FAST FORMAT DOCUMENT

for TM Digital Products

Version B, Effective November 1, 1993

INTRODUCTION

This document describes the revised EOSAT Fast Format for Thematic Mapper (TM) digital products. The changes in this document pertain to expanded header file field descriptions and the addition of a trailer file to the tape structure.

GENERAL FORMAT RULES:

1. All field definitions strictly follow American National Standards Institute (ANSI) and International Organization for Standardization (ISO) standards.

2. Only Band Sequential (BSQ) image structure is supported because data to be written to tape is made available a single band at a time. (Geometric corrections to the image are done one band at a time.)

3. Image files consist of a single band of data.

4. A digital product is referred to as a volume set. Individual tapes are referred to as volumes. A volume set may have one or more volumes, depending on image size and output tape density. Multi-resolution data sets have a volume set for each resolution.

GENERAL FORMAT DESCRIPTION

The Fast Format volume set contains a header file, image files, and **now a trailer file**. The contents and format of the header and image files have not changed. The trailer file provides additional information about the image data. Current ingest software can read the header and image files. Ingest software modification may be required to read the trailer file.

HEADER FILE

The first file on each volume, a Read-Me-First file, contains header data. It is in American Standard Code for Information Interchange (ASCII), to ANSI and ISO standards.

Alphanumeric fields are left justified and numeric fields are right justified. Dates are given in ANSI full year, month, and day-of-month format. All processing options and map projection information for the product are also contained in this file.

IMAGE FILES

All image files contain only one TM band of image pixels. There are no header records within the image file, nor are there prefix and/or suffix data in the individual image records. Image data may be blocked or unblocked. Blocking is performed to condense as much data onto the tape as possible; map-oriented full scenes otherwise would not fit onto four tapes.

TRAILER FILE

The last volume of the Fast Format image set includes a trailer file after the image files. This file may require software modification to read, but does not need to be read to ingest the image files. The trailer file contains ephemeris information to compute the approximate spacecraft position for each pixel in the image. This file is in ASCII, to ANSI and ISO standards. For information about the current content of the trailer file refer to EOSAT's Fast Format Trailer File Document.

NOTE: EOSAT will use the trailer file to test the utility of new fields for customer use. Users should code the ingest of this file carefully because other data may be added to future versions of the trailer file. We recommend that you follow a procedure similar to:

1) Read the line as an 80 character ASCII string.
2) Decode the first few characters and test against expected entries.
3) Continue to read and decode if the first characters match the expected entry, otherwise print the line for visual interpretation.
4) Terminate on the characters END OF TRAILER FILE.

The file is in ASCII and is readable as whole, and printable using standard system command utilities. Some users may prefer to "dump" the trailer file and print it using standard command language operations and therefore will not need to write new code.

Detailed Format Description

HEADER FILES

The header file contains a single 1536-byte ASCII record. The accompanying table describes its format, including the number of bytes, the FORTRAN format statement and a brief description of each field in the header file. All alphanumerics are left justified, and all numerics right justified. Fields of fixed (constant) values are represented with capital letters in quotes (e.g., "PRODUCT ="). Variable fields are represented with lower case letters. In both fixed and variable fields, blank spaces are indicated by the Greek character "δ" (delta).

Fields 35, 37, 39, 61, 95, 97, and 99 of each volume's header file must be read in order to import the image data. These fields are volume specific and must be read for each volume of a set.

Fields 41, 43, 47, and 63-93 contain information necessary to convert from image coordinates to map projection and geodetic (latitude and longitude) coordinates.

Field 10 (bytes 90-93) identifies the Thematic Mapper (TM) instrument mode and multiplexer where mode 1 = bands 1,2,3,4,5,6,7.

Fields 21-33 (bytes 301-401) contain the maximum and minimum detected radiance levels within the scene for the corresponding bands present on the current volume. (See Field 95 to identify which bands are present on the current volume.) The maximum and minimum radiance values are in radiance units: milliwatts/(square cm-steradian). The nominal maximum and minimum radiance values for each satellite are included in Table 1.

These values can be used to calculate the gains and biases to convert the image digital counts to spectral radiance values. To obtain gains and biases, use the following equation:

$$\text{Gain} = \left(\frac{\text{Maximum Radiance}}{254}\right) - \left(\frac{\text{Minimum Radiance}}{255}\right)$$

Bias = Minimum Radiance

Table 1 Radiance Values for Landsats 4 and 5 in milliwatts/(square cm-steradian)

Landsat 4			Landsat 5	
Maximum	Minimum		Maximum	Minimum
1.104547	-0.022181	Band 1	1.059476	-0.016946
2.455621	-0.049292	Band 2	2.611919	-0.041805
1.402240	-0.033929	Band 3	1.639662	-0.026226
3.128049	-0.128175	Band 4	2.949823	-0.059251
0.643351	-0.015569	Band 5	0.683888	-0.016548
1.568660	0.125240	Band 6	1.524310	0.123780
0.457179	-0.009181	Band 7	0.424707	-0.008528

Table 2 Bandwidths for Landsats 4 and 5 in microns.

	Band1	Band2	Band3	Band4	Band5	Band6	Band7
Landsat 4	0.066	0.081	0.069	0.129	0.216	1.000	0.250
Landsat 5	0.066	0.082	0.067	0.128	0.217	1.000	0.252

Note: These calculated Gain and Bias values will give spectral radiance values in units of milliwatts/(square cm-steradian). To obtain band radiance units of milliwatts/(square cm-steradian-micron), divide the computed radiance value by the detector bandwidth. The bandwidths for Landsat 4 and 5 in microns, are included in Table 2.

Field 35 (bytes 439-441) contains the tape spanning flag, which indicates whether the tape is part of a multi-volume set. This field will be "1/1" (one of one) for tapes containing one or more complete image files and will be either "1/2" or "2/2" for full-scene image files spanning two volumes.

Field 37 (bytes 456-460) identifies the first image line on the tape volume. This is "1" unless the tape is the second or higher numbered volume of a multi-volume set (e.g. field 35 is "2/2"). In this case it is the line number in the complete image of the first image line on the tape (nominally N/2 + 1 for two-tape sets, where N is the total number of lines in the image). This is a right-justified ASCII numeric field.

Field 39 (bytes 476-480) contains the number of image lines on the tape volume. This is the number of lines in each image file (the same as field 61) for tapes containing one or more complete image files. For multi-volume sets it is the number of image lines on the tape volume (nominally N/2 for two-tape sets, where N is the total number of lines in the image). This is a right-justified ASCII numeric field.

Field 41 (bytes 495-500) identifies the orientation angle of the scene. For non-polar scenes the orientation angle of the scene is relative to the scene alignment to map or grid north. For non-polar, map-oriented scenes this field should be zero. A negative angle implies a clockwise rotation of the scene to align with map north whereas a positive angle implies a counterclockwise rotation of the scene to align with map north. To calculate the orientation angle of any image use the following equation:

$$\text{ANGLE} = \arctan\left(\frac{\text{NORTHDIFF}}{\text{EASTDIFF}}\right)$$

Where

NORTHDIFF = URNORTH - ULNORTH
EASTDIFF = UREAST - ULEAST
URNORTH = Upper right corner point Northing (field 77)
ULNORTH = Upper left corner point Northing (field 69)
UREAST = Upper right corner point Easting (field 75)
ULEAST = Upper left corner point Easting (field 67)

Field 47 (bytes 560-565) contains the Universal Transverse Mercator zone code or the National Ocean Survey (NOS) State Plane Coordinate System zone code number when either of these map projections are selected (see fields 43 or 45).

Field 61 (bytes 1108-1112) would also normally be read before importing the image data files. This field contains the total number of lines in the image and is needed to determine the amount of disk space required for the image.

Fields 63-93 (bytes 1117-1344) contain the corresponding corner pixel locations (latitude, longitude, easting, northing) relative to the resampled pixel center for all bands on the current tape volume. To calculate the Northing and Easting of any pixel within the image use the map coordinates of the image corner points and the following equations:

$$PE = \frac{(NP-P)(NL-L)ULE+(P-1)(NL-L)URE+(NP-P)(L-1)LLE + (P-1)(L-1)LRE}{(NP-1)(NL-1)}$$

$$PN = \frac{(NP-P)(NL-L)ULN+(P-1)(NL-L)URN+(NP-P)(L-1)LLN+(P-1)(L-1)LRN}{(NP-1)(NL-1)}$$

Where

PE = Desired pixel location Easting
PN = Desired pixel location Northing
ULE = Upper left corner point Easting (field 67)
URE = Upper right corner point Easting (field 75)
LLE = Lower left corner point Easting (field 91)
LRE = Lower right corner point Easting (field 83)
ULN = Upper left corner point Northing (field 69)
URN = Upper right corner point Northing (field 77)
LLN = Lower left corner point Northing (field 93)
LRN = Lower right corner point Northing (field 85)
P = Pixel number of desired location (counted from left)
L = Line number of desired location (counted from top)
NP = Number of pixels per image line (field 59)
NL = Total number of lines in the output image (field 61)

Field 95 (bytes 1361-1367) contains the band identifiers for the image files on the tape volume. This field is composed of seven one-byte sub-fields containing from one to seven of the band identifiers "1", "2", "3", "4", "5", "6", "7". The band identifiers are listed in the order in which the image files appear on the tape and are left justified in the seven-byte ASCII alphanumeric field.

Field 97 (bytes 1386-1389) contains the blocking factor used to minimize the number of CCT tapes required to accommodate the image set. This field is always '1' for 8mm tapes. (See Blocking Factor explanation under Image Files.)

Field 99 (bytes 1406-1410) contains the physical tape record length. The value is right justified in an ASCII numeric field. The number of pixels (samples) per image line can be determined by dividing this field by the value in field 97 or by reading field 59 (bytes 1086-1090).

Field 101 (bytes 1427-1428) contains the sun elevation angle in degrees for the scene center location at the scene center acquisition time. This angle specifies the solar parallel of altitude on the celestial sphere as referenced from the celestial horizon of the scene center.

Field 103 (bytes 1443-1445) contains the sun azimuth (west) in degrees for the scene center location at the scene center acquisition time. This angle specifies the vertical circle (west) on which the sun's location is measured from the principal vertical circle of the scene center.

Field 115 (bytes 1528-1531) contains the horizontal offset of the true scene center from the nominal WRS scene center in units of whole pixels. A negative value implies a westerly offset of the scene center from the nominal WRS scene center in daytime scenes (rows 1-120) and an easterly offset of the scene center in nighttime scenes (rows 125-244).

IMAGE FILE FORMAT

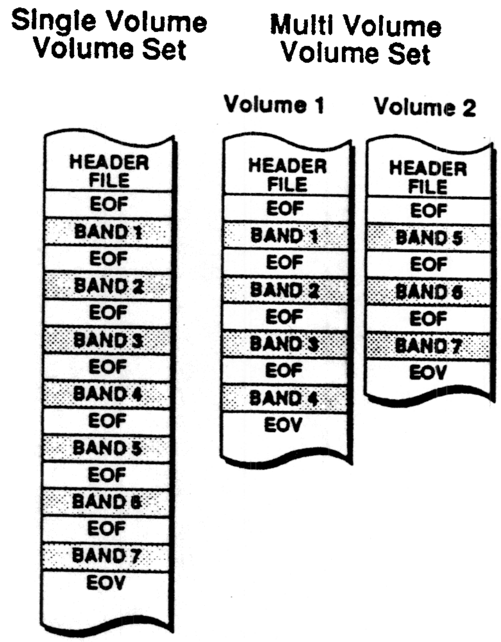
BLOCKING FACTOR

Blocking factor is a procedure EOSAT uses to minimize the number of CCT tapes required to accommodate a full-scene seven band image set. Image data is written to tape in individual records and between each record is an inter-record gap (IRG), 0.35 of an inch, separating image file records. Unblocked data, also described as having a blocking factor of one, contains one line of image data per tape record. Data written at a blocking factor of three consolidates three lines of image data into one tape record. By using blocking factors, a significant amount of CCT tape space is saved within each image file. For example, a blocking factor of three eliminates two IRGs required in the unblocked format to write out the same three image lines, saving 0.70 inches; for a Landsat scene, the total savings is more than 116 feet of tape.

Blocked data have a maximum tape record of 32,768 bytes (pixels). Depending on the image line length, EOSAT Image Processing System (EIPS) software calculates the maximum number of image lines that can be consolidated into a tape record. This number of image lines within the tape record is the tape blocking factor as set in the product header file (field 97). The actual length of the tape record, as determined by the image data line length and blocking factor, is also calculated by the EIPS software and set in the product header file (field 99). Copying blocked data from tape to disk is normally handled by the system software on your computer. Your system software will need the blocking factor to separate the image data lines from within the tape record. Certain computer operating systems cannot read large (32,768 byte) records from tape. (Check with your system manager.) We can provide unblocked products (blocking factor set to one) that will have more tapes per scene than blocked data. Certain full-scene, map-oriented products cannot be produced at a blocking factor of one because the files are too big. All subscene products are supplied with the blocking factor set to one.

TAPE STRUCTURE

Examples of the tape structure for a single-volume and a multi-volume set are presented below. Each file is followed by an End-Of-File (EOF) marker. An End-Of-Volume (EOV) marker consists of three EOFs.



CCT TAPE STRUCTURE

The cartographic software package used in processing the Landsat imagery is described in the following references:

General Cartographic Transformation Package (GCTP)
Software Reference
NOAA Technical Technical Report NOS 124 CGS 9
General Cartographic Transformation Package GCTP, Version II
Atef A. Elassal - February 1987
U.S. Dept. of Commerce
National Geodetic Information Center, NOAA
Rockville, MD 20852

USGS Map Projection Reference
Map Projections - A Working Manual
U.S. Geological Survey Professional Paper 1395
(Supersedes USGS Bulletin 1532)
John P. Snyder - 1987
U.S.G.S. Map Sales
P.O. Box 25286
Denver, CO 80225

Appendix A: Path-Oriented Products

This appendix contains the map projections and ellipsoid used in EOSAT's path-oriented TM digital products. This list of map projections shows the two-digit USGS projection number found in field 45 of the header file, the name, and the identifier used in field 43 of the header file. The ellipsoid includes the semi-major axis and the semi-minor axis.

MAP PROJECTIONS

09	Transverse Mercator	TM
21	Space Oblique Mercator	SOM
06	Polar Stereographic	PS

EARTH ELLIPSOID

	Semi-Major Axis (meters)	Semi-Minor Axis (meters)
International 1909	6378388.000000	6356911.946130

Appendix B: Map-Oriented Products

This appendix contains the map projections and the ellipsoids used in EOSAT's map-oriented TM digital products. This list of map projections shows the two-digit USGS projection number found in field 43 of the header file, the name, and the identifier used in field 43 of the header file. The list of ellipsoids includes the semi-major axis and the semi-minor axis.

MAP PROJECTIONS

01	Universal Transverse Mercator	UTM
02	State Plane Coordinate System	SPCS
03	Albers Conical Equal Area	ACEA
04	Lambert's Conformal Conic	LCC
05	Mercator	MER
06	Polar Stereographic	PS
07	Polyconic	PC
08	Equidistant Conic (Type A & B)	EC
09	Transverse Mercator (Gauss-Krueger)	TM
10	Stereographic	SG
11	Lamberts Azimuthal Equal Area	LAEA
12	Azimuthal Equidistant	AE
13	Gnomonic	GNO
14	Orthographic	OG
15	General Vertical Near-Side Perspective	GVNP
16	Sinusoidal	SIN
17	Equirectangular (Plate Carree)	ER
18	Miller Cylindrical	MC
19	Van Der Grinten I	VDG
20	Oblique Mercator (Type A & B)	OM
21	Space Oblique Mercator	SOM

EARTH ELLIPSOIDS

	Semi-Major Axis (meters)	Semi-Minor Axis (meters)
Clarke 1866	6378206.400000	6356583.800000
Clarke 1880	6378249.145000	6356514.869550
International 1967	6378157.500000	6356772.200000
International 1909	6378388.000000	6356911.946130
WGS 66	6378145.000000	6356759.769356
WGS 72	6378135.000000	6356750.519915
GRS 1980	6378137.000000	6356752.314140
Airy	6377563.396000	6356256.910000
Modified Airy	6377340.189000	6356034.448000
Everest	6377276.345200	6356075.413300
Modified Everest	6377304.063000	6356103.039000
Mercury 1960	6378166.000000	6356784.283666
Modified Mercury 1968	6378150.000000	6356768.337303
Bessel	6377397.155000	6356078.962840
Walbeck	6376896.000000	6355834.846700
Southeast Asia	6378155.000000	6356773.320500
Australian National	6378160.000000	6356774.719000
Krassovsky	6378245.000000	6356863.018800
Hough	6378270.000000	6356794.343479
6370997 Sphere	6370997.000000	6370997.000000

	Field	Bytes	Format	Description
*	1	1-9	A9	"PRODUCTδ="
*	2	10-20	A11	Product order number in 'yydddnnn-cc' format
	3	21-26	A6	"δWRSδ="
*	4	27-35	A9	WRS Path/Row/Fraction in 'ppp/rrrff' format
	5	36-54	A19	"δACQUISITIONδDATEδ="
	6	55-62	A8	Date in 'yyyymmdd' format
	7	63-74	A12	"δSATELLITEδ="
	8	75-76	A2	Satellite number: 'L4' 'L5'
	9	77-89	A13	"δINSTRUMENTδ="
*	10	90-93	A4	Instrument type: 'TMmn' where "m" = mode number "n" = multiplexer number
	11	94-108	A15	"δPRODUCTδTYPEδ="
*	12	109-122	A14	Product type: 'MAPδORIENTEDδδ', 'ORBITδORIENTED'
*	13	123-137	A15	"δPRODUCTδSIZEδ="
*	14	138-147	A10	Product size: 'FULLδSCENE', 'SUBSCENEδδ', 'MAPδSHEETδ'
*	15	148-225	A78	Map sheet name (if applicable)
	16	226-255	A30	"δTYPEδOFδGEODETICδPROCESSINGδ="
*	17	256-265	A10	Type of geodetic processing used: 'SYSTEMATIC', 'PRECISIONδ', 'TERRAINδδδ'
	18	266-278	A13	"δRESAMPLINGδ="
	19	279-280	A2	Resampling algorithm used: 'CC', 'BL', 'NN'
*	20	281-300	A20	"δRADδGAINS/BIASESδ=δ"
*	21	301-316	A16	Maximum and Minimum detectable radiance values for the first band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format. The maximum and minimum radiance units: milliwatts/(square cm - steradian). See Detailed Format Description for band gain and bias value conversions.
*	22	317-317	1X	Blank
*	23	318-333	A16	Maximum and Minimum detectable radiance values for the second band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format (if applicable).
*	24	334-334	1X	Blank
*	25	335-350	A16	Maximum and Minimum detectable radiance values for the third band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format (if applicable).
*	26	351-351	1X	Blank
*	27	352-367	A16	Maximum and Minimum detectable radiance values for the fourth band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format (if applicable).
*	28	368-368	1X	Blank
*	29	369-384	A16	Maximum and Minimum detectable radiance values for the fifth band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format (if applicable).
*	30	385-385	1X	Blank
*	31	386-401	A16	Maximum and Minimum detectable radiance values for the sixth band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format (if applicable).
*	32	402-402	1X	Blank
*	33	403-418	A16	Maximum and Minimum detectable radiance values for the seventh band (see Field 95) on the tape in 'mm.mmmmm/n.nnnnn' format (if applicable).
*	34	419-438	A20	"δVOLUMEδ#/#δINδSETδ="
*	35	439-441	A3	Tape volume number and number of volumes in tape set in 'n/m' format (for multi-volume image).
*	36	442-455	A14	"δSTARTδLINEδ#="
*	37	456-460	I5	First image line number on this volume (for multi-volume image)
*	38	461-475	A15	"δLINESδPERδVOL="
*	39	476-480	I5	Number of image lines on this volume (for multi-volume image)
	40	481-494	A14	"δORIENTATIONδ="

* Indicates a changed or additional field from Rev. A.

NOTES: 1.) Double quotes are fixed fields and single quotes are product specific fields.
2.) The character δ (delta) stands for blank.

	Field	Bytes	Format	Description
	41	495-500	F6.2	Orientation angle in degrees (may be negative)
	42	501-513	A13	"δPROJECTIONδ="
	43	514-517	A4	Map projection name
	44	518-537	A20	"δUSGSδPROJECTIONδ#δ="
	45	538-543	I6	USGS projection number
	46	544-559	A16	"δUSGSδMAPδZONEδ="
	47	560-565	I6	USGS map zone
	48	566-594	A29	"δUSGSδPROJECTIONδPARAMETERSδ="
	49	595-954	15D24.15	The USGS projection parameters in standard USGS order. The meaning of these values depends on the projection used.
	50	955-972	A18	"δEARTHδELLIPSOIDδ="
	51	973-992	A20	Ellipsoid used
	52	993-1010	A18	"δSEMI-MAJORδAXISδ="
	53	1011-1021	F11.3	Semi-major axis of earth ellipsoid in meters
	54	1022-1039	A18	"δSEMI-MINORδAXISδ="
	55	1040-1050	F11.3	Semi-minor axis of earth ellipsoid in meters
	56	1051-1063	A13	"δPIXELδSIZEδ="
	57	1064-1068	F5.2	Pixel size in meters
*	58	1069-1085	A17	"δPIXELSδPERδLINE="
*	59	1086-1090	I5	Number of pixels per image line
*	60	1091-1107	A17	"δLINESδPERδIMAGE="
*	61	1108-1112	I5	Total number of lines in the output image (on all volumes)
	62	1113-1116	A4	"δULδ"
	63	1117-1129	A13	Geodetic Longitude of Upper Left corner of image. As per FIPS PUB 70, longitude will be expressed as degrees, minutes, seconds. Example: 5 degrees, 15 minutes, 13.2 seconds west of the prime meridian will be expressed as "0051513.2000W."
	64	1130-1130	1X	Blank
	65	1131-1142	A12	Geodetic Latitude of Upper Left corner of image. As per FIPS PUB 70, latitude will be expressed as degrees, minutes, seconds. Example: 9 degrees, 4 minutes, 24.2334 seconds north of the equator will be expressed as "090424.2334N."
	66	1143-1143	1X	Blank
	67	1144-1156	F13.3	Easting of Upper Left corner of image in meters X
	68	1157-1157	1X	Blank
	69	1158-1170	F13.3	Northing of Upper Left corner of image in meters Y
	70	1171-1174	A4	"δURδ"
	71	1175-1187	A13	Geodetic Longitude of Upper Right corner of image
	72	1188-1188	1X	Blank
	73	1189-1200	A12	Geodetic Latitude of Upper Right corner of image
	74	1201-1201	1X	Blank
	75	1202-1214	F13.3	Easting of Upper Right corner of image in meters X
	76	1215-1215	1X	Blank
	77	1216-1228	F13.3	Northing of Upper Right corner of image in meters Y
	78	1229-1232	A4	"δLRδ"
	79	1233-1245	A13	Geodetic Longitude of Lower Right corner of image
	80	1246-1246	1X	Blank
	81	1247-1258	A12	Geodetic Latitude of Lower Right corner of image
	82	1259-1259	1X	Blank
	83	1260-1272	F13.3	Easting of Lower Right corner of image in meters X
	84	1273-1273	1X	Blank
	85	1274-1286	F13.3	Northing of Lower Right corner of image in meters Y

* Indicates a changed or additional field from Rev. A.

NOTES: 1.) Double quotes are fixed fields and single quotes are product specific fields.
2.) The character δ (delta) stands for blank.

	Field	Bytes	Format	Description
	86	1287-1290	A4	"δLLδ"
	87	1291-1303	A13	Geodetic Longitude of Lower Left corner of image
	88	1304-1304	1X	Blank
	89	1305-1316	A12	Geodetic Latitude of Lower Left corner of image
	90	1317-1317	1X	Blank
	91	1318-1330	F13.3	Easting of Lower Left corner of image in meters X
	92	1331-1331	1X	Blank
	93	1332-1344	F13.3	Northing of Lower Left corner of image in meters Y
	94	1345-1360	A16	"δBANDSδPRESENTδ="
	95	1361-1367	A7	Bands present on this volume
	96	1368-1385	A18	"δBLOCKINGδFACTORδ="
	97	1386-1389	I4	Tape blocking factor
	98	1390-1405	A16	"δRECORDδLENGTHδ="
	99	1406-1410	I5	Length of physical tape record
	100	1411-1426	A16	"δSUNδELEVATIONδ="
	101	1427-1428	I2	Sun elevation angle in degrees at scene center
	102	1429-1442	A14	"δSUNδAZIMUTHδ="
	103	1443-1445	I3	Sun azimuth in degrees at scene center
	104	1446-1453	A8	"δCENTERδ"
	105	1454-1466	A13	Scene center geodetic longitude expressed in degrees, minutes, seconds as above. This is the true center of the full scene from which the product image was made, and does not necessarily fall inside the product image.
	106	1467-1467	1X	Blank
	107	1468-1479	A12	Scene center geodetic latitude expressed in degrees, minutes, seconds as above. This is the true center of the full scene from which the product image was made, and does not necessarily fall inside the product image.
*	108	1480-1480	1X	Blank
*	109	1481-1493	F13.3	Scene center easting in meters X
*	110	1494-1494	1X	Blank
*	111	1495-1507	F13.3	Scene center northing in meters Y
*	112	1508-1513	I6	Scene center pixel number measured from the product upper left corner, rounded to nearest whole pixel (may be negative).
	113	1514-1519	I6	Scene center line number measured from the product upper left corner, rounded to nearest whole line (may be negative).
	114	1520-1527	A8	"δOFFSET="
	115	1528-1531	I4	Horizontal offset of the true scene center from the nominal WRS scene center in units of whole pixels (as specified in the pixel size field (Field 57)). May be negative.
	116	1532-1535	A4	"δREV"
	117	1536-1536	A1	Format version code (A-Z). This document describes version B.

* Indicates a changed or additional field from Rev. A.

NOTES: 1.) Double quotes are fixed fields and single quotes are product specific fields.
2.) The character δ (delta) stands for blank.

Fast Format Trailer File

FAST Format Trailer File Document
For TM Digital Products Version 1.0
Effective November 1, 1993

The last volume of the FAST format image set includes a trailer file after the image files. This file may require software modification to read, but does not need to be read to ingest the image files. The trailer file contains ephemeris information to compute the approximate spacecraft position for each pixel in the image. This enables users to compute terrain displacement and bi-directional reflectance image analysis functions. This file is in American Standard Code for Information Interchange (ASCII), to American National Standards Institute (ANSI) and International Organization for Standardization (ISO) standards.

The ephemeris information contains seven orbit point records across the scene which specify the spacecraft position, velocity, and subsatellite point in image coordinates.

NOTE: EOSAT will use the trailer file to test the utility of the new fields for customer use. Users should code the ingest of this file carefully because other data may be added to future versions of the trailer file. We recommend that you follow a procedure similar to:

1) Read the line as an 80 character ASCII string.

2) Decode the first few characters and test against expected entries.

3) Continue to read and decode if the first characters match the expected entry, otherwise print the line for visual interpretation.

4) Terminate on the characters END OF TRAILER FILE.

The file is in ASCII and is readable as whole, and printable using standard system command utilities. Some users may prefer to "dump" the trailer file and print it using standard command language operations and will not need to write new code.

The trailer file contains fifteen ASCII records, each eighty bytes long. The format of each of these records is described in the following table.

Record #1 - File Header

The first record contains fixed text to identify the beginning of the trailer file.

Field	Bytes	Format	Description
1	18	A18	"BEGINδTRAILERδFILE"
2	62	62X	Blank filled.

Record #2 - Scene Center Reference

The second record contains the scene center date and time. These fields provide the imaging time for the scene center point defined in the FAST format header file. The time is expressed in spacecraft time (UTC).

Field	Bytes	Format	Description
1	27	A27	"SCENEδCENTERδ DATE δANDδ TIME"
2	9	A9	Scene center date as " yyyymmdd"
3	11	A11	Scene center time as " hhmmss.sss"
4	33	33X	Blank filled.

Record #3 - Datum Shift

The third record contains the geocentric datum shift parameters. These parameters are used to convert the Earth Centered Inertial (ECI) spacecraft ephemeris data to ellipsoid centered Cartesian coordinates relative to the local datum. These shift parameters are expressed in meters and should be subtracted from the geocentric position vectors contained in records 9 through 15 to convert them to datum (ellipsoid) centered coordinates.

Field	Bytes	Format	Description
1	23	A23	"DATUMδSHIFTδPARAMETERS="
2	10	F10.1	Geocentric datum shift X component.
3	10	F10.1	Geocentric datum shift Y component.
4	10	F10.1	Geocentric datum shift Z component.
5	27	27X	Blank filled.

Record #4 - Number of Orbit Points

The fourth record contains the number of ephemeris (orbit) point records contained in the file. This is fixed at seven.

Field	Bytes	Format	Description
1	24	A24	"NUMBERδOFδORBITδRECORDS="
2	2	I2	Orbit record count (always 7).
3	54	54X	Blank filled.

Record #5 - Time of First Orbit Point

The fifth record contains the time of the first orbit point in seconds from the scene center time provided in the second trailer file record. The first point is nominally generated 15 seconds before the scene center.

Field	Bytes	Format	Description
1	26	A26	"TIMEδOFδFIRSTδORBITδPOINT="
2	8	F8.3	Time offset for first orbit point.
3	46	46X	Blank filled.

Record #6 - Time Interval Between Orbit Points

The sixth record contains the time interval between orbit points in seconds. Ephemeris points are normally generated every 5 seconds.

Field	Bytes	Format	Description
1	26	A26	"TIMEδBETWEENδORBITδPOINTS="
2	8	F8.3	Time interval between orbit points.
3	46	46X	Blank filled.

Record #7 - Orbit Record Header

The seventh record describes the layout of the seven orbit records to follow. The fields in this record are aligned to serve as column headers above the orbit record fields below.

Field	Bytes	Format	Description
1	11	A11	"Xδδδδδδδδδδ"
2	11	A11	"Yδδδδδδδδδδ"
3	11	A11	"Zδδδδδδδδδδ"
4	9	A9	"XDOTδδδδδ"
5	9	A9	"YDOTδδδδδ"
6	9	A9	"ZDOTδδδδδ"
7	10	A10	"PIXELδδδδδ"
8	10	A10	"LINEδδδδδδ"

continued

Records #8 through #14 - Orbit Data Records

The seven orbit records contain spacecraft state vectors (position and velocity) at five second intervals over the scene. The middle point (point #4) corresponds to the scene center. Each record contains the geocentric spacecraft position vector (X,Y,Z) in meters, the spacecraft velocity vector (XDOT,YDOT,ZDOT) in meters per second in Earth fixed coordinates, and the pixel/line image coordinates of the corresponding subsatellite point.

Field	Bytes	Format	Description
1	11	F11.1	Cartesian X coordinate in meters.
2	11	F11.1	Cartesian Y coordinate in meters.
3	11	F11.1	Cartesian Z coordinate in meters.
4	9	F9.2	Velocity X component in meters/sec.
5	9	F9.2	Velocity Y component in meters/sec.
6	9	F9.2	Velocity Z component in meters/sec.
7	10	F10.2	Subsatellite point pixel location.
8	10	F10.2	Subsatellite point line location.

Record #15 - File Terminator

The fifteenth and last record in the trailer file contains fixed text and identifies the end of the trailer file.

Field	Bytes	Format	Description
1	16	A16	"ENDδTRAILERδFILE"
2	64	64X	Blank filled.

Sample Trailer File

A sample FAST format trailer file is contained in the following figure.

```
BEGIN TRAILER FILE
SCENE CENTER DATE AND TIME= 19920123 173450.975
DATUM SHIFT PARAMETERS=     -8.0   160.0   176.0
NUMBER OF ORBIT RECORDS=     7
TIME OF FIRST ORBIT POINT=   -15.000
TIME BETWEEN ORBIT POINTS=  5.000
    X          Y          Z          XDOT      YDOT      ZDOT      PIXEL     LINE
  -2454403.3 -5442583.4 3800677.4  -3191.85  -2930.05  -6234.87  4470.82    145.78
  -2470333.5 -5457151.8 3769449.7  -3180.20  -2897.25  -6256.19  4222.40   1257.24
  -2486205.2 -5471555.9 3738115.9  -3168.45  -2864.38  -6277.34  3973.49   2368.60
  -2502017.8 -5485795.5 3706676.7  -3156.58  -2831.44  -6298.31  3724.11   3479.86
  -2517770.8 -5499870.2 3675133.1  -3144.59  -2798.43  -6319.10  3474.25   4591.02
  -2533463.6 -5513779.6 3643485.9  -3132.50  -2765.34  -6339.72  3223.93   5702.09
  -2549095.6 -5527523.4 3611736.1  -3120.29  -2732.19  -6360.15  2973.17   6813.07
END TRAILER FILE
```