# The Cosmic X-Ray Background NanoSat-2 (CXBN-2): An Improved Measurement of the Cosmic X-Ray Background

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ABSTRACT

CXBN-2 is a follow-on mission to CXBN, a 2-U cubesat that was launched on September 13, 2012 as a secondary payload on the NASA ELaNa VI OUTSat mission. While CXBN is successfully operating on orbit, a number of improvements are envisioned that would improve the precision of the scientific measurement (increase the S/N) made by CXBN and improve the reliability of the spacecraft bus while advancing the flight software and therefore the mission and spacecraft capabilities. CXBN-2 is proposed with these design improvements incorporated. Much has been learned by the team on the operations end that will be incorporated into both the spacecraft design and the ground segment. Additionally, mission operations at Morehead State University now utilizes the substantial gain of our 21 m Antenna system, when combined with Software Defined Radio systems and techniques, significantly reduces mission risk by implementing the ability to detect and decode extremely weak beacons, telemetry, and down-linked data from small spacecraft in LEO with limited prime power and transmission power.

The goal of the CXBN-2 mission is to increase the precision of measurements of the Cosmic X-Ray Background in the 30-50 keV range top a precision of <5%, thereby constraining models that attempt to explain the relative contribution of proposed sources lending insight into the underlying physics of the early universe. The mission addresses a fundamental science question that is clearly central to our understanding of the structure, origin, and evolution of the universe by potentially lending insight into both the high energy background radiation and into the evolution of primordial galaxies. CXBN-2 will map the Extragalactic Diffuse X-Ray Background (DXB) with a new breed of Cadmium Zinc Telluride (CZT) detector (first flown on CXBN) but with twice the detector array area of its precursor and with careful characterization and calibration. The DXB is a powerful tool for understanding the early universe and provides a window to the most energetic objects in the far-away universe. Although studied previously, existing measurements disagree by about 20%. With the novel CZT detector aboard CXBN-2 and an improved array configuration, a new, high precision measurement is possible. In ~1 year of operation the experiment will have collected 3 million seconds of good data, reaching a broadband S/N ~250.

The science mission requirements fortunately allow for the design of a relatively simple spacecraft, making this mission ideal for the CubeSat form factor. The science measurements that will be performed with CXBN-2 represents an improvement over the initial CXBN mission owing to four enhancements:

1.) the addition of a second CZT array doubles the array area representing a $\sqrt{2}$ increase in statistics and increased reliability through redundancy
2.) careful characterization of the CZT arrays on the ground pre-flight. Hot pixels will be eliminated and the energy response of the array will be mapped allowing more effective interpretation of the science data
3.) careful calibration of the array for both flux and gain using calibrated Americium 241 sources on the ground and on-orbit

4.) extensive GEANT simulation of the contribution of secondary particles from cosmic ray protons interacting with the spacecraft structures that will be reduced from the data to improve the accuracy of the measurements

All of the major subsystems comprising the satellite are highly evolved and have flight heritage—having been developed by the team for other missions, and having flown on CXBN. CXBN-2 is a 2UCubesat that can share space with a separate 1U Cubesat in a standard 3U CalPoly Picosat Orbital Deployer (PPOD). Its total weight is 2.6 kg. Innovative systems include upgraded versions of the CXBN power distribution and handling system (PMD), command and data handling system (C&DH)-- now based on a Cortex Arm processor, and an innovative attitude determination and control system (ADACS) developed at Morehead and vetted on CXBN.

The conops is characterized by a sun-pointing, spinning spacecraft (1/6 Hz) in LEO with a non-equatorial inclination. Trajectories over the primary Earth station at Morehead State University (MSU in Morehead, KY) are necessary to acquire the science data and spacecraft telemetry as the MSU Earth station (21 M antenna with a newly implemented UHF focal plane array) will serve as the primary command and data acquisition facilities. Both the science program and the engineering of the spacecraft will conducted by graduate and undergraduate students in concert with university faculty mentors. With improvements derived from the team's experience with CXBN, CXBN-2 has the potential to increase the precision of an important measurement that will lend insight into the astrophysics of the early universe. CXBN-2 is collaboration between Morehead State University (Morehead, KY, USA), Kentucky Space LLC (Lexington, KY USA) and Space Tango (Lexington, KY USA).