Chapter 1

Overview of the XTE Technical Appendix

1.1 Purpose and Scope

This appendix provides proposers with detailed technical information about XTE and its scientific instruments. The person who reads this appendix will be able to (i) determine when XTE can observe a specific source; (ii) determine whether the observation can be made as a TOO; (iii) identify the capabilities of XTE for scientific studies; (iv) determine whether a proposed observation is feasible; (v) determine how to best use XTE's capabilities.

The first item is covered in Chapter 2 which discusses the constraints imposed upon a given observation. Chapter 3, which covers the second item, describes the data rights and TOOs.

The third item is covered in Chapters 4 (PCA), 5 (HEXTE), 6 (ASM), and 7 (EDS) which contain descriptions of each of the scientific instruments and their operating modes.

The fourth and fifth items are covered in Chapters 8, 9, and 10 which contain, respectively, a complete walk-through to determine an EDS configuration using software tools provided by the XTE GOF and the HEASARC, feasibility examples for the PCA, and for HEXTE. The "feasibility" of the EDS is covered in each of these chapters as needed. The complexity of the XTE's data system requires a proposer to demonstrate the feasibility of a particular observation and to specify the data mode/configurations and telemetry rates of the proposed observation. The reader is urged to read very carefully the EDS section (Chapter 7) to understand fully the capabilities of the EDS.

Additional information describing software, the XTE User's committee, and related issues are presented in appendices to this appendix.

1.2 A Quick Comparison of the XTE Instruments

A line drawing of XTE is visible in Figure 1 showing the location of XTE's instruments. The user can propose observations with two of XTE's instruments: the PCA (Proportional Counter Array) and HEXTE (High-Energy X-ray Timing Experiment). Data from the third instrument, the ASM (All-Sky Monitor) are not proprietary. The two instruments are co-aligned but cover different energy ranges so the two instruments complement each other. The following briefly describes the two instruments. Proposers are urged to read the detailed properties of each instrument.

- Energy range: the PCA has Xenon (Xe) proportional counters covering the 2-60 keV range; HEXTE uses NaI/CsI phoswich detectors covering the 15-250 keV range.
- Energy resolution: the PCA resolution is 18% at 6 keV while the HEXTE resolution is 18% at 60 keV.
- Effective area: the PCA has 3000 cm^2 at 3 keV, 6000 cm^2 at 10 keV, and 800 cm^2 at 50 keV. HEXTE has 1200 cm^2 at 50 keV, 1100 cm^2 at 100 keV, and 300 cm^2 at 200 keV.
- field of view: the fields-of-view of both instruments are 1° FWHM circular.
- temporal resolution: the PCA has a 1 μs time resolution while HEXTE has 10 μs time resolution.

Proposers will receive data from both instruments as a result of a successful proposal.

1.3 Update

The material in this technical appendix will be updated prior to each NRA.

Comments are welcome. E-mail comments to `xtenra@athena.gsfc.nasa.gov`.

Chapter 2

Observing Constraints

2.1 Scheduling

The list of successful proposals generated by the proposal review will be fed into the SPIKE scheduler (Scientific Planning Interactive Knowledge Expert system) to produce two mission time lines: a long-term time line that will cover about six months of observations with a resolution of ~1 week; and a short-term time line that will cover about a week of observations with a resolution of ~1 minute. The short-term timeline will be updated every week. SPIKE automatically takes into account the various constraints on XTE observations and chooses the most efficient overall time line within these constraints. The constraints are described below.

2.2 Constraints

The constraints on how and when XTE can observe a given target fall into four broad categories:

- viewing constraints, i.e., when during a year a source may be observed
- sampling constraints, i.e., when during a day a source may be observed
- operational constraints, i.e., how a source may be observed
- user-imposed constraints, i.e., how the source is to be observed

The issue of feasibility (i.e., whether the instruments can observe a given target) is considered separately in Chapters 9 (for observations using PCA) and 10 (for observations using HEXTE). Each constraint category is covered in a separate section below.

2.3 Viewing Constraints

The only viewing constraint is the sun avoidance constraint. For XTE, the solar avoidance angle is $>30^{o}$. In other words, XTE will not point closer to the Sun than 30°. A solar avoidance angle of $>30^{o}$ leaves approximately 93% of the sky visible to XTE, permitting coordinated observations with ground-based observers.

2.4 Sampling Constraints

2.4.1 South Atlantic Anomaly

Satellites launched into low-Earth equatorial orbits pass through the South Atlantic Anomaly (SAA). SAA passages occur consecutively on about 6 of the 14-15 satellite orbits per day. During passage through the SAA, the high particle flux renders the instruments unusable. Even after emerging from the SAA, the level of induced radiation, which will be seen as a background component, may be enhanced.

2.4.2 Earth occultation

Sources not near the orbit poles will suffer Earth occultation. Typically, Earth occultations last about 30 minutes and occur every satellite orbital period (100 minutes).

2.4.3 Regions of low geomagnetic rigidity

In the six orbits per day which do not pass through the SAA, there are still regions of high particle background where the geomagnetic rigidity is low. Regions of low geomagnetic rigidity produce intervals with enhanced backgrounds. It is not completely clear how the instruments will be affected by these regions prior to launch. The usual practical effect is to reduce the amount of “good” observing time per day for weak sources. Proposers should not expect continuous data streams even for sources not affected by Earth occultation.

2.5 Operational Constraints

2.5.1 Direct contact

Communications with the spacecraft are through the Tracking Data Relay Satellite System (TDRSS). TDRSS contact can be maintained during approximately 70-80% of each orbit, but there may be additional limitations, for example, when the space shuttle is in orbit. Contact will occur through the MA (Multiple Access) and SA (Single Access) telemetry links. There will be a 10-minute command contact every orbit. The data that are used in monitoring observations and in determining the presence of TOOs will be delivered each orbit. The details of TDRSS scheduling should not constrain most XTE users. This section is largely included to remind users that telemetry, and hence telemetry contacts, will be a limitation.

2.5.2 Maneuvering and attitude determination

XTE is a three-axis stabilized spacecraft in which the instruments can be pointed anywhere in the sky but at least 30° away from the Sun. The roll axis of the spacecraft is defined to be along the pointing vector of the PCA and HEXTE optical axes. The pitch axis is parallel to the axis of rotation of the solar panels, while the yaw axis is aligned with the ASM boom. Rotation around the roll axis is restricted to keep the Sun off the spacecraft's thermal radiators (The Sun will never be more than 5° from the X-Z plane during an observation.). Pitch is restricted to an interval between 0° and 150°, where 0° is defined as the roll axis points directly away from the Sun; 90° is defined as the yaw axis pointing directly at the Sun. Rotation around the yaw axis is unrestricted.

The spacecraft attitude control system (ACS) contains optical star trackers, gyroscopes, digitial fine Sun sensors, coarse Sun sensors, magnetometers, reaction wheels, and torquer bars to determine and to control attitude during any conditions. The star trackers are CCDs capable of tracking about 5 stars as faint as 6th magnitude in a field of approximately 8^ox8^o. Two trackers, each offset by a few degrees from the PCA and HEXTE boresights, have fields-of-view overlapping the target direction. The gyros are capable of holding attitude to within 10" over half an orbit without star tracker information. Their accuracy is not expected to be affected appreciably by spacecraft maneuvers. The fine Sun sensors are positioned such that they provide information at all legitimate attitudes during orbit day with an accuracy of about 1'. Attitude solutions will be in the telemetry stream. Other data will also be available so attitude may be recomputed at a later date.

2.5.3 Minimum viewing time

Maneuvers will likely be scheduled during SAA passages or earth occultations. XTE can maneuver at ~6° per minute; approximately 500 sec of overhead occurs per maneuver. Approximately 20 maneuvers per day are anticipated.

Therefore, the minimum on-target time will be 256 sec. This choice is a multiple of the basic HEXTE observing cycle length (the on-source/off-source nodding of the HEXTE clusters). A time of this length minimizes the impact of short points on the overall efficiency.

2.5.4 Multiple pointings and raster scans at large extended objects

Multiple pointings are defined as offsets occuring within $0^o.5$ of a particular direction (i.e, a move followed by a dwell) and will be considered multiple targets for the proposal process. Raster scans (slow drifts across the target followed by a small maneuver to set up for the next drift) are permissible provided the minimum viewing time (defined above) is not violated for the entire raster scan. The user who wishes a raster scan of a target will be expected to provide the RA and Dec of the end points of each scan line of the raster as well as the limits on the slew (drift) rate. The size of the raster box may be alternatively specified. Users should note that a specific orientation of the raster may not be achievable within the orientation limits of the spacecraft (Section 2.5.2 above).

2.5.5 Spacecraft jitter

As the XTE spacecraft orbits the Earth, it is buffeted by high-altitude atmospheric turbulence causing the instantaneous attitude to jitter. The 3σ rate of fluctuation is expected to be 0.1-0.2 arcmin per X sec. This jitter can not be corrected for and limits the precision to which one can constrain source variability.

2.5.6 Telemetry rates and on-board storage capacity

The spacecraft and ground systems can support scheduled access to the satellite for tens of minutes per orbit at rates of 48-1024 Kbps. Command telemetry can be accommodated at 1kbps. The on-board storage capacity is ~906 Mbits. The average telemetry rate for the PCA/EDS is ~18 Kbps (which includes the Standard Modes rates of ~3.3 Kbps) while the HEXTE limit is ~5 Kbps. Users must justify telemetry rates that are greater than the Standard Mode values.

2.6 User-imposed Constraints

2.6.1 Coordinated Observations

Coordinated observations occur when the user desires multiple bandpass coverage of a target. The multiple bandpasses can be XTE/ground-based (i.e., optical or infrared) or XTE/other satellite-based. The constraint must be specified as a particular time to start and to stop the observation (specified in absolute time: Year, Month, Day, Hour, Minute). The user must supply as much information as possible about the non-XTE bandpasses to be included. ‘Special handling’ may be indicated; approximately four such targets will be handled per month. ‘Special handling’ emphasizes the importance of matching the absolute coordinated schedule and permits the investigator to change the schedule up to 60 days prior to the start of the observation. The ‘special handling’ flag will be reviewed for its appropriateness by the peer evaluation panel.

2.6.2 Phase-dependent Observations

A phase-dependent observation is one in which XTE must observe the target at a particular point in the target’s orbit. The user must specify the Epoch and Phase of the observation as well as the phase window in which the observation is to be done.

2.6.3 Contiguous Observations

This constraint is used to eliminate interruptions to the data stream in an observation of a target. Please note that XTE will be operated in a “contiguous” mode as the default. The average target will thus obtain quasi-contiguous data by default, with interruptions resulting from SAA, earth occulta-

tion, and other standard orbital constraints. If an observation is desired to be done without interruptions (say from Earth occultation or SAA passage), the observation will require a contiguous constraint. Such a constraint must be justified in the proposal.

2.6.4 Time-of-Day Observations

This constraint is most clearly applicable to ground-based observers who want XTE observations at the same time as their optical observations, but for which a "coordinated observation" is overly restrictive. For example, if an object is to be studied every night for 4 nights, there is little use in specifying a coordinated observation of length 4 days. The user must specify the UT times to start and to end the observation.

2.6.5 Monitoring Observation

The monitoring constraint is used to check the target's flux or state over a long interval of time in a repetitive manner.

2.6.6 Alternate Targets

Alternate targets will be permitted at a limited level. The criteria for a target to be accepted as an alternate are given below. Basically, alternate targets provide the GO with an option to not waste observing time if a particular source appears "uninteresting". *It will be the proposer's responsibility to provide the alternate target at the time the proposal is submitted*. The target and the alternate will be judged by the review committee. Read the criteria *very* carefully.

- the alternate target observation must be at least 4 orbits in duration and have approximately the same earth occultation schedule as the original target (an efficiency constraint);
- the user must be present during the observation or an iron-clad conditional must be specified;
- the review committee must approve the target, the alternate, and the conditional;
- only one alternate per target will be permitted
- the instrument configuration must be identical for target and alternate
- the alternate must produce the same or a lower telemetry rate;
- a limit of 1 alternate target per month will be permitted during the Cycle-1 period (as a test of the procedure).

Note that the proposer does *not* receive additional time for the alternate. The time awarded to the proposal is awarded to the target plus the alternate. Time expended in slewing to the target and checking the conditional is charged against the total time awarded to the proposal. Necessarily, the alternate will receive less exposure time. In addition, the alternate target is *not* carried over to a subsequent

observing cycle. In other words, if the primary target is observed, separate observations will not be scheduled for the alternate nor will the alternate become a target on the next cycle's observing list.