XMM

Interface Control Document - XSCS Orbit Access Software

XMM Doc. Ref: XMM-SOC-ICD-0019-OAD

OAD Doc. Ref: OAD-XMM-IA-ICD-ORB-SOC

Issue 1.1

September 15, 1998

	Signature	Date		
Custodian:	....	....	S Pallaschke	TOS-GFM
Agreed:	....	....	R E Münch	TOS-GF
	....	....	N Peccia	TOS-GCM
	....	....	D Heger	TOS-MOX
Released:	....	....	H Nye	TOS-MOX

Distribution List

DESIGNATION	NAME
D/TOS-GF	R. Münch
D/TOS-GFO	F. Dreger G. Gienger P. Mahr R. Mugellesi
D/TOS-GFM	J. Dow S. Pallaschke M. Rosengren
D/TOS-GFS	A. Schütz
Logica	A. McDonald
EDS	F. Delhaise S. Kasten H. Müller
Terma	P. Gladney C. Greco
D/TOS-GCM	N. Peccia M. Merri E. Perdrix
D/TOS-MOX	H. Nye D. Heger
D/TOS-MOI	P. Maldari M. Schmidt
Serco	J. Wardill
Total:	23

Document Status Sheet

1. DOCUMENT TITLE:		Interface Control Document - XSCS Orbit Access Software	
2. DOCUMENT REFERENCE NUMBER:			XMM-SOC-ICD-0019-OAD/OAD-XMM-IA-ICD-ORB-SOC
3. ISSUE	4.REVISION	5. DATE	6. REASON FOR CHANGE
Draft	1.0	1996/11	Initial draft of document.
Issue	1.0	1997/10	Updated according remarks from J. Dow and S. Pallaschke
Issue	1.1	1998/09	Updated to include reference to new AMS keywords ICD

Document Change Records

<table>
<tr><td colspan="2" rowspan="3">Document Change Records</td><td>DCR NO</td><td>0</td></tr>
<tr><td>DATE</td><td>September 15, 1998</td></tr>
<tr><td>ORIGINATOR</td><td>S. Pallaschke</td></tr>
<tr><td colspan="2">1. DOCUMENT TITLE:</td><td colspan="2">Interface Control Document - XSCS Orbit Access Software</td></tr>
<tr><td colspan="2">2. DOCUMENT REFERENCE NUMBER:</td><td colspan="2">XMM-SOC-ICD-0019-OAD/
OAD-XMM-IA-ICD-ORB-SOC</td></tr>
<tr><td colspan="2">3. DOCUMENT ISSUE/REVISION NUMBER:</td><td colspan="2">Issue 1.1</td></tr>
<tr><td>4. PAGE</td><td>5. PARAGRAPH</td><td colspan="2">6. REASON FOR CHANGE</td></tr>
<tr><td>page ix</td><td></td><td colspan="2">Added new ICD to list of reference documents</td></tr>
<tr><td>page 7</td><td></td><td colspan="2">Added reference to new ICD</td></tr>
<tr><td>page 11,
14, 15</td><td></td><td colspan="2">Corrected error codes</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
</table>

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 0 (Draft): June 1995

AD.2 XMM Mission Implementation Requirements Document
PX-RS-0461
Issue 3.2: Septembre 1997

AD.3 XMM Flight Dynamics Support Requirements Compilation
XMM-MOC-RC-0001-OAD
Issue 1.0

AD.4 OAD Principles
Standards for time and coordinate systems
May 1994

Reference Documents (RD):

RD.1 XMM FDS-XMCS File Transfer Mechanism ICD
XMM-MOC-ICD-0018-DPD
Issue TBD

RD.2 XMM Alternate Orbit with Apogee in the South
MAS WP 391, G.Janin, Jan.1997

RD.3 XMM: Optimisation of the Ground Station Visibility
FDD WP 581, M. Rosengren, Sept. 1997

RD.4 XMM ICD AMS Keyword Specifications for File Ingestion into AMS,
XMM-SOC-ICD-0023-GC

-

Glossary of Terms

A

ACAM Assisted Circular Access Method
AD Applicable Document
AHF Attitude History File
AMS Archive Management System; part of the XMM SOC
AOCS Attitude and Orbit Control System
AOS Acquisition Of Signal
APES Antenna Pointing Elements
APF Attitude Parameter File
ASCII American Standard Code for Information Interchange

B

BOL Beginning Of Life

C

CCHK Attitude Constraint Checker Software. Provided by XFDS to SOC.

D

DAT Digital Audio Tape
DCA Dedicated Control Area
DCR Dedicated Control Room
DEC Declination; range -90 degrees …+90 degrees
DEVLAN ESOC's development LAN
DPD Data Processing Division (at ESOC)
DBOB Database of Observable Bins. Provided by XFDS to SOC.

E

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

F

FD Flight Dynamics
FDD Flight Dynamics Division (formerly known as OAD) also referred to as D/TOS-GSED/FDD or GF
FDCE Failure Detection and Correction Electronics
FDR Flight Dynamics Room
FDS Flight Dynamics (Support) System
FDDB Flight Dynamics Database provided by DORNIER or MCSD
FOP Flight Operations Plan
FOR Frame of Reference
FOV Field Of View
FSS Fine Sun Sensor, optical sensor mounted along the S/C Z-axis
FTP File Transfer Protocol

G

H

I

ICD Interface Control Document
ICS Instrument Command Sequence
ICP Instrument Command Parameters; parameter file for the POS
ICV Intercenter Vector: tracking information to be provided to NASA stations
INTEGRAL International Gamma Ray Astrophysics Laboratory
IPF Immediate Parameter File
IPS Inertial Pointing and Slew mode (AOCS mode)
IMU Inertial Measurement Unit: a S/C rate sensor (like e.g. a gyro)
ISO Infrared Space Observatory

J

J2000.0 Geocentric mean equatorial of epoch J2000.0

L

LAN Local Area Network

LCT	Company which developed the LCT Ranging System, i.e. Laboratoire Central de Telecommunication, Velizy, France
LEOP	Launch and Early Orbit Phase
LEOPOLD	Orbit determination facility
LIT	Listen-In Test
LOS	Loss Of Signal

M

MCR	Main Control Room
MCSD	Mission Control Systems Division (formerly known as DPD) also referred to as D/TOS-GSED/MCSD or GC
MIP	Mission Implementation Plan
MOBIAS	Reaction Wheel Unit (RWU) momentum BIAS (activity)
MOC	Mission Operation Centre
MOD	Mission Operations Department (at ESOC)
MOUT	Message Out
MPTS	Multi Purpose Tracking System
MSSS	Multiple Satellite Support System - a predecessor of ORATOS

N

NCTRS	Network Commanding, Telemetry and Ranging System: a Protocol Converter, part of the Mission Control System

O

OAD	Orbit and Attitude Division (at ESOC), now called FDD
OBDH	On-Board Data Handling
ODS	Operational Data Server
OFDDB	Operational Flight Dynamics Database (optimised copy of the FDDB)
OM	Optical Monitor
OPSLAN	ESOC’s operational LAN
ORATOS	Orbit and Attitude Operations System

P

PMS	Payload Monitoring System (a part of the XMM XSCS)
PPF	Pointing Properties File
PSF	Planning Skeleton File
POS	Preferred Observation Schedule

Q

QA	Quality Assurance

R

RA	Right Ascension; range 0 degrees …+360 degrees
RAM	Random Access Memory
RCS	Reaction Control System
RD	Reference Document
REACH	REmote Access to Circular History-files
REPOS	Re-planned EPOS
RPE	Relative Pointing Error
RPOS	Re-planned POS
RWU	Reaction Wheel Unit

S

SAD	System Assurance Document
SAS	Sun Acquisition Sensor
SCOS	Spacecraft Control and Operations System
SCF	Star Catalogue Facility
SDB	operational Spacecraft DataBase
SOC	Science Operation Centre
SOM	Spacecraft Operations Manager (MOD)
SSO	Solar System Object
SPACON	Spacecraft Controller (MOD)
SPCR	Satellite Pointing Change Request
STDM	Spacecraft Trajectory Data Messages
STR	Star Tracker
SVT	System Validation Test

T

TBC	To Be Confirmed
TBD	To Be Decided
TC	TeleCommand

THR	Thruster
TM	TeleMetry

U

URD	User Requirements Document

X

XFDS	XMM Flight Dynamics System (developed by FDD)
XMCS	XMM Mission Control System (developed by MCSD)
XSCS	XMM Science Control System (developed by MCSD)
XMM	X-Ray Multi Mirror

1 Introduction

The X-ray Multi Mirror (XMM) satellite is designed to observe the soft X-ray portion of the electromagnetic spectrum. It is planned to inject the satellite into an Earth orbit by an Ariane-5 launcher in August 1999. As a result of the mission analysis [RD.2], [RD.3] the following orbit type has been selected:

height of perigee	7000	km
height of apogee	114100	km
semi-major axis	66940	km
eccentricity	0.8005	
inclination	40	degrees
arg. of perigee	50	degrees
orbital period	47.87	hours

In order to obtain good ground station coverage from Kourou, Fr. Guyana and Perth, Australia, a subsatellite longitude at apogee of about 90 degrees West (at beginning of life) was recommended in the above mentioned mission analysis work. Within this configuration the satellite can be tracked from ground for about 95% of the entire revolution. Of course, this orbit type with the desired subsatellite longitude at apogee will not be reached directly by the launcher. A few orbit correction manoeuvres will be required during the initial orbit phase in order to increase the perigee altitude from 600 km to about 7000 km and to reach the subsatellite longitude at apogee of about 90 degrees West. All the manoeuvres required for these orbit changes are planned to be carried out within the first few revolutions.

2 Orbit Determination

2.1 XMM Orbit Determination

The orbit determination will be based on range and Doppler measurements from Kourou and Perth. The MPTS MKIII will be used for tracking and the performance is:

- for range: bias of less than 20m including the various model errors; noise of less than 10m.
- for Doppler: bias of less than 1 mm/s including the various model errors; noise of less than 2 mm/s

It is assumed that tracking (range and Doppler) can be carried out without any restrictions during the entire passes.

As the attitude control will be carried out through spinning wheels, momentum control will be required. Taking ISO as an example where momentum control is performed close to perigee, we experienced that the orbit determination had to be carried out primarily over 1.5 revolutions because of the difficulty in modelling the momentum control effect. The resulting error in the semi-major axis was about 50m. Considering the experience with ISO we took a somewhat pessimistic assumption for the XMM orbit determination accuracy, i.e. an error in the semi-major axis of a few hundred meters. Based on these figures the uncertainty in the propagation delay for all ground stations involved would be of the order of less than 30 microsec. It has to be mentioned, that this uncertainty is only valid for the first few days of the propagation period.

2.2 Orbit Determination Method

The orbit determination subsystem has to provide the satellite state (position and velocity) for the past and for the future. This information is required by the other subsystems of the Flight Dynamics area, and of course by other units outside Flight Dynamics, such as Spacecraft Operations, Ground Stations and Science Centres. Data closely related to the satellite motion, such as eclipse times and ground station visibility is also provided by the orbit determination subsystem.

Very often the orbit determination is based on tracking measurements from various ground stations. The raw tracking measurements received from the ground stations are not directly suitable for orbit determination. In order not to overload the actual orbit determination with a large amount of measurements, a data reduction is required. The original raw tracking measurements are smoothed and a normal point is selected and kept as a so-called observation. The observations form the basis for the orbit determination. This is achieved by batch-wise processing of the observations using parameter estimation applying a least squares method. The orbit determination is performed in the following three steps:

- Using an initial set of parameters, the assumed satellite motion is generated for the time interval of the selected observations;

- These generated satellite state vectors are compared with the actual observations and
- based on the differences resulting from this comparison, improvements to the initial set of parameters can be computed. This is performed by means of an iterative least squares approach.

The improved set of orbital parameters is essentially the output of this part.

For fast and simple computation of the satellite state for any specific time it is essential to provide a routine which does not require the full orbit propagation method used before. For this reason the satellite movement, which has been determined within the above described method, is approximated 'piecewise' by a combination of a Kepler orbit and Chebyshev polynomials. The computed coefficients are stored on a data set, which permits easy and fast retrieval of the satellite state. Because only a small amount of data needs to be stored, the orbit file will contain data of the entire history, which is of high interest for evaluation and recomputation purposes. This orbit file constitutes the central place for the satellite state retrieval.

3 Overview of Interfaces

3.1 List of tracking data input files

The interfaces are described in a separate ICD issued by GSED/MCSD. A summary will be given in the table below (not yet written)

Description	Name	Chapter	Origin
MPTS MkIII range			
MPTS MkIII Doppler			
MPTS MkIII meteo			
Antenna angles (plus meteorological data)			

3.2 List of interface files internal to Flight Dynamics

Description	Name	Chapter	Subsystem
Momentum Control information			
Orbit manoeuvre input			
Orbit manoeuvre evaluation			

3.3 List of output files

As mentioned above the orbit determination subsystem produces the following output files:

Description	Name	Chapter	Destination
Orbit file related items:			
Orbit file for Flight Dynamics internal	orbit		FDS
plus retrieval routine	ORBIT		
Orbit file for external interfaces (ASCII)	orbita	5.1	XMCS XSCS
plus retrieval routine	ORBITA		
propagation delay routine	SIGDEL		XMCS

Description	Name	Chapter	Destination
Eclipse file	eclip		FDS
Events file related items:			
Events file	stef		FDS
Revolution numbers	revno	5.3	XSCS FDS
plus retrieval routines	DATREV and REVDAT	5.4.1 and 5.4.2	
station predictions: (not yet written)			
STDM (possibly in two formats for STC I and for STC II)			XMCS
APES			XMCS
WIMPY			XMCS

In addition to the various retrieval routines, some further standard routines will be delivered, which are listed under section “Further Standard Routines” at 5.5 and “Time Conversion Routines” at 5.6.

4 Summary of XSCS interfaces and procedure for delivery of orbit data

The interfaces mentioned above with respect to XSCS are based on the requirements listed in the following documents:

- Minutes of XMM MOC/SOC/FD meeting to discuss requirements on FD, 30.Oct.96
- Note on SOC requirements on DBOB generation, J.Riedinger, 8.Nov.96
- Note on XMM orbit interface for SOC, S.Pallaschke, 29.Jan.97
- Note on orbit file delivery, M.Merri, 6.May 97

It is envisaged to update the orbit file once per revolution in order to provide predictions with high accuracy. With this procedure the effect of the momentum control near perigee would always be taken into account in the generation of the predictions.

The orbit file provided to XSCS via the ODF is an extract of the primary orbit file of the Flight Dynamics system and will contain only the current period, i.e. several weeks of history plus predictions of adequate duration.

This orbit file contained within the ODF can be read using the retrieval routine ORBITA. In addition to this retrieval routine a further routine is made available which is required for the calculation of the subsatellite point and the altitude derived from the inertial spacecraft position.

4.1 Transaction Data Files

See [RD.4]

5 Description of Interfaces

5.1 Orbit File in ASCII Format

The file is not intended for direct interpretation, but via access by the Fortran routine supplied. (See “ORBITA - File Read Routine” on page 11.)

The content and format of the file is defined in the following tables. The format definition follows the ANSI FORTRAN notation for format statements (e.g. A29 means 29 ASCII characters, 5X means 5 spaces, I2 means a 2 character denary integer and F7.2 means a 7 character fixed point number with 2 decimal places).

For each period of time there is a header block as shown in Table 1, followed by a number of polynomial coefficient blocks as shown in Table 2. The number of polynomial coefficient blocks depends upon the accuracy that is required.

Name	Format	Description
SCID	I3,2X	will contain the S/C body identification. The SCID is assigned before launch to the spacecraft, and remain the same throughout the mission.
PREREC	A1,2X	a single character flag indicating if the data is predicted (P) or reconstituted (R)
GENTIM	A20,2X	date and time when the header block was written to the file in CCSDS time code A format (**YYYY-MM-DDThh:mm:ssZ**)
SRTTIM	A20,2X	date and time of the start of the period for when the data is valid in CCSDS time code A format (**YYYY-MM-DDThh:mm:ssZ**).
ENDTIM	A20	date and time of the end of the period for when the data is valid in CCSDS time code A format (**YYYY-MM-DDThh:mm:ssZ**).
LF		is a single line-feed character (ASCII $0A_{hex}$)
NREC	I3	an internally used record identifier.
DAYBEG	F12.6	Modified Julian Date 2000 (MJD 2000, i.e. the date 0.0 refers to the 1st January 2000 at 0:00:00), of the start of the period for when the data is valid.
DAYEND	F12.6	Modified Julian Date 2000 (MJD 2000), of the end of the period for when the data is valid.
EPOCH	F15.9	Modified Julian Date 2000 (MJD 2000), of the epoch for the reference Kepler orbit.

Name	Format	Description
ORBIN	F11.3	Revolution number for this epoch.
SMAXIS	F13.5	Semimajor axis 'a', in km, of the reference Kepler orbit.
OMOTIN	F13.5	Inverse mean motion = 'a*sqrt(a/μ)' of the reference Kepler orbit in seconds/rad (μ = central Earth potential).
LF		is a single line-feed character (ASCII $0A_{hex}$)
NREC	I3	an internally used record identifier.
XYZPOS(3)	3F11.3	are the x-y-z components of the position vector in km of the reference Kepler orbit.
XYZVEL(3)	3F11.7	are the x-y-z components of the velocity vector in km/s of the reference Kepler orbit.
RDIST	F11.3	is the absolute value of the position vector of the reference Kepler orbit in km.

Name	Format	Description
NREC	I3	an internally used record identifier
POLPOS(3)	3F11.3	are the polynomial coefficients of the x-y-z components of the position vector in km of the reference Kepler orbit.
POLVEL(3)	3F11.7	are the polynomial coefficients of the x-y-z components of the velocity vector in km/s of the reference Kepler orbit.

Depending upon the accuracy required the number of the coefficient blocks will vary between 0 and 10 inclusive

The coordinate system is the Inertial Mean Geocentric Equatorial System of year J2000.0, with the x-axis towards the mean vernal equinox, the x-y plane coinciding with the mean equatorial plane and the z-axis toward north. Time and coordinate systems used for orbital operations at ESOC are described in “OAD Principles, Standards for time and coordinate systems, May 1994”.

5.2 *Orbit Files Access Routine*

5.2.1 *ORBITA - File Read Routine*

The orbit file can be read by a FORTRAN subroutine. The calling sequence is shown below.

5.2.1.1 *Synopsis*

```
SUBROUTINE ORBITA (MJDATE, CODE, FILE-UNIT, IERROR,
SATNUM, X, REVNUM)
```

5.2.1.2 *Input*

Parameter	Description
`DOUBLE PRECISION MJDATE`	Requested epoch in MJD-2000. See “JD2000 - Convert Calendar Date to Modified Julian Date 2000” on page 17.
`INTEGER`[a] `CODE`	Number of components desired of state vector dimension of array X(); 3: S/C position; 6: position and velocity
`INTEGER FILE-UNIT`	Logical Fortran Unit number of orbit file

a. In this document, it is assumed that all integers are **4**-byte integers.

5.2.1.3 *Output*

Parameter	Description
`INTEGER IERROR`	Error code See “Return” on page 11.
`INTEGER SATNUM`	Satellite number
`DOUBLE PRECISION X(CODE)`	spacecraft position [km] (and velocity [km/s])
`DOUBLE PRECISION REVNUM`	revolution number; *Note:* this is a DOUBLE PRECISION! - do not confuse with “DATREV - Revolution Number from Time” at 5.4.1

5.2.1.4 *Return*

`ORBITA` returns return one of the following return codes:

Return Code	Description
`0`	no error
`1`	`MJDATE` is too early (outside the interval for which orbit information is available)
`2`	`MJDATE` is too late (outside the interval for which orbit information is available)
`3`	wrong value of ‘`CODE`’
`4`	‘FILE-UNIT’ out of range [<1]
`6`	read error from compressed orbit file
`7`	compressed orbit file content is inconsistent

5.2.1.5 Description

For reading an orbit file, the User must assign a FORTRAN IO unit number to it. This FORTRAN IO unit number shall be used for the parameter FILE-UNIT, and the satellite number is returned as the parameter SATNUM. By verifying the latter, the User can check that a block from the correct orbit file has been read. The subroutine ORBITA does not explicitly open the orbit file.

At the first call of the subroutine ORBITA, the orbit file is read from the beginning until a block is found whose time interval contains the input value MJDATE. In case there is some time overlap between blocks, the first one that contains MJDATE is selected.

After a block is found, the decompressing is performed as described below. The content of the block is kept inside the subroutine and is reused at the next call of ORBITA, if the new value of MJDATE lies within its time interval. If the new MJDATE lies beyond the end of the interval, the orbit file is read forward until a matching interval is found.

The orbit file is read from its beginning at a new call of ORBITA when:

- The new value of MJDATE lies before the start time of the interval for the last read block;
- The error return code IERROR was non-zero at the last call;
- The new call specifies a new file with a new number FILE-UNIT.
- An update of the orbit file was made between reads.

5.3 Revolution Number File

The file has the name revno and contains the information of the perigee times and the associated revolution numbers. The file is updated at the time when the orbit events are calculated. However, this revolution number file provides the entire history of the mission form launch onwards plus the requested predictions, whereas the orbit events file only contains the information of the current period.

5.4 Read Revolution Number File Routines

Two routines will be provided either to retrieve the revolution number corresponding to a given time or to retrieve the time interval for a given revolution number.

5.4.1 DATREV - Revolution Number from Time

5.4.1.1 Synopsis

```
SUBROUTINE DATREV (FILE-UNIT, MJDATE, NUMREV, TS, TE,
IERROR)
```

5.4.1.2 Input

Parameter	Description
`INTEGER FILE-UNIT`	Logical number of input data file
`DOUBLE PRECISION MJDATE`	Input date expressed as Modified Julian day, from 2000. See “JD2000 - Convert Calendar Date to Modified Julian Date 2000” on page 17.

5.4.1.3 Output

Parameter	Description
`INTEGER NUMREV`	Revolution number
`DOUBLE PRECISION TS`	start time (true anomaly = 0 degrees) of revolution NUMREV expressed as Modified Julian day, from 2000
`DOUBLE PRECISION TE`	end time (true anomaly = 360 degrees) of revolution NUMREV expressed as Modified Julian day, from 2000
`INTEGER IERROR`	Return code

5.4.1.4 Return

Return Code	Description
0	no error
1	MJDATE is too early (outside the interval for which orbit information is available)
2	MJDATE is too late (outside the interval for which orbit information is available)
4	‘FILE-UNIT’ out of range [<1]
6	read error from revolution number file
7	revolution number file content is inconsistent

5.4.1.5 Description

DATREV retrieves the revolution number as well as its start- and end-date for a given time.

5.4.2 REVDAT - Perigee Times from Revolution Number

5.4.2.1 Synopsis

```
SUBROUTINE REVDAT (FILE-UNIT, NUMREV, TS, TE, IERROR)
```

5.4.2.2 Input

Parameter	Description
INTEGER FILE-UNIT	Logical number of input data file
INTEGER NUMREV	Revolution number

5.4.2.3 Output

Parameter	Description
DOUBLE PRECISION TS	start time (true anomaly = 0 degrees) of revolution NUMREV expressed as Modified Julian day, from 2000. See “DJ2000 - Convert Modified Julian Date 2000 to Calendar Date” on page 18.

Parameter	Description
DOUBLE PRECISION TE	end time (true anomaly = 360 degrees) of revolution NUMREV expressed as Modified Julian day, from 2000. See "DJ2000 - Convert Modified Julian Date 2000 to Calendar Date" on page 18.
INTEGER IERROR	Return code

5.4.2.4 Return

Return Code	Description
0	no error
1	'NUMREV' too small (outside the interval for which orbit information is available)
2	'NUMREV' too large (outside the interval for which orbit information is available)
4	'FILE-UNIT' out of range [<1]
6	read error from revolution number file
7	revolution number file content is inconsistent

5.4.2.5 Description

REVDAT retrieves the start and end date for a given revolution number.

5.5 Further Standard Routines

As mentioned above some further routines from the standard orbit libraries will be provided for the calculation of the subsatellite point using the routine GEOLAT. Since this routine requires as input the satellite position vector in the Earth fixed coordinate system, another routine has to be called before which converts the state vector retrieved through the routine ORBITA from the J2000 system to the Earth Fixed one.

5.5.1 GJ2EFS - convert geocentric position vector (J2000) to Earth-fixed

5.5.1.1 Synopsis

```
SUBROUTINE GJ2EFS (MJDATE, XJ2000, XEFS)
```

5.5.1.2 *Input*

Parameter	Description
`DOUBLE PRECISION MJDATE`	Input date expressed as Modified Julian day, from 2000. See “JD2000 - Convert Calendar Date to Modified Julian Date 2000” on page 17.
`DOUBLE PRECISION XJ2000(3)`	Spacecraft position vector in the J2000 system; [X, Y, Z in km]

5.5.1.3 *Output*

Parameter	Description
`DOUBLE PRECISION XEFS(3)`	position vector in the Earth-fixed system (see [AD.4])

5.5.1.4 *Return*

`GJ2EFS` does not return any codes

5.5.1.5 *Description*

`GJ2EFS` converts a position vector conversion from geocentric J2000 to Earth-fixed system.

5.5.2 *GEOLAT - get sub-satellite longitude, latitude and height*

5.5.2.1 *Synopsis*

```
SUBROUTINE GEOLAT (X, LONGITUDE, LATITUDE, HEIGHT)
```

5.5.2.2 *Input*

Parameter	Description
`DOUBLE PRECISION X(3)`	Spacecraft position vector in earth-fixed system (see [AD.4]); [X, Y, Z in km]

5.5.2.3 *Output*

Parameter	Description
`DOUBLE PRECISION LONGITUDE`	sub-satellite longitude (in radians)

Parameter	Description
DOUBLE PRECISION LATITUDE	sub-satellite latitude (in radians)
DOUBLE PRECISION HEIGHT	height above the Earth in km

5.5.2.4 Return

GEOLAT does not return any codes

5.5.2.5 Description

GEOLAT calculates sub-satellite longitude and latitude and the height above the Earth form an Earth-fixed position vector.

5.6 Time Conversion Routines

5.6.1 JD2000 - Convert Calendar Date to Modified Julian Date 2000

5.6.1.1 Synopsis

```
SUBROUTINE JD2000 (MJDATE, YEAR, MONTH, DAY, HOUR,
MINUTE, SECOND)
```

5.6.1.2 Input

Parameter	Description
INTEGER YEAR	Year A.D.; e.g. 1999
INTEGER MONTH	Month of the year; 1 … 12
INTEGER DAY	Day of the month; 1 … 28, 29, 30, 31
INTEGER HOUR	Hour of the day; 0 … 23
INTEGER MINUTE	Minute of the hour; 0 … 59
DOUBLE PRECISION SECOND	Second of the minute; 0.0 … 59.999…

5.6.1.3 Output

Parameter	Description
DOUBLE PRECISION MJDATE	Modified Julian Date 2000

5.6.1.4 Return

`JD2000` does not return any codes

5.6.1.5 Description

`JD2000` calculates Modified Julian Date (MJD2000) from calendar date.

5.6.2 DJ2000 - Convert Modified Julian Date 2000 to Calendar Date

5.6.2.1 Synopsis

```
SUBROUTINE JD2000 (MJDATE, YEAR, MONTH, DAY, HOUR,
MINUTE, SECOND)
```

5.6.2.2 Input

Parameter	Description
`DOUBLE PRECISION MJDATE`	Modified Julian Date 2000

5.6.2.3 Output

Parameter	Description
`INTEGER YEAR`	Year A.D.; e.g. 1999
`INTEGER MONTH`	Month of the year; 1 … 12
`INTEGER DAY`	Day of the month; 1 … 28, 29, 30, 31
`INTEGER HOUR`	Hour of the day; 0 … 23
`INTEGER MINUTE`	Minute of the hour; 0 … 59
`DOUBLE PRECISION SECOND`	Second of the minute; 0.0 … 59.999…

5.6.2.4 Return

`JD2000` does not return any codes

5.6.2.5 Description

`JD2000` calculates calendar date from Modified Julian Date (MJD2000).

5.7 Delivery Mechanism

The following routines are delivered as FORTRAN 77 source code files:

- ORBITA - File Read Routine
- DATREV - Revolution Number from Time

- REVDAT - Perigee Times from Revolution Number
- GJ2EFS - convert geocentric position vector (J2000) to Earth-fixed
- GEOLAT - get sub-satellite longitude, latitude and height
- JD2000 - Convert Calendar Date to Modified Julian Date 2000
- DJ2000 - Convert Modified Julian Date 2000 to Calendar Date