEC VAX REAL*4
6129 6130 6131 6132 S/C Z-AXIS GEOGRAPHIC LONGITUDE IN DEG VAX REAL*4	6133 6134 6135 6136 S/C Z-AXIS GEOCENTRIC LATITUDE IN DEG VAX REAL*4
6137 6138 6139 6140 S/C X-AXIS GEOGRAPHIC LONGITUDE IN DEG VAX REAL*4	6141 6142 6143 6144 END OF FILE FIELDS OUT OF KENYA TO IRMCRA OCT 371 OCT 363 OCT 040 OCT 373 HEX F9 HEX F3 HEX 20 HEX FB S/C X-AXIS GEOCENTRIC LATITUDE IN DEG OUT OF NSSDCA WITH DATA TYPE=VAX REAL*4

Figure 5: Structure of the Major Frame Trailer. The details are given in the text.

are explicitly given in Figure 5 and will not be repeated here. The two magnetic field parameters will be computed using the IGRF 1985 model extrapolated to 1988.5 as recommended by R. A. Langel of Goddard Space Flight Center. The last field (6141-6144) in the major frame is a unique one because it is given a value by KENYA that is changed by NSSDCA. In order to transfer the major frames from KENYA to IRMCRA without incidence end-of-file markers are

NSSDC Master Catalog Display: Data Set

San Marco Distributed Data

NSSDC ID:SPIO-00238

Other ID

88-026A-00D

Availability: At NSSDC, Ready for Offline Distribution (or Staging if Digital)

Description

This data set consists of 34 9-track tapes containing the San Marco data that were recorded at the San Marco Equatorila Range (SMER) launch facility in Kenya and than post-processed at the Operations Control Center (OCC) in Rome, Italy a at the NSSDC in Maryland, USA. The data format (called the Distributed Data Format, DDF) is described in two accompanying documents. The data format remained unchanged as the data were distributed from the SMER to OCC to NSSDC and to the PIs. Level 0 processing of the telemetry data was done at SMER and than recorded on the DDF tapes. During the postprocessing at OCC and NSSDC fill bits were replaced with the appropriate values.

Mission Name

San Marco-D/L

Disciplines

Space Physics: Ionospheric Studies
Space Physics: Thermospheric Studies

Archive Location

National Aeronautics and Space Administration (National Space Science Dat

Media Information

34 Digital Magnetic Tape

Personnel Information

Experiment Information
Mission Information

NSSDC Space Physics page

NSSDC home page

For questions about this dataset, please contact: