Innovative X-ray Star Scanner for Spin Stabilized MicroSatellites

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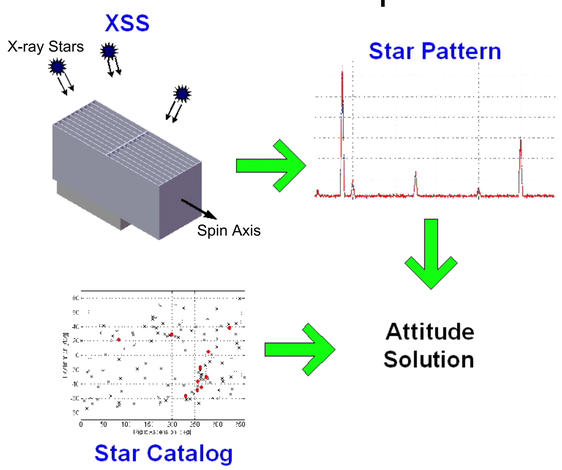
X-ray Star Scanner (XSS) Concept



Recent advances in the design of microsatellites have led to renewed interest in the missions that can be flown with small spacecraft and small payloads. The CubeSat platform and the Plug-and-Play concept have prompted the development of attitude determination hardware typical of larger, more sophisticated, three axis stabilized spacecraft, including miniature gyroscopes and star cameras. The X-ray Star Scanner (XSS) is a new class of attitude sensor, designed to support precision spin-stabilized CubeSat missions by providing arcminute attitude accuracy in a size compatible with a CubeSat, in fact occupying less than half of a 1U CubeSat module. The scientific and technological advances necessary to make this instrument possible are in place. A robust catalog of x-ray guide stars is available through several all-sky surveys performed in x-rays. Solid state x-ray detectors and their related support electronics have been flown. The concept of using guide stars to determine the attitude of a spinning vehicle has been demonstrated using flight data. The XSS fills the need created by the CubeSat and Plug-and-Play platforms for accurate attitude determination on a spin stabilized platform provided in a small package.

XSS Enabled Missions

Offering arcminute level pointing in a low SWaP package, the XSS will open new opportunities for CubeSat class missions using spin-stabilized platforms:

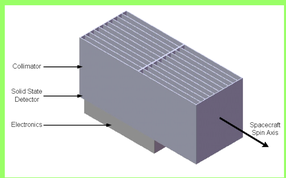
- Scanning astronomy (e.g. all-sky surveys)
- Stable pointing astronomy (e.g. spectroscopy and timing)
- Solar physics
- Earth and planetary observations (e.g. Thompson spinners)
- Fundamental physics (e.g. STAR)

XSS Development Status

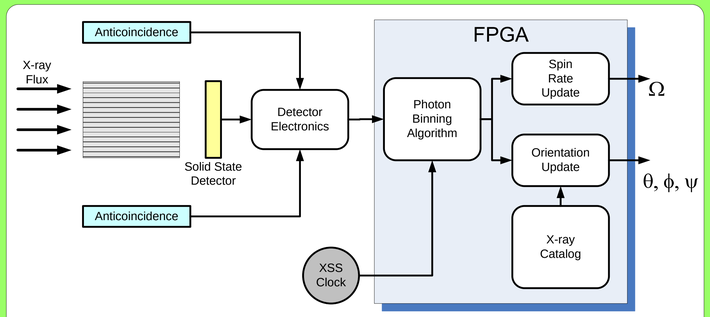
XSS development is currently funded by NASA through a Phase I SBIR, with the following objectives:

- Develop requirements to meet the needs of future CubeSat missions
- Identify potential applications for XSS enabled spin-stabilized microsatellites
- Develop a preliminary mechanical and electrical design
- Develop XSS attitude determination algorithms compatible with low processing power electronics (e.g. FPGA's)
- Predict key performance metrics for the XSS (accuracy, SWaP)

XSS Block Diagram

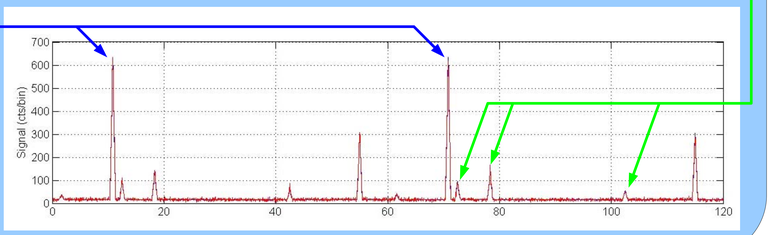


Mass	< 1 kg
Power	< 1 W
Volume	< 1 U

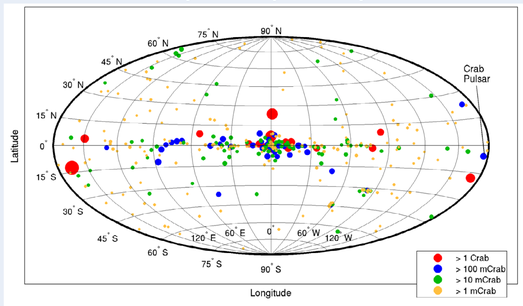


The XSS Attitude Measurement

- As spacecraft rotates, stars enter and exit XSS collimator field-of-view, creating a pattern of pulses
- XSS electronics process the pulses to determine spacecraft spin rate and orientation
- Repeating pattern of x-ray stars is a measure of spin rate
- Overall pattern of stars indicates the orientation and spin phase of the vehicle



X-ray All-Sky Surveys[1]

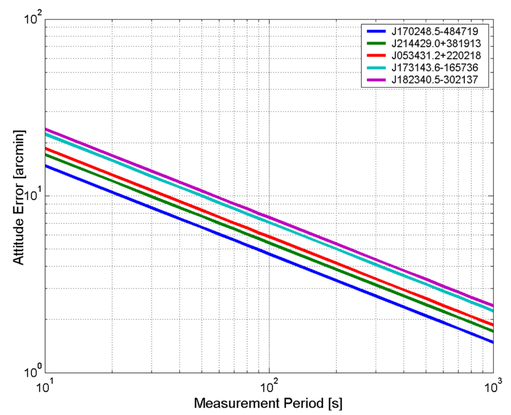


- Soft X-ray emissions: <1 keV to ~10 keV
- X-ray sky mapped by astronomy community with several missions over last 40 years
- Strongest sources emit 100's of photons per second per cm^2 of collecting area
- Source positions known to < 20 arcsec
- X-ray sources distributed over full-sky
- Several relatively strong sources
- Large variation in source strength suggests source confusion may not be an issue
- Sun also bright x-ray source
- Performance is typically shot-noise limited
- Cosmic background typically 1 photon per second per cm^2

[1] Voges, W., et al. "The ROSAT All-Sky Survey Bright Source Catalogue." Astronomy and Astrophysics. August 13, 1999.

Predicted X-ray Star Scanner Performance

- XSS occupies less than half a 1U space
- Simple analysis shows arcminute level pointing for measurement bandwidth of 10 mHz
- Assumes multiple scans overlayed to reduce shot noise
- Arcminute level performance demonstrated previously with HEAO flight data[2]



[2] Hanson, J. E., "Principles of X-ray Navigation," Doctoral Dissertation, Stanford University, 1996, URL: http://il.proquest.com/products_umi/dissertations/

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