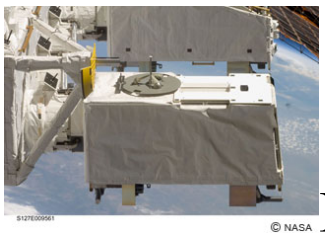


MAXI

MAXI archive

Version 1.1

DATE 19 Nov 2018

Prepared by: Lorella Angelini (HEASARC/NASA) & Ken Ebisawa (DARTS/JAXA)

Table of Contents

1 Introduction 4
1.1 Purpose 4
1.2 Applicable Documents 4
2 Archive: Overview and Content 5
2.1 MAXI data 5
2.2 MAXI CALDB 6
2.3 MAXI software 6
3 MAXI Region Event File archive 7
3.1 Files and Naming convention 7
3.2 Header Keywords 7
3.3 Directory structure 10
3.4 Database table 11
4 The MAXI CALDB data 11
5 Appendix A: References 12

CHANGE RECORD PAGE (1 of 2)

DOCUMENT TITLE : MAXI Archive			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Version 1.0	Oct 2018	All	First version
Version 1.1	Nov 2018	All	Update definition of the software keyword, Add comment on TIMEDEL

1 Introduction

1.1 Purpose

The primary MAXI archive is at DARTS at ISAS/JAXA. The MAXI archive includes the data, software and calibration files necessary to analyze the data. This document defines the content, of the MAXI archive to include science data, calibration files and software. The MAXI archive is also available from the High Energy Astrophysics Science Archive Research Center (HEASARC) that also distributes the MAXI software package within the HEAsoft and the calibration data via CALDB. At the time of this writing the mission is still operating. The operation is approved by JAXA at least until the end of March 2021[1].

This document contains the following information:

- Description of the different data and their organization
- Description of filename conventions and file format types (FITS or GIF)
- Description of the associated database tables
- List of the CALDB files

1.2 Applicable Documents

The requirements contained in this ICD were derived from the following documents:

- Requirements to archive data at the HEASARC (http://heasarc.gsfc.nasa.gov/docs/heasarc/heasarc_req.html)
- Tdat format description http://heasarc.gsfc.nasa.gov/docs/software/dbdocs/tdat.html

[1] Subject to yearly performance review, which MAXI is very likely to pass.

2 Archive: Overview and Content

2.1 MAXI data

The Monitor of All-sky X-ray Image (MAXI) experiment, placed on the International Space Station (ISS) consists of two detectors, the Gas Slit Camera (GSC) and the Solid-State Camera (SSC). The science data for both instruments together with their housekeeping and attitude arrives in Japan and are stored together with the orbit into a database. The telemetry is sent from ISS through NASA to JAXA/Tsukuba Space Center, and stored in the dedicated PostresSQL database (hereafter **MAXI DB**). The MAXI real-time alert system continuously accesses the MAXI DB and gives alerts for transient events. Contents of the MAXI DB are converted into **DB FITS dumps**, which are database table dump files with a FITS header. The data processing starts from these files and generates high level files. The data processing includes two steps: 1) first the data are calibrated and cleaned and 2) afterward the data are organized in files that cover the all sky in specific time interval. The data processing includes:

- *First step*. Either from the DB FITS dump files or from the MAXI DB, science data are extracted in time order, together with the relevant housekeeping, and processed. The processing calibrates the science data by assigning position and correct for the gain each event. This data set is named hereafter "**Processed Event Files".** Further the Processed Event Files are cleaned for unwanted time intervals and/or out of bounds of the monitored parameters. The data set after the cleaning are named hereafter "**Cleaned Event Files".** All files in the Processed or Cleaned Events are in FITS.

- *Second step*. The **Cleaned Event Files** are divided in equal square degree in sky for a defined time interval set to one day. The division in sky uses the **H**ierarchical **E**qual **A**rea iso**L**atitude **Pix**elization of a sphere method known as HEALPix. This method allows such a pixelization as to produce subdivision of the spherical surface where each pixel covers the equal surface area. The sky is divided into 768 regions (or tiles), each of 7.329 x 7.3298 sq deg, and includes one day of data. This data set is named "**Region Event Files"** and they are the start for the data analysis. In 10 years mission the total number of files is about 2,803,200 and each file is less than 50 MB (it has been estimated that a Region Event File containing Sco X-1 is about 10 Mbyte).

The step one and two are applied to both the GSC and SSC instruments. The Region Event Files for each HEALPix pixel are created for the GSC and SSC covering the same one day time interval.

The SSC is composed of horizontal (SSC-H) and zenithal arrays (SSC-Z), therefore the **Region Event File set** for the SSC comprises two sets of 768 files one for the horizontal array and one for the zenithal array. The GSC is composite by 12 counters however these counters are merged when created the **Region Event File set.** MAXI is operated with two bit-rates, medium and low. The low-bitrate data is always available, while the medium bit rate is only available for some time periods. SSC observations are made only when the medium bitrate is available while the GSC observations use both bit-rates. Therefore in one day interval for the GSC there is always

one set of data (768 files) in the lower bit rate while the second set in medium bit rate is not always available. Instead for the SSC (SSC-H and SSC-Z) in one day interval data are present only if the medium bit rate was available.
The Region Event Files data are archived together with the relevant auxiliary files which include housekeeping, attitude, orbit, dptc, geafrc, gebfrc, issancsarj, issancpm and makefilter. There is one set of auxiliary files for one day interval.
The archive at ISAS includes **DBFITS dump, the Processed, the Cleaned and the Region Event File**s data set. The MAXI public archive only includes the **Region Event Files** and this data set is also archived at the HEASARC.
A database reporting summary information is generated using all the Region Event file and allow users to browse via the web-base search engine the Region Event Files data set.

2.2 MAXI CALDB

The calibration files in the archive are those relevant to operate in the Region Event File dataset but also include files used to create the Processed Event Files. The calibration files are included in CALDB and put on line and distribute via the standard HEASARC CALDB.
The most relevant calibration files are those that operate on the Region Event File necessary to create the response and the exposure correction for the finale analysis of the MAXI data.

2.3 MAXI software

The MAXI software package includes tools that operate on the Region Event File data set. They select events for a specific source and calculate the exposure and the appropriate response file. The MAXI package is included and distributed in HEAsoft. The MAXI package includes the following tools :

- mxproduct – Generate the high level products (images lightcurves spectra and response) for both instruments by running in sequence the MAXI ftools sequentially.
- mxextract – Create a single event file from multiple region event files for a given coordinates (RA, DEC) and radius.
- mxscancur – Determine the source position relative to the GSC or SSC instrument.
- mxgscandat/mxsscandat – Calculate the time to when a source is in each of the GSC FOV/ SSC FOV.
- mxgtiwmap– Calculate a weighted spatial distribution of events on the detector.
- mxlcscan–Calculate a source light curve.
- mxgrmfgen/mxsrmfgen–Create a spectral response file for GSC / SSC.
- mxdownload_wget – find and downloads on local disk the appropriate archived files for a given sky position and time interval.

3 MAXI Region Event File archive

3.1 Files and Naming convention

The Region data set includes the following science event data files for each day:

- 768 event files for the GSC (all the 12 counters combined) in low bit rate and if available a similar set in medium bit rate
- 768 event files for the SSC horizontal array (SSC-H) in medium bit rate if available
- 768 event files for the SSC zenithal array (SSC-Z) in medium bit rate if available

The filename for the event files follows the convention:

- mx_mjdMMMMM_gsc_BIT_NNN. evt
- mx_mjdMMMMM_sscC_BIT_NNN.evt

where MMMMM indicates the MJD date, C is set h or z to id the horizontal and zenithal SSC arrays respectively, BIT is the bit-rate, either med or low and NNN is the region ID running from 001 to 768 and.
For each day interval there are several auxiliary files. All possible auxiliary files are:

Table 1	
Auxiliary filename	**Description**
mx_mjdMMMMM.att	Attitude file valid for GSC and SSC
mx_mjdMMMMM.orb	Orbit file valid for GSC and SSC
mx_mjdMMMMM.tim	Time info used in processing, valid for GCS and SSC
mx_mjdMMMMM.fra	Free-run clock file for GSC-A(GSC0,1,2,3,4,5)
mx_mjdMMMMM.frb	Free-run clock file for GSC-A(GSC0,1,2,3,4,5)
mx_mjdMMMMM.iat	ISS attitude file
mx_mjdMMMMM.ias	ISS ancillary file: Joint angles of solar paddles: alpha
mx_mjdMMMMM.isp	ISS ancillary file: Joint angles of solar paddles: beta
mx_mjdMMMMM.mkf	Make filter file valid for the GSC and SSC
mx_mjdMMMMM_gsc.hk	GSC housekeeping file
mx_mjdMMMMM_ssch_dp.hk	SSC-H array data processor housekeeping file
mx_mjdMMMMM_ssch_e.hk	SSC-H array housekeeping file related to the CCD
mx_mjdMMMMM_sscz_dp.hk	SSC-Z array data processor housekeeping file
mx_mjdMMMMM_sscz_e.hk	SSC-Z array housekeeping file related to the CCD
mx_mjdMMMMM_ssch.mkf	Housekeeping for the SSC-H array related to the CCD
mx_mjdMMMMM_sscz.mkf	Housekeeping for the SSC Z array related to the CCD
mx_mjdMMMMM_gscM_BIT.gti	GTI for each of the GSC counter for the HV on/off. M is a value from 0-9 or a,b and BIT is either low or med

3.2 Header Keywords

The Region Event Files and the relevant auxiliary files must have in the primary header or extensions the following set of keywords:

Table 2			
Keyword	**Value**	**Comment**	**Filled by**
*a) Define the instrument and datamodes. The keyword with the * are present only when appropriate.*			
TELESCOP	'MAXI'	/ Telescope mission name	Pipeline
INSTRUME **	'string'	/Instrument name (GSC, SSC_H or SSC_Z)	Pipeline
DETNAM **	'string'	/ Detector subsystem (ALL for GSC, NONE for SSC_H and SSC_Z)	Pipeline
DATAMODE *	'string'	/Data mode (32BIT or 64BIT for GSC, STANDARD for SSC_H and SSC_Z)	Pipeline
b) Keywords that ID the observation.			
OBS_ID	'MJDyyyyy'	/Observation ID	Pipeline
OBJECT *	'NNN'	/ Tile number	Pipeline
c) Coordinates of the center of the tile.			
RA_NOM *	0.0	/ [deg] RA of the region center	Pipeline
DEC_NOM *	0.0	/ [deg] Dec of the region center	Pipeline
EQUINOX *	2000	/Equinox of celestial coord system	Pipeline
RADECSYS *	'FK5'	/Celestial coord system	Pipeline
d) Timing keywords			
TIMESYS	'TT'	/ Time System	Pipeline
MJDREFI	51544	/MJD reference day 01 Jan 2000 00:00:00	Pipeline
MJDREFF	7.4287037037037E-04	/MDJ reference (fraction of day)	Pipeline
TIMEUNIT	' s'	/Time unit for timing header keywords	Pipeline
TIMEREF	'LOCAL'	/Reference Frame	Pipeline
CLOCKAPP	T	/If clock correction are applied (F/T)	Pipeline
TSTART	0.0	/Start time	Pipeline
TSTOP	0.0	/Stop Time	Pipeline
DATE-OBS	'yyyy-mm-dd'	/Start Date	Pipeline
TIME-OBS	'hh-mm-ss'	/Start Time	
DATE-END	'yyyy-mm-dd'	/Stop Date	
TIME-END	'hh:mm:ss'	/Stop Time	Pipeline
TIMEDEL *	value*	/Integration time	Pipeline
TELAPSE *	value	/ TSTOP-TSTART	Pipeline

EXPOSURE *	'value'	/ Exposure in second	Pipeline
ONTIME *	'value'	/Actual time on source	Pipeline
LIVETIME *	'value'	/Corrected for any deadtime	Pipeline
e) Record processing , software and calibration checksum & datasum			
CREATOR	'string'	/Software that create 1st the file	Task name
PROCVER	'00.00.00.00'	/Processing version	Pipeline
SEQPNUM	nn	/Number of times the dataset has been processed	Pipeline
ORIGIN	'JAXA'		Pipeline
SOFTVER	'XXXXXXXXX '	/Heasoft version	Pipeline
CALDBVER	'value'	/CALDB version	Pipeline
DATE	'yyyy-mm-ddThh:mm:ss'	/File creation date	Pipeline
CHECKSUM	'value'	/ data unit checksum updated date	Any Tasks
DATASUM	'value'	/ HDU checksum updated date	Any Tasks

- PROCVER containing the value of the processing version specified as MM.XX.YY.NN, where MM, XX, YY, and NN are digits whose values are set as follows:
  - MM.XX are assigned to the pipeline processing changes, MM major changes, XX small changes. This is a string.
  - YY is for new version of maxi software used in the processing (not that released within HEAsoft).
  - NN is for new version of CALDB in the pipeline.

- SEQPNUM containing the number of times a sequence has been processed within a processing version. This is a numerical value with no leading zeros.

- SOFTVER containing the version of the HEASOFT version used in the pipeline and do not include MAXI processing software. This is defined as :
  - Hea_DDmmmYYYY_Vn.nn_MAXI_DDmmmYYYY_Vnn

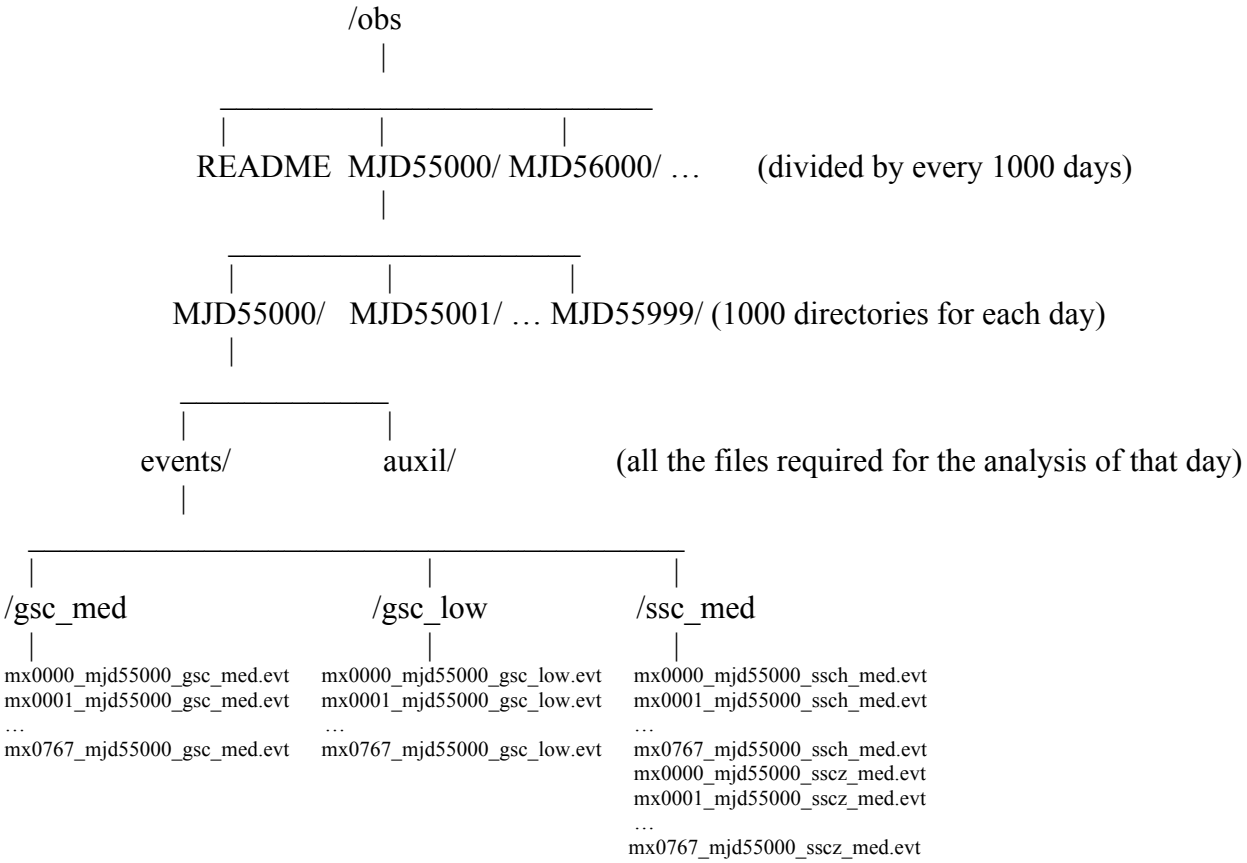
  where DD is the day, mmm is the first 3 characters of the month name, YYYYY the year and nn is version number as advertised in the software distribution.

- CALDBVER containing the version of the calibration index that gives the calibration file list used during the processing of a given observation. This is a string defined as follows: gcsYYYYMMDD_sscYYYYMMDD_genYYYYMMDD
  where the YYYYMMDD referenced to the latest CALDB version for that instrument.

Note : the keywords ID with a "*" in Table 2 are not included in the housekeeping files. The keywords ID with "**" are included in housekeeping files that are relevant to specific instrument. All keywords in Table 2 are applicable also to GTI files or extension.
The TIMEDEL values are 5.0E-5 for GSC, and 5.86547 for SSC respectively.

3.3 Directory structure

The MAXI archive is divided in two directories: the obs/ and the trend/ . The first contains the science data the second contains files mainly for the instrument team to monitor particular parameters team (e.g. radiation belt monitor data, ISS attitudes relative to the velocity vector). The structure of the obs/ directory is the following :



The README file at the obs/ level lists the center position in RA and DEC of each of the 768 Region Event Files.
The data are first divided in directories containing 1000 days named as MJDXXXXX where XXXXX is the mjd value corresponding to the 1000 included in the directory. For example MJD55000 includes sub-directories from MJD 55000 to 55999. Below he data are divided in subdirectories containing data for one day interval named after the mjd of the that day. Each sub-directory has all the files required for the data analysis of that day.
Each day directory contains the events/ and auxil/ directories, which holds the Region Event Files and the auxiliary files, respectively. The events directory has up to three sub-bit ddirectories gsc_low/ gsc_med/ ssc_med/ corresponding to the instruments bit-rates (SSC has only medium bit-rate data). The gsc_low/ and gsc_med/ subdirectories have 768 Region Event Files each corresponding to the 768 Healpix regions. The ssc_med/ has 768 files for the Z array and 768 for the H. If a Helpix region is not observed within that day, event files are not created. The auxil/ directory contains all files required for data analysis for that particular day (Table 1).

.

3.4 Database table

The database table named ***maximaster*** records information related to each of the Region Event Files, e.g., start, stop, ID and others. Each entry in the database table has a unique identifier and a standard format for time and sky position. The times listed in all tables use the ISO convention, e.g., YYYY-MM-DD HH:MM:SS.sss, specified in one field. Sky positions, Right Ascension and Declination, are given in the table as decimal degrees in the J2000 equinox.
The database content has one row for each science Region Event File. The parameters are the following :

- Unique identifier for the table. 8-digits number where the first 5 digits are the MJD of the day the last 3 the region number ,
- MJD value of the observation day.
- Start time provided as YYYY-MM-DD hh:mm:ss
- Stop time provided as YYYY-MM-DD hh:mm:ss
- Right Ascension (2000) of the center of the field. The value corresponds to the pre-set 768 regions.
- Declination (2000) of the center of the field. The value corresponds to the pre-set 768 regions.
- Region number or tile number. It is a 3-digits string ranging from 000-767.
- GSC medium bit rate flag. If set to 0 indicates that the science file for the gsc med region is missing. If set 1 the file is present.
- GSC low bit rate flag. If set to 0 indicates that the science file for the gsc low region is missing. If set 1 the file is present.
- SSC medium bit rate flag for the H-array. If set to 0 indicates that the science file for the ssc h-array region is missing. If set 1 the file is present.
- SSC medium bit rate flag for the Z-array. If set to 0 indicates that the science file for the ssc z-arry region is missing. If set 1 the file is present.
- String to identify from which file the information is taken,
  The values are : gsc_med, gsc_low , ssch, sscz. The string indicates that the information for that specific region number and day is taken from the gsc_med or gsc_low of ssch or sscz file respectively. If set to None indicates that the science region file is missing for all instruments and all the flag are set to 0.

4 The MAXI CALDB data

The MAXI calibration files are the files needed to run the MAXI tools and generate the high level products for a given sky position as spectrum and lightcurve and to generate arf/rmf . The calibration files used to calibrate and screened the Processed and Cleaned data sets are not included in CALDB.
The calibration data are stored in the CALDB with the following directory structure

/maxi

/gsc /ssc

.

/bcf caldb.indx. /cpf /index /bcf caldb.indx /cpf /index

The /bcf directories contain files which are not directly related to creating or applicable to the higher level products extracted from the Region Event Files event. The /index directory includes the archive of the caldb index files for any previous update.
The list of files in CALDB are :

Filename	Description
GSC/BCF	
mx_gsc{0,1,2,3,4,5,6,7,8,9,a,b}_colea_YYYYMMDD.fits	Integrated collimator effective area per counter as a function of photon incident angle in COL coordinate (theta,phi).
mx_gsc{0,1,2,3,4,5,6,7,8,9,a,b}_hvhist_YYYYMMDD.fits	HV history data
mx_gsc{0,1,2,3,4,5,6,7,8,9,a,b}_piparam_YYYYMMDD.fits	PI spectral-channel parameters
mx_gsc{0,1,2,3,4,5,6,7,8,9,a,b}_teldef_YYYYMMDD.fits	Teldef
mx_gsc_mfptab_YYYYMMDD.fits	Table of X-ray mean free path in beryllium
mx_gsc_ssdock_YYYYMMDD.fits	Information on the time of Space Shuttles to the ISS
GSC/CPF	
mx gsc{0,1,2,3,4,5,6,7,8,9,a,b}_arfcorr_YYYYMMDD.fits	Arf correction files.
mx_gsc{0,1,2,3,4,5,6,7,8,9,a,b}_hvxxx_detxXXXX.rmf	Rmf file for GSC.
SSC/BCF	
mx_ssc{h,z}_teldef_YYYYMMDD.fits	Telescope definition files.
mx_ssc{h,z}_colea_YYYYMMDD.fits	Collimator effective area.
mx_ssc{h,z}_quanteff_YYYYMMDD.fits	Quantum efficiency of CCD.
mx_ssc{h,z}_rnfparam_YYYYMMDD.fits	Parameters to create RMF.
mx_ssc{h,z}_col_YYYYMMDD.fits	Collimator slat-plane position.
SSC/CPF	
mx_ssc{h,z}_arf_YYYYMMDD.fits	arf .

5 Appendix A: References

Papers describing the MAXI mission and instruments :

- "The MAXI Mission on the ISS: Science and Instruments for Monitoring All-Sky X-Ray Images", Matsuoka, M. et al., PASJ, 61, 999 (2009)
- " Gas Slit Camera (GSC) onboard MAXI on ISS", Mihara T. et al. PASJ, 63, S623 (2011)
- " In-Orbit Performance of MAXI Gas Slit Camera (GSC) on ISS", Sugizaki, M. et al. PASJ, 63, S635 (2011)
- "Solid-state Slit Camera (SSC) on Board MAXI", Tomida, H., PASJ. 63, 397-405 (2011).
- "In-Orbit Performance of the MAXI/SSC onboard the ISS", Tsunemi, H., et al., PASJ. 62, 1371-1379 (2010).

Additional information about MAXI mission is available at the following web addresses:

- http://maxi.riken.jp

.

- http://darts.isas.jaxa.jp/astro/maxi/
- http://iss.jaxa.jp/en/kiboexp/ef/maxi/
- https://www.nasa.gov/mission_pages/station/research/experiments/603.html