CX-7402-00001
Baseline Version
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Constellation-X

Baseline Technical Requirements and Assumptions for Mission Architecture Studies

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Constellation-X Baseline Technical Requirements and Assumptions for Mission Architecture Studies

1.0 Introduction

The baseline requirements and assumptions for Constellation-X are provided in this document. To facilitate mission studies, assumptions for the configuration, weight and power have been provided for the optics and detectors. This information should be considered as a starting point and may change pending the outcome of the ongoing technology development efforts.

2.0 Top Level Mission Requirements

The baseline top-level mission performance requirements are provided in table 1.

Table 1

Top Level Mission Performance Requirements	
Effective Area	15,000 sq. cm @1keV (30,000 sq. cm collecting area) 6,000 sq. cm @ 6.4 keV 1,500 sq. cm @ 40 keV
Telescope Angular Resolution	15” HPD from 0.25 to 10 keV 1’ above 10keV
Minimum Spectral Resolving Power	300 from 0.25 keV to 10.0 keV 3000 at 6 keV 10 at 40 keV
Band Pass	0.25 to 40 keV
Minimum Diameter Field of View	2.5’<10 keV 8’>10 keV
Mission Life For Full Constellation	3 years minimum 5 years goal
Redundancy/Reliability	No one failure to result in loss of more than 33% of the mission science (TBR)

These requirements assume a viewing efficiency greater than 90% per orbit during the life of the mission. For orbits with lower viewing efficiencies, the total mission effective area must increase proportionately (TBR), or the duration of the mission must increase proportionally to the loss in viewing efficiency (TBR). The full effective area must generally be available for use on the same target at the same time.

In general, targets of interest will be distributed over the entire celestial sphere. The mission orbit and attitude constraints must be such that 90% (TBR) of the celestial sphere is accessible at least twice per year, with viewing windows not shorter than 2 weeks (TBR) in duration; and 100% of the celestial sphere is available at least once a year with a minimum viewing window of one week (TBR). Observations of a single target will generally be from 2 (TBR) to 48 (TBR) hours in duration.

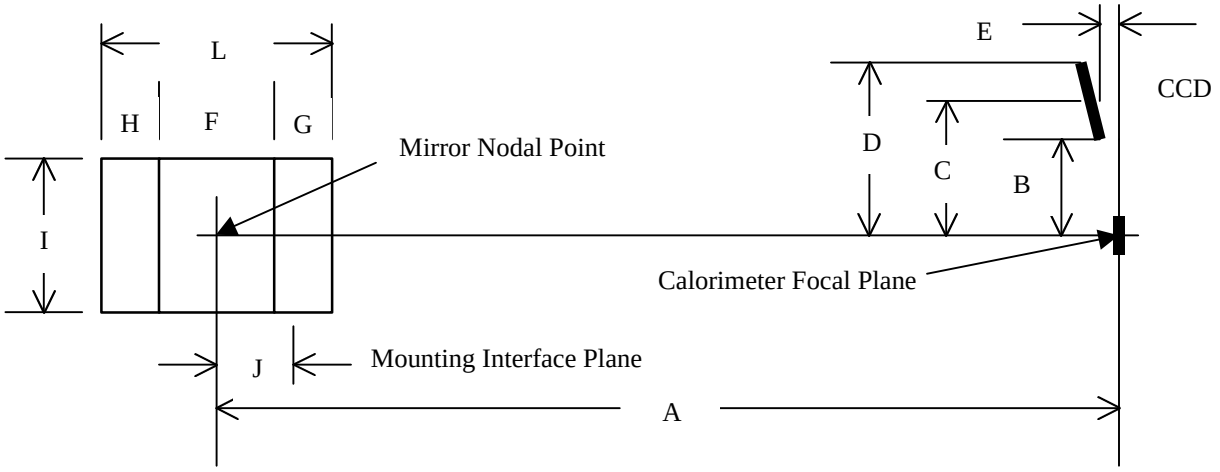
3.0 Instrument Configurations and Assumptions

Two co-aligned telescope systems, the Spectroscopy X-ray Telescope (SXT) and the Hard X-ray Telescope (HXT) will be used to achieve the top-level requirements. The SXT covers the 0.25 to 10.0 keV energy band and the HXT covers the 6 to 40 keV energy band.

The SXT's and HXT's may be distributed on one (TBR) or more satellites to achieve the overall mission objectives. Each satellite must include at least one SXT and HXT, and every satellite must have the same number and size of SXT's and HXT's, so that the instrument complement for each satellite is identical.

3.1 Spectroscopy X-ray Telescope (SXT)

SXT configuration options are provided in figure 1. Table 2 indicates how many SXT optic subassemblies of each configuration are required to meet the minimum mission effective area requirements. The mass, power and temperature requirements for the SXT optics are also provided in table 2.



Parameter	LONG 1.3M	1.8M
A – Focal Length	8400	10000
B – CCD Placement	480	584
C – CCD Placement	604	737
D – CCD Placement	728	890
E – CCD Placement	23.7	28.9
F – Optics Length	1000	1000
G – Post-collimator/grating length	450	450
H – Pre-collimator length	300	500
I – SXT Subassembly Diameter	1400	1980
J – Mounting Interface Plane Distance from Mirror Nodal Point	550	550
L – SXT Subassembly Overall Length	1750	1950
NOTES: All dimensions in mm SXT interface is 3 point kinematic mount on location mounting plane indicated		

Figure 1. SXT Options and Geometry.

Table 2

SXT Optic Parameters		
Optic Configuration	Long 1.3m	1.8 m
Optic Subassemblies per Mission	6	3
Optic Subassembly Total Mass (kg)	462	1214
Heater Power (watts)	200 (TBR)	380 (TBR)
Operating Temperature	20C $\pm$ 1C	20C $\pm$ 1C
Optics Radial Temperature Gradient	$\leq$ 0.5C	$\leq$ 0.5C
Optics Axial Temperature Gradient	$\leq$ 1.0C	$\leq$ 1.0C
Grating Axial Temperature Gradient	$\leq$ 1.0C	$\leq$ 1.0C

There shall be one microcalorimeter detector or equivalent per SXT, and it shall be located at the SXT focus. The microcalorimeter and associated electronics shall be assumed to have a total mass of 30 kg and total power of 100 watts. The detector head, which must be cooled to 0.065 $\pm$ 0.002K, shall be assumed to weigh 3 kg and require minimal power.

One CCD detector or equivalent shall be used as a readout device for the grating spectra. The positioning of the CCD is shown in figure 1. The CCD detector size and mass information is provided in table 3.

Table 3

CCD Detector Size and Mass Information			
Subassembly	**Size (m)**	**Mass (kg)**	**Power (watts)**
Detector Assembly (includes array and pre-amp)	0.1 x 0.1 x 0.4	20	5 (TBR)
Electronics Box 1	0.1 x 0.1 x 0.1	8	TBD
Electronics Box 2	0.1 x 0.1 x 0.1	8	TBD
Instrument Processor Assembly	0.2 x 0.4 x 0.1	12	TBD

The CCD's within the detector assembly must be maintained at a temperature of -90C$\pm$ TBD. The total power of the CCD, including all assemblies, is 40 watts.

3.2 Hard X-ray Telescope (HXT)

The high energy imaging capability is provided by HXT optics subassemblies coupled to HXT imaging detectors. Three optic/focal length options are provided in table 4.

Table 4

HXT Optic Parameters			
Number of HXT's (Mission Total)	18	12	15
Optic Diameter (m)	0.28	0.40	0.33
Optic Subassembly Diameter x Length (m)	0.33 x 0.2	0.45 x 0.3	0.38 x 0.3
Focal Length (m)	9.0	10.5	10.5
Optic Subassembly Mass (kg)	26	55	38
Heater Power (watts per HXT optic)	20	30	25

There must be one HXT detector aligned to each HXT optic subassembly. The HXT detector assemblies should be assumed to weigh 17 kg each. An additional 10 kg per HXT detector shall be required for radiation shielding in low earth orbits. The HXT detector envelope information is provided in figure 2.

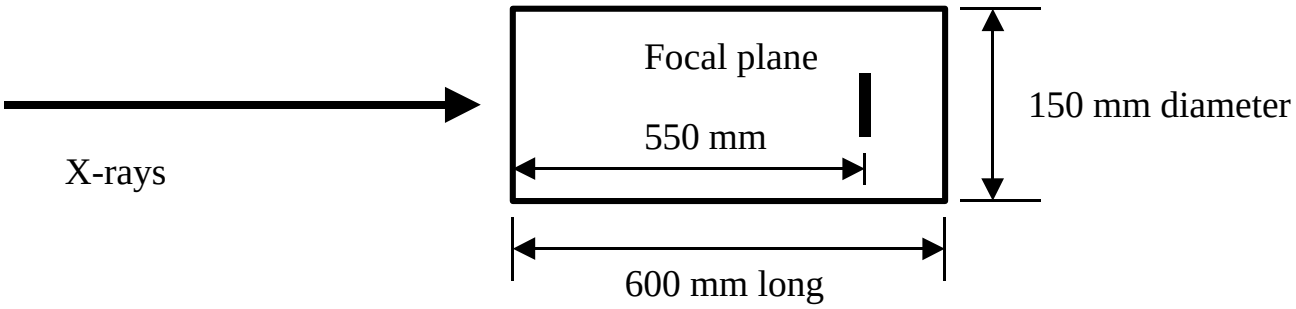


Figure 2. HXT Detector Envelope

4.0 Top Level Mission Derived Requirements

The top level mission derived requirements are provided in table 5.

Table 5

Top Level Mission Derived Requirements	
Pointing	
Pointing Knowledge (3 sigma)	2 arc sec pitch, yaw (TBR) 30 arc sec roll
Pointing Control (3 sigma)	30 arc sec pitch, yaw 60 arc sec roll
Pointing Stability (3 sigma)	1 arc sec/2 sec (TBR) pitch, yaw 5 arc sec/sec roll
Safety Pointing Constraints	$\geq$ 45 degrees from Sun
Science Pointing Constraints	$\geq$ 45 degrees from Sun $\geq$ 30 degrees from Sunlit Earth and Moon
Data	
Science and Instrument Engineering Data Rate (Mission Total Daily Average)	192 kbps
Peak Data Rate (Sum of all satellites)	5460 kbps
Stray Light	
Stray Light on CCD and microcalorimeter	$\leq$ 1e9 photons/sq. cm/sec
Stray Light on HXT detectors	no limit (TBR)
Stray X-rays	
Unfocused X-rays	Protection equivalent to 0.005” tantalum over solid angles outside SXT Field of View
Radiation	
Radiation – Total Dose	TBD
Radiation – Galactic Cosmic Environment	TBD

It shall be assumed that none of the science instruments can operate while in the South Atlantic Anomaly. In addition, the inclination for low earth orbits should not exceed 45 degree (TBR) to limit background on the HXT detectors.

Table 6 provides the derived requirements for the alignment and stability between each of the optics subassemblies and its associated focal plane detector(s). These alignments must be achieved upon deployment of the observatory on-orbit and maintained throughout the life of the mission. The stability requirements stated must be maintained during X-ray measurement periods up to 48 hours.

Table 6

Telescope Internal Alignment and Stability Requirements						
	dX	**dY**	**dZ**	**ThetaY**	**Theta Z**	**Theta X**
	(mm)	**(mm)**	**(mm)**	**(arcmin)**	**(arcmin)**	**(arcmin)**
Alignment	0.50	0.50	0.50	1.0	1.0	1.0
Stability	0.20	0.05	0.10	0.5	0.5	1.0

The internal alignment and stability requirements in table 6 are levied in all six degrees of freedom as defined below:

dX – Deviation of focal plane from mirror in X (focus) direction
dY – Deviation of focal plane from mirror in lateral axis Y, which is defined to be the dispersion axis of the grating
dZ – Deviation of the focal plane from mirror in lateral axis Z, which is defined to be perpendicular to the dispersion axis (cross-dispersion)
Theta Z – Angular deviation of focal plane from mirror about lateral axis Z
Theta Y - Angular deviation of focal plane from mirror about lateral axis Y
Theta X - Angular deviation of focal plane from mirror about lateral axis X, typically referred to as Twist

A sealed aperture door shall be provided for the SXT's to limit acoustic inputs and contamination to the SXT. The door shall be designed for a one-time deployment only.

Acronym List

CCD	Charge-Coupled Device
GSFC	Goddard Space Flight Center
HPD	Half Power Diameter
HXT	Hard X-ray Telescope
SXT	Spectroscopy X-ray Telescope
TBD	To Be Determined
TBR	To Be Resolved

Constellation-X Change Request

Document: Constellation-X Baseline Technical Requirements and Assumptions for Mission Architecture Studies, CX-7402-00001

Initiator:

Change Description:

Paragraph, Table and/or Figure:
From:

To:

Rationale for Change:~~Rationale for Change:~~

Approval (Project Formulation Manager):

Send Change Request to: Anna.Montoro@gsfc.nasa.gov

Change Summary

Date	Change Description