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EUROPEAN SPACE AGENCY

EARTHNET PROGRAMME

FORMAT SPECIFICATIONS FOR LANDSAT MSS SYSTEM CORRECTED COMPUTER COMPATIBLE TAPES PRODUCED AT FUCINO (ITALY)

1 October 1979

CCT FORMAT

The MSS CCTs produced at FUCINO are available on 9-track tapes only at either 1600 or 800 bpi desnities. CCTs include both the radiometric and the geometric corrections.

At Fucino LANDSAT images are framed consistently with the Worldwide Reference System for LANDSAT data retrieval. This system specifies the nominal values for latitude and longitude of images taken over any region of the world.

The corrected MSS CCT is made up of five basic types of records: JSC Header Record, LANDSAT Header Record, Geometric Transformation Record, Radiometric Look-Up Table Records and MSS Data Records. The first record on the CCT, JSC Header Record, is a mixture of EBCDIC form as specified by a user. The MSS data records contain binary data only.

The JSC Header Record contains information about the Sun elevation and azimuth angles, the Earth rotation angle and the satellite altitude. An end of file mark is written at the end of this record.

The LANDSAT Header Record contains the information required to identify the LANDSAT frame and the type of processing which was performed on scene data. The geometric transformation record contains the information pertaining to the geometric corrections that were applied. The Radiometric Look-Up Tables define the radiometric transformations which were applied to the data by the Fucino station. The last of the look-up table records is followed by an of file mark.

SEQUENTIAL NUMBER OF TAPE. This will always be 1 for 1600 bpi Tapes. Of the two 800 bpi tapes required for a single scene, it will be 1 for the first tape and 2 for the second.

TIME OF TAPE START SINCE BEGINNING OF FRAME. This is the time, in terms of microseconds, at which the CCT data recording was started with respect to the beginning of the standard LANDSAT Frame image product. It is equal to zero for standard frames.

PROCESSING FLAGS. The seven flags, reading from left to right are:

— Spare Flag # 1
  ϕ N/A
  1 N/A

— Radiometric Levels
  ϕ for 64 levels
  1 for 256 levels

— Geometric Correction
  ϕ for no correction
  1 for correction

— Spare Flag # 4
  ϕ N/A
  1 N/A

— Radiometric Corrections
  ϕ for statistical calibrations
  1 for step wedge calibrations

— Spare Flag # 6
  ϕ N/A
  1 N/A

— Character Code
  ϕ for EBCDIC
  1 for ASCII

3. TRANSFORMATION RECORD

The 720 bytes of the transformation record are used to store 36 floating point numbers (Format 36E20.10) in either EBCDIC or ASCII Code. These parameters define the frame centre, orientation of the frame with respect to the Universal Transverse Mercator (UTM) grid, and the various parameters used to define the precision corrections which were applied during the production of the CCT. Figure 3 shows a sample transformation block.

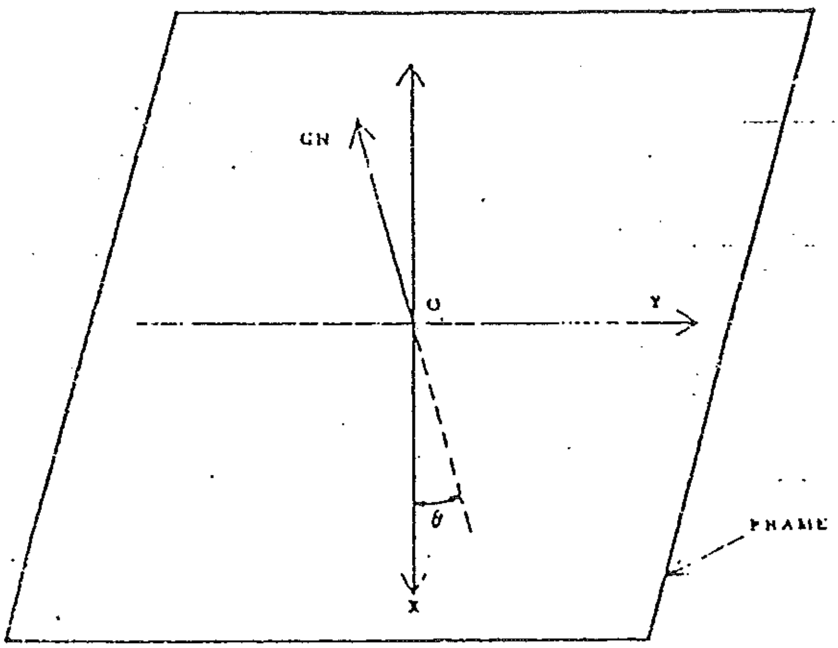
UTM ZONE NUMBER. During precision processing, a given frame is mapped into a single UTM zone. If the frame covers areas from more than a single zone, the zone of greatest coverage is chosen and extended to cover the frame. The first entry of the Transformation Block defines this UTM zone.

UTM COORDINATES OF FRAME. The UTM coordinates of the frame centre are expressed as UTM Northing (second entry) and UTM Easting (third entry) in metres from the equator and the central meridian of the UTM zone. The central meridian is 500,000. An Easting greater than 500,000 is east of the central meridian, and one less than 500,000 is located to the west.

0.3100000000E 02	0.4773118500E 07	0.3113818750E 06	0.2517369092E 00
0.2152378387E 03	0.0000000000E 00	0.3703999996E 01	0.3703999996E 01
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
0.0000000000E 00	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00

Figure 3. – Transformation block

ORIENTATION OF THE FRAME. The orientation of the frame with respect to the above specified UTM grid is given in radians. Figure 4 is a diagram showing the geometry. The angle θ includes the convergence of the meridians (i.e. the angle at the frame centre between true north and grid north) and satellite nominal heading. This number appears in entry 4.



O – IMAGE FRAME CENTRE
GN – DIRECTION OF UTM GRID NORTH
OX – DIRECTION OF ALONG-TRACK SATELLITE MOTION
OY – DIRECTION OF ACROSS-TRACK SCAN MOTION

Figure 4. – Frame Orientation

PSEUDO ALTITUDE. The pseudo-altitude of the satellite given in km is contained in entry 5. In order to obtain the true altitude, this must be multiplied by the X Scale Factor (entry 7).

Y OFFSET. The Y offset in km is given in entry 6. This parameter results from the effective roll function.

SCALE FACTORS. The X and Y scale factors are given in entries 7 and 8, respectively. These give the scale in the X (along track) and Y (across track) directions respectively, and correct for aspect ratio. They refer to the 70 mm film image, as produced at Fucino.

ORDER OF ATTITUDE POLYNOMIALS. Entry 9 contains the order N of the attitude polynomials. If this number is 0, no correction parameters are available.

ATTITUDE POLYNOMIALS. Entries 10–18 contain the parameters (p_r) of the precision corrected roll function, 19–27 those (p_p) of the precision corrected pitch function and 28–36 those (p_y) of the precision corrected yaw function. For example, the first parameters of the roll, pitch and yaw functions are given by entries 10, 19 and 28 respectively; the second parameters by entries 11, 20 and 29; the third parameters by entries 12, 21 and 30, etc.

The attitude angles of LANDSAT, e.g. roll for any given point x in the image is computed by the following equation:

$$\text{roll} = \sum_{k=1}^{N+1} p_r(k) \cdot x^{k-1}$$

where:

$p_r(k)$ is the appropriate parameter for a given attitude angle, i.e. from words 10 to 10+N for roll, 19 to 19+N for pitch and words 28 to 28+N for yaw,

x is the distance between the frame center and the point in question in the direction of along-track satellite motion.

4. RADIOMETRIC LOOK–UP TABLE RECORDS

There are five radiometric look-up table records, one for each band. Each is 1620 bytes in length. The tables contain the entries used to correct this CCT. There are 64 entries for each of the 26 sensors. As there are six sensors in each of the first four bands, the records are in (3841I, 8I4X) format or its equivalent. Since there are only two sensors for the thermal band, it is written with a format equivalent to (1281I, 1108X). Each table entry has a value in the range 0–255. Figure 5 shows a sample print out of these records.

These tables are derived from either the calibration data transmitted from the satellite or a statistical analysis of the scene data itself. The procedure used is described in detail in Appendix B.

The last of the look up records is followed by an end of file mark.

6. MSS DATA SETS

A data set is defined as the ancillary data and all of the video data for one scan line for all active channels (bands). For LANDSAT–1 and 2, a data set will consist of four physical records, each 3780 bytes in length. The first two bytes of a physical record give the number of that record within its data set. The ancillary data are given in bytes 3–180 of the first record and in bytes 3603–3780 of the next three records. Band 4 video data are given in bytes 181–3780 of the first physical record. For bands 5, 6 and 7, video data are given in bytes 3–3602 of the second, third and fourth records, respectively. The physical format for a typical data set is shown below. All data in the record are in binary.

A video data block is that part of the record containing the actual scene video information. For LANDSAT–1 and 2, each such data block is 3600 bytes long. Byte 1 of

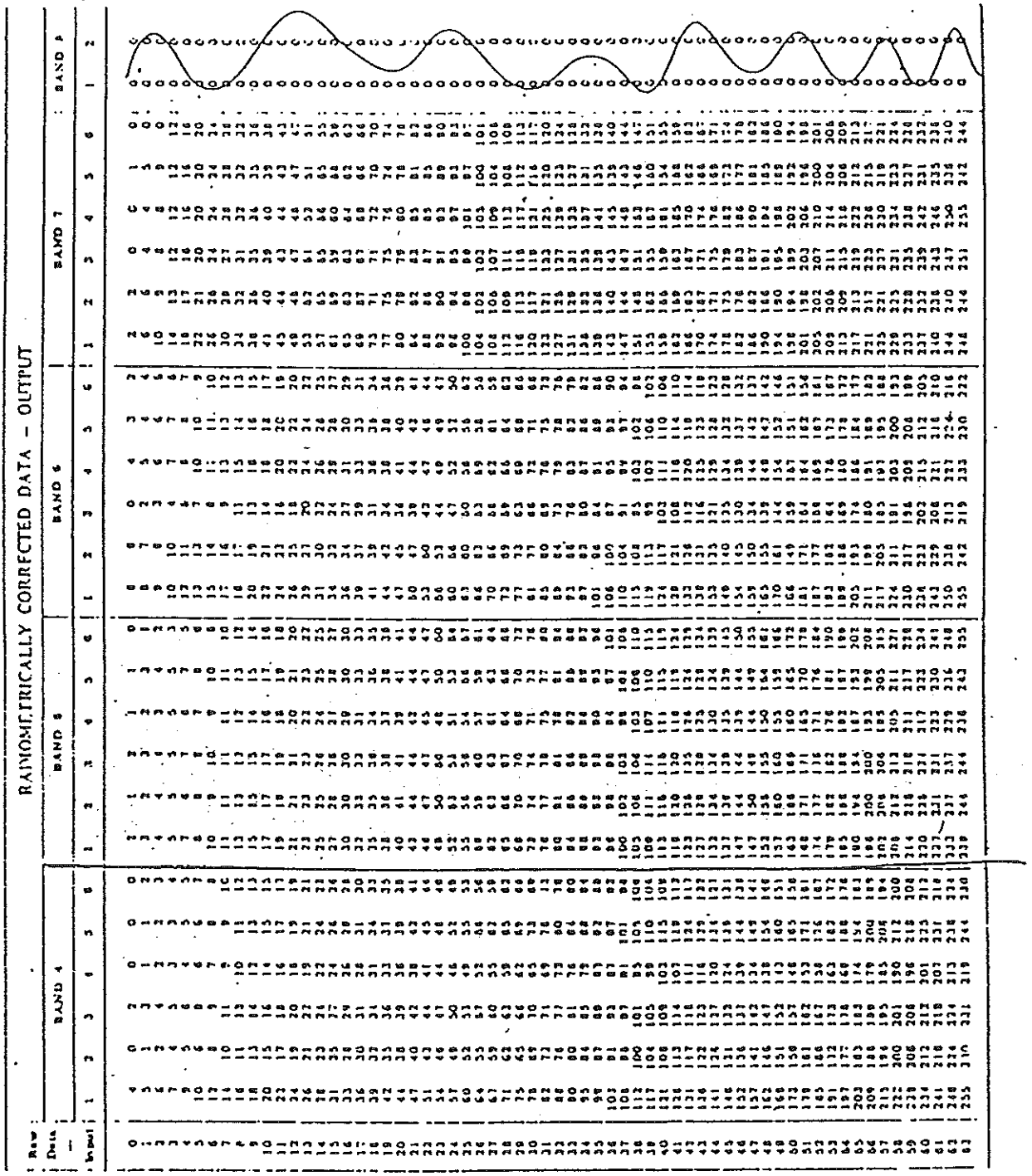
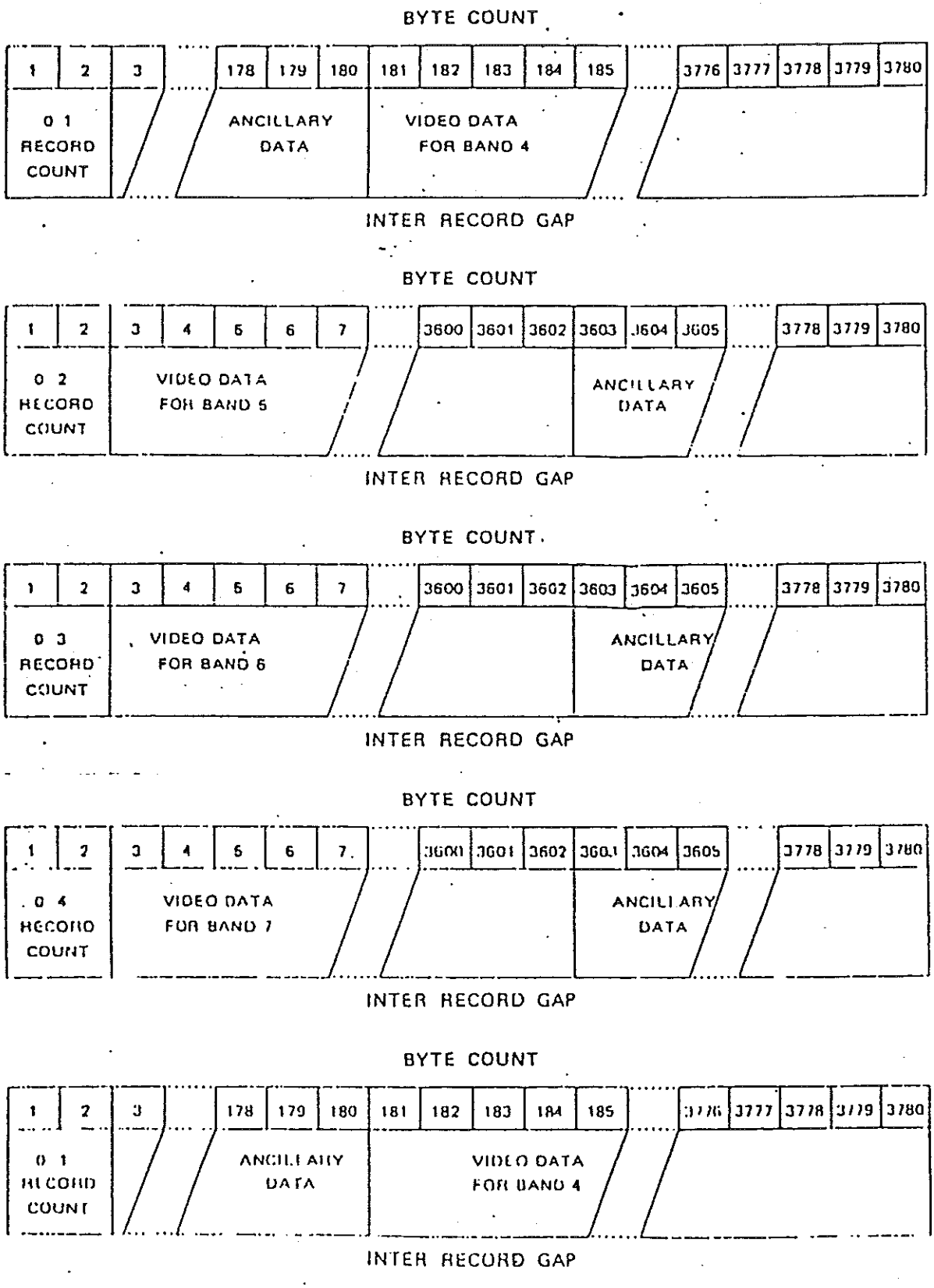


Figure 5. – Radiometric Look-up Table Record

the first video data block is byte 181 of physical record 1. Byte 1 of the second, third and fourth video data blocks is byte 3 of the corresponding physical records, namely 2, 3 and 4 respectively.



The correspondence between physical records and data blocks is given below:

Physical Record Number	Physical Record Byte No	Data Block Descriptor	Data Block Byte No.		No. of Bytes
1	1 - 2	Counter	-	01	2
1	3 180	Ancillary Data Block	1 - 178	Ancillary Data	178
1	181 3780	Video Data Block 1	1 - 3600	Video Data for Band 4	3600
2	1 2	Counter	-	02	2
2	3 - 3602	Video Data Block 2	1 - 3600	Video Data for Band 5	3600
2	3603 - 3780	Ancillary Data Block	1 - 178	Ancillary Data	178
3	1 2	Counter	-	03	2
3	3 3602	Video Data Block 3	1 - 3600	Video Data for Band 6	3600
3	3603 3780	Ancillary Data Block	1 - 178	Ancillary Data	178
4	1 2	Counter	-	04	2
4	3 - 3602	Video Data Block 4	1 - 3600	Video Data for Band 7	3600
4	3603 - 3780	Ancillary Data Block	1 - 178	Ancillary Data	178

ANCILLARY DATA BLOCK. The data provided in the 178-byte ancillary data block are described below.

DATA BLOCK BYTE No.	DESCRIPTION	No. of BYTES
1 - 4	Time in GMT at start of scan. A 32 bit value calculated from Satellite Time Code as (((hours * 60) + minutes) * 60) + seconds) * 100. If Satellite Time Code is not valid, time is equal to previous value.	4
5 - 7	Zero fill.	3
8 11	All zero if bands 4 to 7 in sync, all non zero if sync lost.	4
12	Zero fill.	1
13 14	End of Video flag count	2
15 - 16	Minor frame sync loss count	2
15 - 68	Zero fill	54
69 70	Scan line number (= data set number) 1 to 2286	2
71 104	Zero fill	34
105 106	MSS data start position within the scan (which also includes leading and trailing zeros) relative to beginning of record. See Note 1 below.	2
107 108	Position of last MSS data pixel within the scan relative to beginning of record. See Note 2 below.	2
109-110	Uncorrected Line Length	2

(cont.)

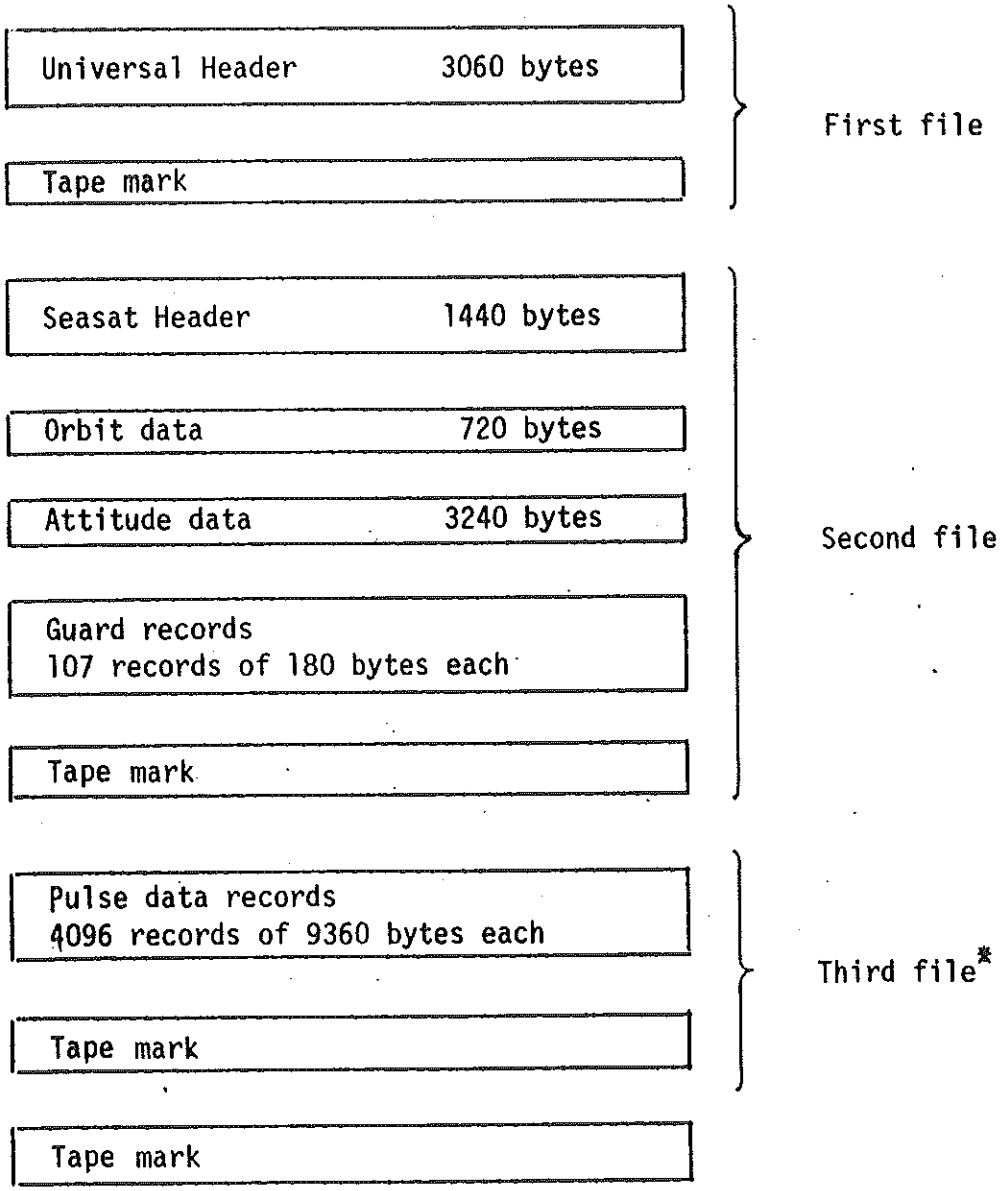
DATA BLOCK BYTE No.	DESCRIPTION	No. of BYTES
112-116	Satellite Time Code 112 = tens of days, days 113 = tens of hours, hours 114 = tens of minutes, minutes 115 = tens of seconds, seconds 116 = tenths of seconds, hundredths of seconds Note: hundreds of days digit is not provided. BCD format.	5
117	Sensor set for this swath: 1 = Sensors 1, 7, 13, 19 2 = Sensors 2, 8, 14, 20 3 = Sensors 3, 9, 15, 21 4 = Sensors 4, 10, 16, 22 5 = Sensors 5, 11, 17, 23 6 = Sensors 6, 12, 18, 24	1
118-172	Zero fill	55
173-176	X-Coordinate of scan line in meters	4
177-178	One fill	2

Note 1: MSS data start position is computed as follows:
Band 4: START=A, where A=value stored in bytes 105-106
Band 5: START=A-178-2
Band 6: START=A-178-4
Band 7: START=A-178-6

Note 2: MSS data stop position is computed as follows:
Band 4: STOP=B, where B=value stored in bytes 107-108
Band 5: STOP=B-178-2
Band 6: STOP=B-178-4
Band 7: STOP=B-178-6

VIDEO DATA BLOCKS. Each video data block contains 3600 data bytes in the format, as previously described. MSS band 4 video data are contained in bytes 181-3780 of physical record 1, band 5, 6 and 7 video data are in bytes 3-3602 of physical records 2,3 and 4 respectively.

RADAR SIGNAL CCT FILE STRUCTURE



* The final tape of a set copied from the disk may not contain 4096 records due to the unknown number of fill frames in the original data.