XMM

Interface Control Document
Attitude History File

XMM Doc. Ref: XMM-MOC-ICD-0006-OAD

FDD Doc. Ref: OAD-XMM-IA-ICD-AHF

Issue 2.1

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2	1.3.4	Wrapper file name corrected according to latest version of reference document XMM-SOC-ICD-0007-DPD
5	2.2	Typical size and disk space updated based on latest estimations
11	4.2.1.2 4.2.1.3	Record length changed Type of item no. 8 in header record changed
12	4.2.1.4	Guide star reference number type changed to A12 Reference to note [16] added
13	4.2.1.4	Note 1 updated
14	4.2.1.4	Note 11 updated with definition of solar aspect angle Note 16 added

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4. PAGE	5. PARAGRAPH	6. REASON FOR CHANGE
xi	Reference Documents	The document ‘XMM ICD AMS Keyword Specifications for File Ingestion into AMS’ has been added as reference document. The version number of various other reference and applicable documents have been updated.
3	1.3.4 1.3.5	XFTS transaction details removed. Paragraph 1.3.5 (Transaction Data) added referencing the above mentioned document.
14	4.2.1.4	Typo in Note [7] corrected.

Documentation Tree

RC: Requirements Compilation

IA: Implementation Analysis

SDD: Software Description Document
SAD: System Assurance Document
OPF: Organisation and Planning File
MOD: Mission Operations Document
FDR: Flight Dynamics Report

Table of Contents

References

Applicable Documents (AD):

AD.1 XMM Mission Implementation Plan
XMM-MOC-PL-0100
Issue 2: 25/05/97

AD.2 Time and Coordinate Systems for ESOC Flight Dynamics Operations
OAD Standards
Issue 1: May 1994

AD.3 XMM Technical Requirements
PX-RS-0023
Issue 8: September 1997

Reference Documents (RD):

RD.1 ICD: File Transfer System
XMM-SOC-ICD-0007-DPD
Issue A5: 26/09/97

RD.2 Mission Planning Concept
XMM-MOC-OPS-TN-0002-SMD
Issue 3C: November 1997

RD.3 ICD: POS
XMM-MOC-ICD-0001-DPD
Issue A5: September 1997

RD.4 ICD: EPOS and APF
XMM-MOC-ICD-0015-OAD
Issue 1: December 1997

RD.5 ICD: PSF
XMM-MOC-ICD-0002-OAD
Issue 1.2: September 1998

RD.6 ICD: IPF
XMM-MOC-ICD-0017-OAD
Issue 1: December 1997

RD.7 TN: Pointing Requests in the POS
XMM-MOC-TN-0100-OAD
A.McDonald, June 1997

RD.8 CCSDS Time Formats
CCSDS 301.0-B-2 Blue Book
Issue 2, April 1990

RD.9 Minutes of Meeting: XMM AHF Format
ESOC 27/02/97
J.B.Palmer, 27/02/97

RD.10 TN: Roll Angle
INT-SYS-FD-TN-0004-OAD
J.B.Palmer, 05/03/97

RD.11 Minutes of Meeting: XMM Attitude Representation
ESOC 12/05/97
J.B.Palmer, 14/05/97

RD.12 Definition of Observation Terms
INT/SGS/96-0036/TN
I.J.Chambers, Issue 5, April 1997

RD.13 ESA Error Handbook
EHB.DGD.REP.002
D.G.Dungate, Issue 1, 19/02/93

RD.14 TN: Three Axis Attitude Representation using Position Angle
XMM-MOC-TN-0109-OAD
G.Gienger, 18/07/97

RD.15 XMM ICD AMS Keyword Specifications for File Ingestion into AMS
XMM-SOC-ICD-0023-GC

Glossary of Terms

AD: Applicable Document
AHF: Attitude History File
AOCS: Attitude and Orbit Control System
AMS: Archive Management System
AOS: Acquisition Of Signal
APD[1]: Absolute Pointing Drift
APF: Attitude Parameter File
ASCII: American Standard Code for Information Interchange

BOL: Beginning Of Life

DCR: Dedicated Control Room
DPD: Data Processing Division (at ESOC)

ED: Event Designator
EOL: End Of Life
EPIC: European Photon Imaging Camera
EPOS: Enhanced Preferred Observation Schedule

FD: Flight Dynamics
FDD: Flight Dynamics Division (at ESOC)
FDS: Flight Dynamics System
FDR: Flight Dynamics Room
FOV: Field Of View
FTP: File Transfer Protocol

ICD: Interface Control Document
ICS: Instrument Command Sequence
ID: IDentification
INTEGRAL: INTErnational Gamma Ray Astrophysics Laboratory
IPF: Immediate Parameter File
ISO: Infrared Space Observatory

kB: KiloByte

LEOP: Launch and Early Orbit Phase
LOS: Loss Of Signal

MB: MegaByteM

1. See document [RD.13] for formal definition

MCR: Main Control Room
MIP: Mission Implementation Plan
MOC: Mission Operation Centre
MOD: Mission Operations Department (at ESOC)
MOUT: Message Out

OAD: Orbit and Attitude Division (precursor of FDD at ESOC)
OBDH: On-Board Data Handling
ODS: Operational Data Server
OM: Optical Monitor
OMC: Optical Monitoring Camera
ORATOS: Orbit and Attitude Operations System

PSF: Planning Skeleton File
POS: Preferred Observation Schedule
PX: XMM Project Team (at ESTEC)

QA: Quality Assurance

RAM: Random Access Memory
RD: Reference Document
REACH: REmote Access to Circular History-files
RPE[1]**:** Relative Pointing Error
RPOS: Re-planned Preferred Observation Schedule

SCOS: Spacecraft Control and Operations System
SOC: Science Operation Centre
SOM: Spacecraft Operations Manager (MOD)
SPACON: Spacecraft Controller (MOD)
STR: Star Tracker

TBC: To Be Confirmed
TBD: To Be Decided
TC: TeleCommand
THR: Thruster
TM: TeleMetry
TN: Technical Note

URD: User Requirements Document

1. See document [RD.13] for formal definition

VILSPA: VILlafranca SPAin

XFDS: XMM Flight Dynamics System (developed by OAD)
XMCS: XMM Mission Control System (developed by DPD)
XMM: X-Ray Multi Mirror

1 General Description

1.1 Content Overview

This Interface Control Document (ICD) describes the interfaces between the XMM Flight Dynamics System (XFDS) developed by the Flight Dynamics Division (FDD) at ESOC, the XMM Mission Control System (XMCS) and the XMM Science-operations Control System (XSCS) for the delivery of the following products, to be generated by Flight Dynamics (FD):

- the attitude history file (AHF) providing the attitude and orientation of the spacecraft as a function of time

These files are generated on the XFDS and transferred to the XMCS via electronic file transfer. Transfer to the SOC takes place via the XMCS.

This ICD is also intended to serve as the basis for the respective ICD for the INTEGRAL mission.

1.2 Scope

The attitude history file will be used during the payload verification and routine mission-phases. This ICD is applicable to these phases. Prior to launch, this ICD is applicable for the validation of the interfaces during Ground Segment integration and testing and for simulations of operations.

1.2.1 Compatibility between XMM and INTEGRAL

It is the stated intention to maintain compatibility between the XMM and INTEGRAL on-board and on-ground systems wherever possible. To this end, the design of the attitude history interface will be as generic as possible.

1.3 Subsystem Siting

The XFDS and XMCS are both components of the XMM Mission Operation Centre (MOC) based at ESOC, Darmstadt (D).

The SOC is based at the Villafranca (E) ground station “VILSPA”. During integration and testing, the SOC will be temporarily located at ESOC and ESTEC (Noordwijk (NL)).

1.3.1 Data Source, Destination and Transfer Method

The attitude history file and the associated products are generated and recorded on the XFDS. They are transferred to the XSCS via the XMCS.Details of the transfer method are given in [RD.1]

1.3.2 Generation Method and Frequency

All AHFs transferred across the interface are generated in the sequence described in [RD.2] for each planning period. Data file transfers are initiated automatically. One AHF per revolution will be transferred between SOC and MOC via the XFTS.

Note: A planning period always covers the time interval from one perigee passage to the next. In line with the established ESA terminology this time is consistently referred to in this document as a “revolution”:- the term “orbit”, which describes the time between two passages of the ascending node, is not used in this document.

1.3.3 Relationships with Other Interfaces

Detailed interfaces, describing the format and content of the following types of files that are passed during mission planning, are covered elsewhere:

- Planning Skeleton File according to [RD.5]
- Preferred Observation Sequence (POS) [RD.3]
- Enhanced Preferred Observation Sequence (EPOS), Attitude Pointing File (APF) and EPOS Summary in [RD.4]

The real time interface involved in carrying out a scheduled observation that requires an “attitude trim” manoeuvre is described in [RD.6].

1.3.4 Labelling and Identification

The AHF name and extension will follow the conventions given in [RD.1] and take the form[1];

`AHF__FDSXSS_D_rrrr_nnnn_____vvvvv.XMM`

where:

- **AHF** is the three character designator for every attitude history file
- **FDSXSS** is common to each of the products and indicates that the XFDS is the sender and the XSCS Solaris server is the receiver
- **rrrr** is the four digit revolution number in the range
  0000 ≤ rrrr≤9999
- **nnnn** is the four digit FDS-specific version number in the range
  0001 ≤ nnnn≤9999
- the separating character “_” is explicitly part of the name
- **vvvvv** is the five digit XFTS version number in the range
  00000 ≤ vvvvv ≤99999

Note: **rrrr, nnnn** and **vvvvv** always contain leading zeros.

1. with 2-1-1-1-5 intervening underscores

1.3.5 Transaction Data

See [RD.15].

1.4 Assumptions and Constraints

1.4.1 Usage Constraints

Initiation of traffic on this interface is available only to authorised users of the XMCS, XSCS and XFDS. Access restrictions apply.

2 Interface Characteristics

2.1 Hardware Characteristics and Limitations

Details are given in [RD.1].

2.2 Volume and Size

On any given system it is assumed that the following resources will be needed in order to maintain an adequate and convenient attitude history file:

Absolute worst case! ...

File type	Max. size (per file)	Max. number of coexisting files	Disk space
AHF	20 MB	10	200 MB

Expected nominal case ...

File type	Typical size (per file)	Max. number of coexisting files	Disk space
AHF	400 kB	10	40 MB

“Maximum number of coexisting files” refers to the maximum number of files which must be capable of coexisting on the source and target systems. In other words, the respective system must be capable of hosting this number of files - this does not prohibit that at any given time more or fewer files might actually be present on a given system.

The “absolute worst case” is based on the possibility of having to provide an attitude entry once every 2 seconds[1] for a 48 hour revolution. In practice, one expects to have to provide attitudes at a *far* lower rate.

2.3 Interface Medium Characteristics

Details are given in [RD.1].

2.4 Failure Protection, Detection and Recovery

Details are given in [RD.1].

2.5 End-of-file (or medium) conventions

None.

1. See §4.2.1.1

3 Access

3.1 Programs Using the Interface Data

Details are given in [RD.1].

3.2 Synchronisation Considerations

3.2.1 Timing and Sequencing Characteristics

The full planning sequence for one revolution is described in [RD.2].

3.2.1.1 Attitude History File

The handling of the AHF on the XMCS is initiated by the automatic transfer of an AHF from the XFDS to XMCS or XSCS, at most 2.5 (**TBD**) hours after the last LOS before perigee

3.2.2 Effective Duration

Provided all relevant systems for a particular transfer are operational (XSCS, XMCS, XFDS): neither the SW of a system involved in the transfer nor the network load shall prevent the transfer of a file from being able to complete within 2 (desirable) to 15 (mandatory) minutes from initiation to receipt at its final destination.

3.2.3 Priority Interrupts

The priorities of data file transfers shall be such that the time constraints above can be met.

3.3 Input/Output Protocol, Calling Sequences

Details are given in [RD.1].

3.3.1 Storage Interfaces

No requirements on physical storage (e.g. tape racks, etc.) are associated with this interface.

3.3.2 Formatting

Files will be placed in a “wrapper” together with a contents file and compressed prior to transfer. The format of the wrapper and contents file and the (un)compress

mechanism are defined in [RD.1]. The internal formats of the files inserted in this wrapper are transparent to the file transfer system (XFTS). Following extraction from the wrapper, no re-formatting of the files transferred from XMCS to XSCS will be necessary.

3.3.3 Deletion of Files

All AHFs which are transferred to the XSCS will be archived by the XFDS and XSCS.

4 Detailed Interface Specifications

4.1 Organisation

The Attitude History File is the means by which MOC informs SOC of:

- the reconstituted spacecraft orientation throughout the revolution (in terms of the operational star tracker functional frame as a function of time[1])

The files consist of a series of ASCII records describing the time and the associated attitude together with qualifying/quantifying information where necessary.

4.2 Structure

In what follows the conventions listed below apply:

- record numbering starts at record 1
- offsets are defined in terms of 8 -bit words, starting at offset 0
- item "types" are defined in terms of standard FORTRAN-77 FORMAT edit descriptors
- Unless otherwise indicated, all times are expressed in the A20 form[2]:
  - yyyy-mm-ddThh:mm:ssZ

4.2.1 Attitude History File

4.2.1.1 Attitude History Background

Terminology with respect to "pointing", "target", "observation", etc., has been defined in document [RD.12] and adopted here as far as possible[3].

The attitude history will cater for 3 distinct "phases":

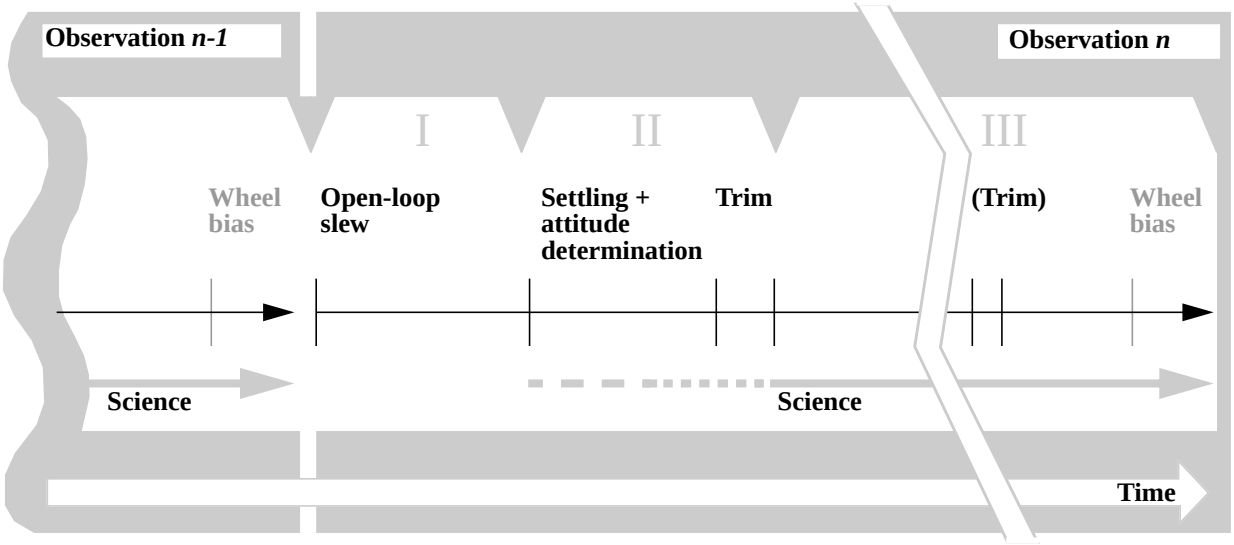
	Phase	Description
I	Open-loop slew	Attitudes entries in the AHF will be interpolations provided by the FDS slew path predictor, but based on the observed start and end attitudes of the slew. The time resolution of AHF entries will be 10 seconds (configurable).
II	Post-slew[a]	Attitudes will be logged in the AHF every 10 seconds (configurable, down to 2 seconds) until the beginning of the stable pointing period.

1. See also document AD.3
2. Refer to document RD.8
3. I.e. where not pre-defined, such as "on-target flag" or terms adopted from other XMM documents

	Phase	Description
III	Stable pointing[b]	There will be only one attitude entry in the AHF for a nominal stable pointing period[c]. However, if the attitude varies by more than 2.5 arcseconds (configurable) new attitude entries will be made in the AHF every 2 seconds (configurable to more than 2 seconds) until such time as the variation falls below 2.5 arcseconds again. For the single nominal attitude entry, only the APD will be provided.

a. attitude determination, trim, settling
b. from the time when the on-target flag is “true”
c. see notes below regarding stable pointing

The above sequence of events is summarised in the following diagram:



Rationale for handling of Stable Pointing:

The attitude variation will be calculated with respect to the x-axis only (there will be no direct information about z-axis jitter) from data selected from a 30-second sliding time window (configurable).

The intention is to give high time-resolution of attitude results for the case where there are short term attitude variations of more than 2.5 arc seconds.

To cater for long-term drift, the result from the 30 second window will also be compared with the initial attitude for this observation and a new AHF entry will be made if the difference is greater than 2.5 arc seconds (configurable). However such entries will be on a one-off basis (i.e. not every 2 seconds).

As noted in the table above, if both the short and long term attitude variation remain within the 2.5 arcsecond limit, there will only be a single attitude entry in the AHF for a given observation.

4.2.1.2 File Characteristics

The AHF will consist of one header followed by several data records.

All records will be **236** bytes long and formatted in ASCII.

Attitude information will be expressed with respect to the mean geocentric equatorial reference system of Equinox J2000.0 (see document AD.2)

4.2.1.3 Header Record

The header record is the first record in the file. It will contain the following items:

Table 1: AHF Header Record Structure

Item	Offset	Note	Type	Description
1	0	[1,2]	A20,1X	Start time of interval covered by this file
2	21	[1,2]	A20,1X	End time of interval covered by this file
3	42	[2]	A20,1X	Time of generation of this file
4	63		I4.4,1X	Revolution number
5	68		I6,1X	Number of records in this file (including this one)
6	75		I4.4,1X	AHF version number
7	80		A5,1X	AHF SW version number
8	86		A150	Space reserved for comments

Notes:

[1] Start and end times set equal to PSF start and end times for the relevant revolution

[2] See §4.2 regarding the time format

4.2.1.4 Data Records

Data records start with record number 2. They will contain the following items:

Table 2: AHF Data Record Structure

Item	Offset	Note	Type	Description
1	0	[1]	A14,1X	Pointing-request-identifier for the data in this record
2	15	[2]	A1,1X	Pointing type-identifier for the data in this record
3	17	[3]	A1,1X	Source-identifier for the data in this record
4	19	[13]	I3,1X	Attitude sequence number for the data in this record
5	23	[4]	A20,1X	Start time of the slew to the pointing-request
6	44	[4,10]	A20,1X	Start time of the stable-pointing period
7	65	[4]	A20,1X	Time from which data in this record are valid
8	86	[5]	F9.2,1X	Duration for which data in this record are valid
9	96		F5.1,1X	On-target flag threshold in arc-seconds
10	102	[6]	A11,1X	Right ascension of viewing direction
11	114	[7]	A11,1X	Declination of viewing direction
12	126	[12]	F11.6,1X	Astronomical position angle in degrees
13	138	[12,15]	F10.6,1X	Roll angle in degrees
14	149	[16]	A12,1X	Guide star reference number in catalogue
15	162	[6]	A11,1X	Guide star right ascension
16	174	[7]	A11,1X	Guide star declination
17	186	[11]	F5.1,1X	Solar aspect angle in degrees
18	192	[8]	I1,1X	Attitude contingency flag
19	194	[9]	A5,1X	Observable APD amplitude in arc-seconds
20	200	[14]	A11,1X	Difference between reconstituted and commanded viewing direction right ascension
21	212	[14]	A11,1X	Difference between reconstituted and commanded viewing direction declination
22	224	[14]	A11,1X	Difference between reconstituted and commanded position angle, in degrees

Notes:

Refer also to §4.2.1.1 + diagram, regarding the sequence of events.

[1] Pointing-request identifier

This identifier will be an echo of the slew ID to be found in the PREQ in the POS (see [RD.3])

The intermediate attitude determinations during a slew will be associated with each other by having the same unique pointing-request identifier as that given in the POS. Similarly for the post-slew attitude, any subsequent attitude resulting from a trim and the stable pointing attitude.

See also item 4 (and note 14 below).

[2] Pointing-request type

This is intended as a flexible means of indicating the type of the event associated with a given AHF record and is of assistance in keeping the AHF as generic as reasonably possible. For XMM the following types are envisaged;

O for an open-loop slew interpolated attitude
C for a closed loop slew attitude
S for settling-period attitude
T for trimmed stable-pointing attitude
P for stable-pointing attitude

where all of the above are results derived from reconstitutions based on observations[1] with the exception of O (derived from the slew path predictor using observed start and end attitudes as input).

[3] This field is an extension of item 2 and may hold, for example, a flag indicating the method of attitude reconstitution (e.g. the attitude may be a result based on FSS output plus star map or may be a propagation from such a result on the basis of motion of the guide star in the STR FOV).

[4] See §4.2 regarding the time format

[5] Duration in seconds, starting from the time from which the record is valid. For slew intermediate attitudes, this duration will be zero indicating an instantaneous result.

[6] Right ascensions in the AHF are expressed as hours, minutes and seconds of arc in the form: HH:MM:SS.SS with HH varying from 00 to 23, MM varying from 00 to 59 and SS.SS varying from 00.00 to 59.99

[7] Declinations in the AHF are expressed as degrees, minutes and seconds of arc in the form: ±DD:MM:SS.S with DD varying from 00 to 90, MM varying

1. “observations” in the sense of results based either on telemetry or other observed data

from 00 to 59 and SS.S varying from 00.0 to 59.9

[8] Attitude contingency flag is as follows:

Set to 0 if no contingency

Set to 1 if the pointing-request attitude at the end of a slew has not been acquired at any time during the requested observation

[9] This item (format F5.1) may be left blank if no APD has been calculated

One main non-observable contribution to the absolute pointing drift is thermo-elastic distortion between STR and instruments. Other observable/predictable contributions are e.g. orbital parallax, sloshing residuals, long term limit cycling of controller.

[10] Start time of observation as per the first toggle of the on-target flag

[11] Angle between the sun direction and the viewing direction; valid for the start time of the stable-pointing (item 6) and varying from 0.0 to 180.0 degrees

[12] Refer to documents [RD.10, RD.14] for definitions of roll and position angle - the position angle quoted here will use the same convention as the position angle as present in the mission planning products [RD.5]

[13] The attitude sequence number is an integer counter starting at zero and is primarily intended to cater for the possibility of an “on-line trim” of the spacecraft attitude. Such a trim will not involve a newly defined observation/exposure-ID (table item 1 and note 1) and thus this sequence number is required to distinguish between stable attitudes. (For INTEGRAL, this counter can be used to distinguish between dither/raster attitudes. During slews, the counter will be incremented for each interpolated attitude.)

[14] Angular differences are expressed in decimal degrees and the respective fields in the AHF are left blank when the differences are not available

[15] Valid for the start time of the stable-pointing (item 6) and varying from -20 to +20 degrees approximately

[16] Format iiii-jjjjj-k (4+5+1)