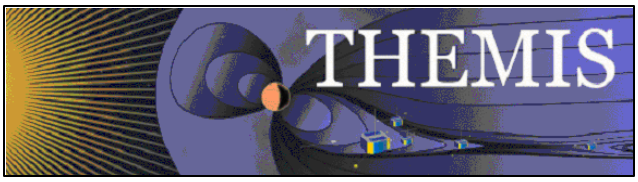


THEMIS
THEMIS Science TIME Definition

THM-SOC-101
September 22, 2006

Timothy Quinn, THEMIS Science Operations

Dr. John Bonnell, THEMIS EFI

Dr. Davin Larson, THEMIS SST

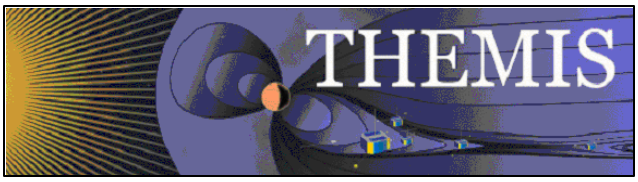
Dr. James McFadden, THEMIS ESA

Dr. Stephen Mende, THEMIS GBO

Dr. Manfred Bester, THEMIS Mission Operations Manager

Peter Harvey, THEMIS Project Manager

Vassilis Angelopoulos, THEMIS Principal Investigator



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Distribution List

Name	Email
Jim Lewis, U.C. Berkeley	jwl@ssl.berkeley.edu
Dr. Tai Phan, U.C. Berkeley	phan@ssl.berkeley.edu
Dr. Ellen Taylor, U.C. Berkeley	ertaylor@ssl.berkeley.edu
Dr. Uli Auster, TUBS	uli.auster@tu-bs.de
Dr. Alain Roux, CETP	Alain.Roux@cetp.ipsl.fr
Dr. Chris Russell, UCLA	ctrussell@igpp.ucla.edu
Dr. Krishan Khurana, UCLA	kkhurana@igpp.ucla.edu
Dr. Dave Sibeck, NASA GSFC	david.g.sibeck@nasa.gov
Dr. Robert McGuire, NASA/SPDF GSFC	robert.e.mcguire@nasa.gov

TBD List

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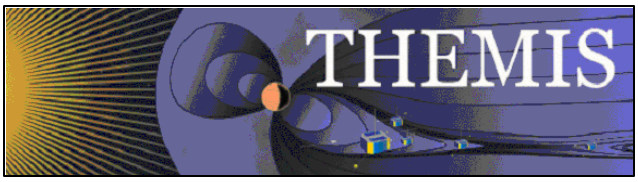

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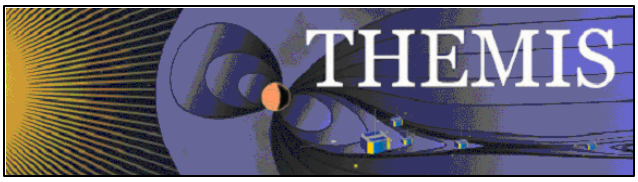


1. Introduction

1.1 Purpose and Scope.

Level 1 data are in CDFs include THEMIS data as data variables which vary with time and depend on a related time variable. Data variables, identified herein as quantities by the generic name VARNAME and the associated time variables are herein called _TIME. This document defines the variable TIME for the THEMIS datasets and describes the way it is linked within the CDF files with the associated data variables.

1.2 Applicable Documents.

1. thm_ fsw_005.xls in: ftp://apollo.ssl.berkeley.edu/pub/THEMIS/2%20Space%20Segment/2.1%20Instrument/2.1.1%20Instrument%20Data%20Processing%20Unit%20(IDPU)/3.1%20FSW/1.%20Docs/

2.	THM_SYS_012_PDMP	THEMIS Project Data Management Plan
3.	THM_SOC_102_STATE_FILE	THEMIS STATE File Definition
4.	THM_SOC_105_FIELDS_L1_VARNAMES	THEMIS FIELDS Variable Name Def's
5.	THM_SOC_108_GMAG_L2_VARNAMES	THEMIS GMAG Variable Name Def's
6.	THM_SOC_109_ASI_L1_VARNAMES	THEMIS ASI Variable Name Definitions
7.	THM_SOC_110_COORDINATES	THEMIS Coordinate Systems Definitions
8.	THM_SOC_113_FGM_CALPROC	THEMIS FGM CAL File and Processing
9.	THM_SOC_113_SCM_CALPROC	THEMIS SCM CAL File and Processing
10.	THM_SOC_113_EFI_CALPROC	THEMIS EFI CAL File and Processing
11.	THM_SOC_113_ESA_CALPROC	THEMIS ESA CAL File and Processing
12.	THM_SOC_113_SST_CALPROC	THEMIS SST CAL File and Processing
13.		

2. Definitions

2.1 THEMIS time definition

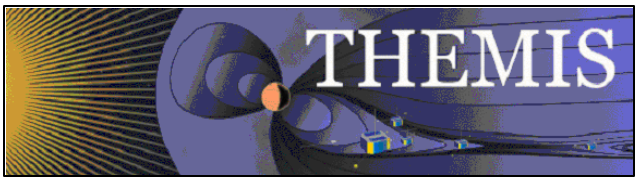
THEMIS TIME shall be UTC and is expected to be accurate to better than +/- 0.5 seconds and have a resolution of $1/2^{16}$ seconds.

2.2 THEMIS "varname_time" representation in L1 and L2 THEMIS CDFs

THEMIS TIME shall be represented as REAL*8 seconds since the THEMIS TIME_BASE

THEMIS TIME_BASE is defined as 1970-Jan-01 00:00:00 UT, without accounting for leap seconds.

Each uniquely named THEMIS TIME shall be accompanied by a non-time varying quantity, of CDF_EPOCH type, which is the CDF_EPOCH of 1970-Jan-01 00:00:00 UT (R*8, un-leaped milliseconds since 0000-Jan-01 00:00 UT).



2.3 "varname_time" variable: naming and association to data

The TIME variable corresponding to data variable "varname" shall be named "varname_time".

The Epoch0 variable corresponding to the EPOCH of the THEMIS TIME_BASE shall be named "varname_epoch0".

When multiple variables are associated with the same time, a suitable name that describes all quantities shall be chosen for the TIME variable.

Every variable "varname" shall be linked to its corresponding "_time" variable by use of two attributes:

1. DEPEND_TIME attribute links "varname" to "varname_time"
2. DEPEND_EPOCH0 attribute links "varname" to "varname_epoch0"

2.4 "varname_epoch" virtual variable: definition, naming and association to THEMIS variables

Each THEMIS variable shall contain one additional virtual variable to represent time, for use by CDAWeb. This variable shall be of type CDF_EPOCH or CDF_EPOCH16, depending on the time resolution required by the quantity. CDF_EPOCH is sufficient for quantities requiring millisecond resolution, whereas CDF_EPOCH16 is required if higher resolution (microsecond or smaller) is required.

Functions: "*comp_themis_epoch*" and "*comp_themis_epoch16*" which will be provided as standard CDF functions will be provided by SPDF. These functions shall construct dynamically the actual _EPOCH variable from its virtual counterpal. These functions shall use INPUT variables: "varname_epoch0" and "varname_time", and shall OUTPUT the "varname_epoch" variable. Selection of the appropriate function name, depending on the EPOCH resolution that is necessary to represent the quantity, is required within the L1DAT mastercdfs.

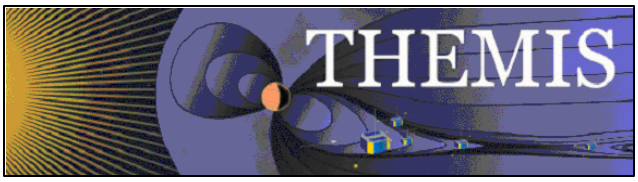
The THEMIS EPOCH shall be defined for each variable as "varname_epoch", unless mu ltiple variables are associated with the same time. In that case, the corresponding name will be used for "_epoch" as was used for the "_time" variable.

Every "varname" data variable shall point to its corresponding _EPOCH virtual variable through the depend_0 attribute.

2.5 "varname_hed"

Packet header information and packet time (but not packet data) shall be included in the L1 files. Such headers shall be named by appending the 3 letters "hed" to the variable name, e.g., "th[a-e]_xxy_hed", or "th[a-e]_xxx_zz_hed" and will be associated with "varname_hed_time", "varname_epoch0", and "varname_hed_epoch" or "varname_hed_epoch16" much like the traditional variable that contains the data.

2.6 "varname_hed_dtcor"



A correction needs to be applied to the packet header time in order to produce correct UTC. This is to be included in the data, once per header packet, in the quantity “varname_hed_dtcor”. The correction will be applied both on the “varname_hed_time” and the “varname_time”.

2.6.1 dtcor contributions from ground-processing of clock drift:

To the extent that the THEMIS on-board clocks are kept to within +/-0.5 sec desired absolute accuracy by sufficient clock “jamming” through ground-station contacts, the only correction expected during the nominal will be due to internal probe timing to synchronize various data packets in accordance with time delays within the IDPU and bus. However, modeling of the THEMIS probe clock may result in higher fidelity absolute timing. On occasion, such as during the initial coast phase of the mission, or during a possible extended phase, such accurate clock modeling attempts may also result in additional timing corrections, to be included in “varname_hed_dtcor”. These are expected to be on the order of 100s of msec and do not matter for distances >1R_E but do matter when studying microphysics from distances of the order of 100km.

2.6.2 ctcor contribution from on board time delays:

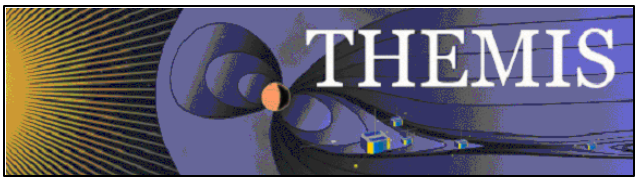
Barring any post-processing of probe clock drifts, dtcor represents the delay between the measurement time of the first vector in a packet and the actual packet time as recorded on the probe. These are generally on the order of 10s of msec. There are two factors that are taken into account to calculate dtcor:

1) The IDPU flight software has a 256 Hz interrupt that drives the packet header writing process. Each data type is assigned one or more of these time slots for header processing: in the case of FGM, apid 405 gets checked at 11 ticks past the second; 460 and 461 get checked at 3 ticks past the second.

Here are the offset times used for the other data types:

apid	offset (sec)
405	11/256
440	7/256
441	23/256
442	39/256
443	55/256
444	71/256
445	87/256
446	103/256
447	119/256
448	135/256
449	2/256
44a	2/256
44b	4/256
44c	4/256
44d	215/256
44e	231/256
460	3/256
461	3/256

(449, 44a, 44b, and 44c are checked 32 times per second beginning at the given offset)



The above table is derived from the "EFI Timing" page from the CTM spreadsheet , version "thm_fsw_003_ctm_v4.020.xls" as of 2007/01/20. Other offsets are recorder in "BKG Timing" sheet of thm_fsw_005.xls spreadsheet which is attached, as of 2007/01/20.

BKG Module 256 Hz Table

	0	1	2	3	4	5	6	7
0	INT00 FS32	n16a	HSK E32A	FGMX	E32B	HST	CMD	EFIL
8	bkg FS32	n16b	HSK E32A	FGMS	E32B	HST	CMD	x
16	DEP FS32	n16a	HSK E32A	ETC	E32B	HST	CMD	EFIL
24	bkg FS32	n16b	HSK E32A	TLM	E32B	HST	CMD	x
32	PWR FS32	n16a	HSK E32A	SCM	E32B	HST	CMD	EFIL
40	bkg FS32	n16b	HSK E32A	FGMS	E32B	HST	CMD	x
48	SSR FS32	n16a	HSK E32A	ACS	E32B	HST	CMD	EFIL
56	bkg FS32	n16b	HSK E32A	x	E32B	HST	CMD	INT3F

This table describes .250 seconds which is repeated 4 times per second.

BKG Module Function Calls Distributed in Time Phase

FN	FREQ	Description
HST	32	TM - High Speed Telemetry Buffer Manager
CMD	32	CMD - Internal Command Execution
HSK	32	HSK - Housekeeping A/D Sampling
E32A	32	EFI - High Rate (32Hz) DMA Manager
E32B	32	EFI - High Rate (32Hz) DMA Manager
FS32	32	EFI - Fit Sampler (32Hz)
EFIL	16	EFI - Low Rate (16Hz) DMA Manager
FGMS	8	FGM - Fluxgate Mag 8 Hz Sampler (AP 405)
FGMX	4	FGM - Fluxgate Mag Driver
SCM	4	SCM - Search Coil Mag Driver
ETC	4	ETC - ESA/SST Driver
DEP	4	DEP - Spin Plane Boom Deployment Manager
SSR	4	SSR - Solid State Recorder Manager
TLM	4	TM - Low Speed Telemetry Manager
ACS	4	ACS - Attitude Calculations
PWR	4	PWR - Power Monitoring
INT00	4	At 0.00 : Clock Latched; At .75 : Start Low Speed Telem
INT3F	4	At 0.50 : CMD Latch, Watchdog; At 1.0 : Ping 1 Sec Mgrs
bkg	16	BKG - Vector Used by ETC TM Manager
n16a	16	BKG - Trigger
n16b	16	BKG - Burst Logic

2) There is some CPU-load-dependent timing jitter in the packet header writing times; in general they won't exactly match the "theoretical" header times one would expect from the interrupt slot assignments described above. However, from the design of the fields instruments, we know that the sample times are synchronized to the 1 Hz tick signal generated by the BAU. In the apid 404 housekeeping telemetry, there is an item that represents the UTC time at the last 1 Hz tick. An adjustment is added to dtcor to align the first sample time with the 1 Hz tick (or for 449, 44a, 44b, and 44c, aligned to a 32 Hz tick).

So the whole process can be described like this:

Let t_hdr be the packet header time.
Let t_dly be the timing offset for this apid, taken from the above table
Let t_nom be the "nominal" packet start time: t_hdr - t_dly
Let t_sec be the UTC time of the last 1 Hz tick preceding t_nom
Let t_per be the packet period, in seconds

Then t_jtr, the "jitter" adjustment, can be expressed as:

```
t_jtr = fmod(t_nom - t_sec, fmin(1.0, t_per))
```

(fmod and fmin are the C floating point modulus and minimum functions).

This expression should be correct even if the 404 packets are decimated -- that is, t_nom - t_sec may have a value of some tens of seconds, and t_jtr will still be calculated correctly as long as the clock isn't drifting too badly)

t_jtr should be close to 0, so if it's too big we correct it:

```
if (t_jtr > 0.5) t_jtr -= 1.0;
```

(It occurs to me that this may not be correct for the high-speed packets; perhaps the correction needs to be one packet period rather than one second if t_per < 1.0)

Finally,

```
dtcor = t_dly + t_jtr;
```

2.7 "range_epoch" variable: definition, naming and association to THEMIS variables

Each THEMIS file shall contain one additional variable to represent begin and end time of the file, intended for use by CDAWeb for tracking THEMIS files.

This variable shall be of type CDF_EPOCH.

The variable name shall be "range_epoch" for all files.

The two values for the "range_epoch" shall be the minimum time and maximum time associated with any of the data variables contained within the file.