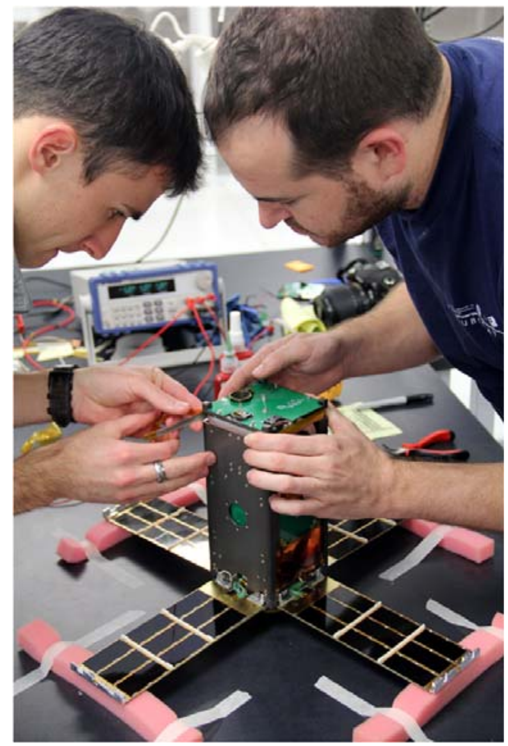
MOREHEAD STATE UNIVERSITY

University SmallSat Programs and Technical Issues

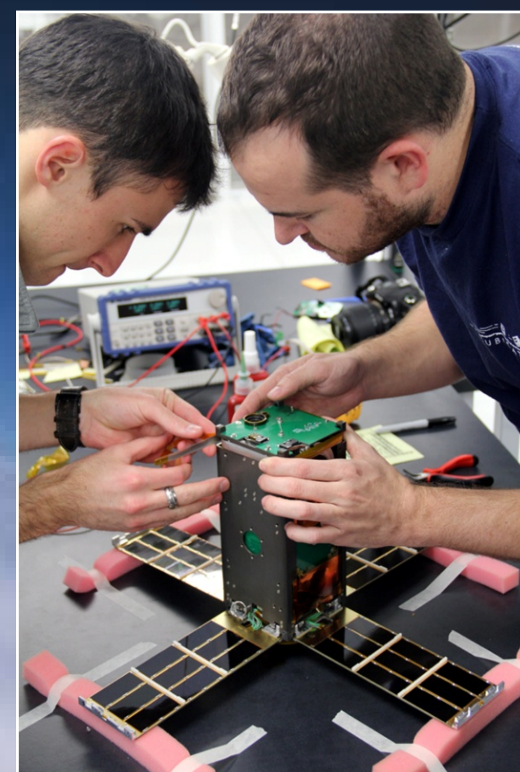
Space Science Center

Morehead KY



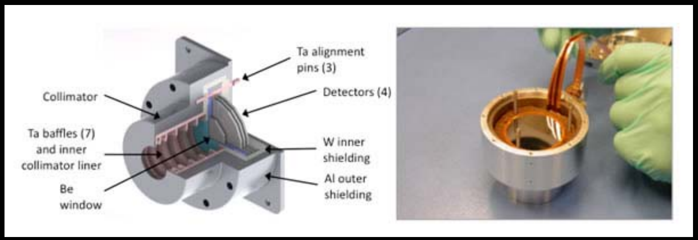
Space Projects Create Opportunities for Students

- Undergraduate Research Experiences
- Instrumentation Experience
- Engineering Design
- Observational Astrophysics Research
- Ground Ops (TT&C)
- Project Management Experience
- Systems-level Engineering Experience



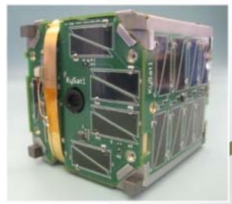
CUBESATS NOW PRODUCING SCIENCE

- CUBESAT technology has now evolved to the point where valuable (if niche) science research is supported
  - RAX-2 (University of Michigan)
  - Dynamic Ionosphere CubeSat Experiment (DICE) is a scientific mission consisting of two cubesats flying in formation. Flew four Electric Field Probe sensors on telescopic booms, two DC Langmuir probes for detection of ions and a three-axis magnetometer for measuring magnetic fields(1.5 Mbit/s downlink)
  - E1-P (HRBE) (Montana State)
  - SwissCube,
- CXBN, CCSWE, STARE…
- Given current budget climate for fundamental research, it is inevitable that Smallsats will increasingly become major contributors as science platforms

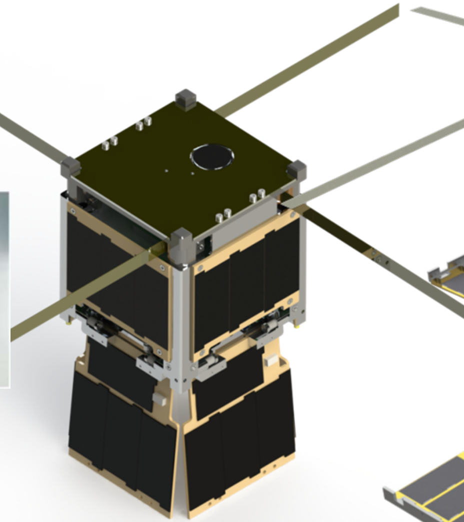


Morehead SmallSat Missions

KySat-1 Secondary on NASA's Glory Mission

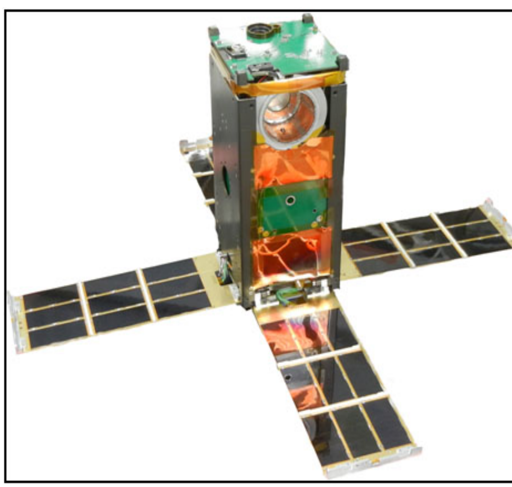


- 1U,2U,3U CubeSats
- Microsat Subsystems
- PocketQubs
- Ground Ops
- Comms Experiments
- GSE Development
- Variety of Customers

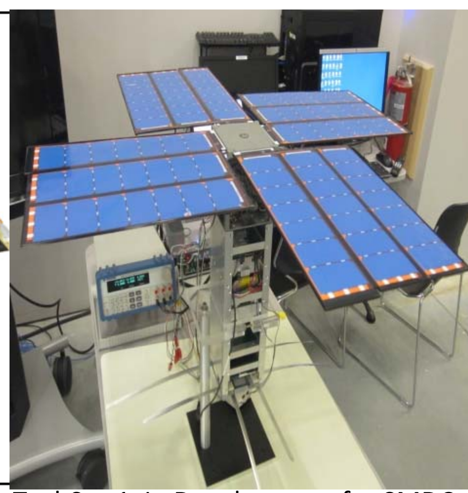


KySat-2 Launches in October 2013

CXBN-2 In Development

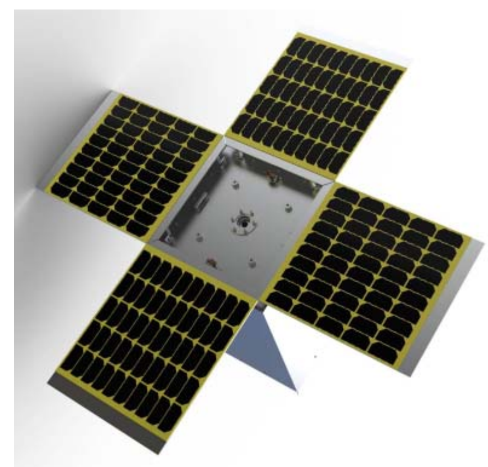


CXBN Launched in 2012



TechSat-1 In Development for SMDC (w/ Honeywell and Radiance)

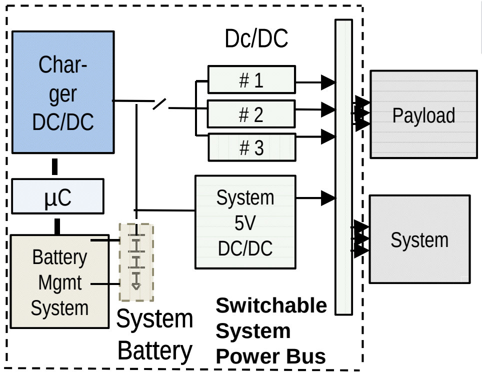
Standard MSU 3-U Bus



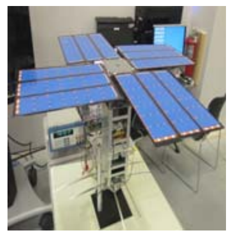
UniSat-5 w/ Univ. of Roma

TechSat-1

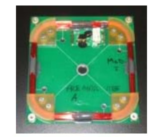
- Power Mgmt & Distribution
- Systems Integration

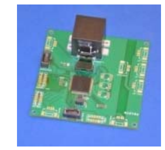


Radiance Technologies



- Nanosat Bus Development,
- Hardware Integration and Test
- SubSystems

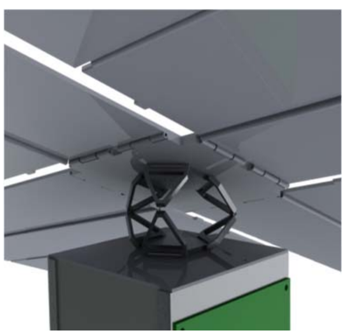




Morehead State

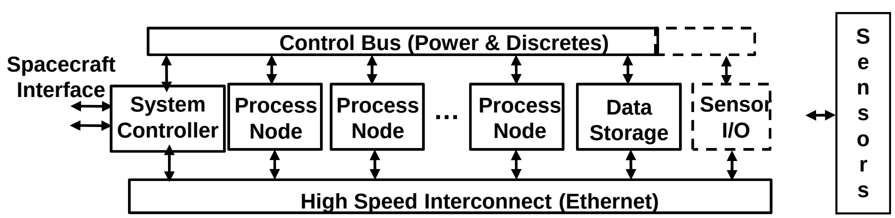
- Articulating Solar Array

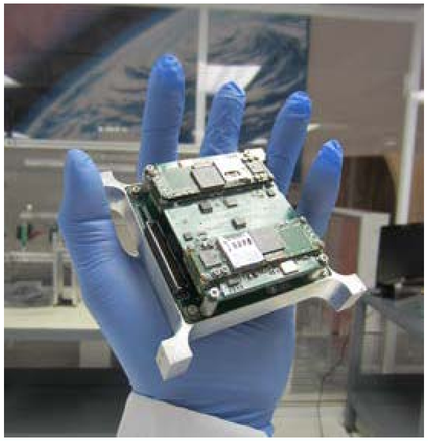
Tethers Unlimited



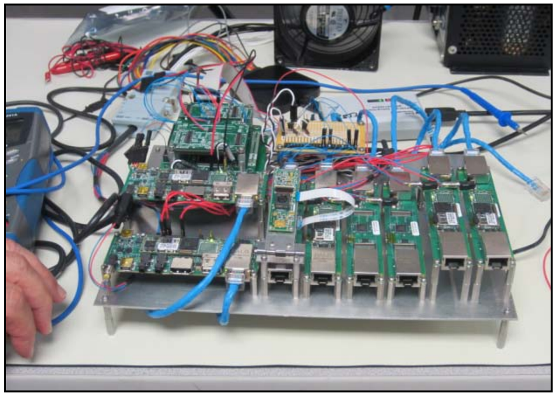
- Dependable Multiprocessor Payload

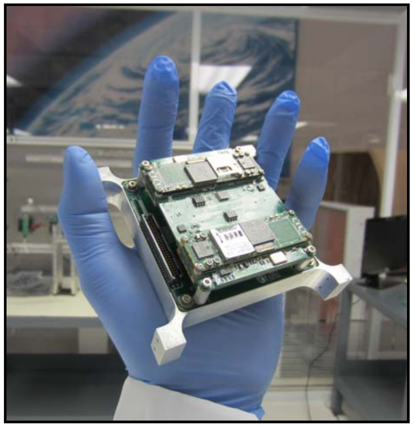
Honeywell and Morehead





DM Cube: Dependable Multiple Processor for Nanosat Applications





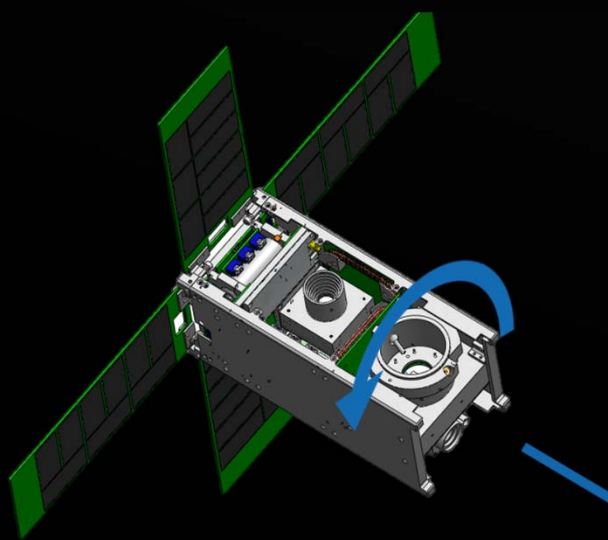
- •Developed by Morehead and Honeywell Space and Defense for the US SMDC
- •Based on small, light-weight, low-power, low-cost, Gumstix™ COM (Computer-On-Module)-based, for high-performance onboard payload processing
- •Leverages $14M NASA NMP ST8 investment in the development of DM technology
- • Scalable cluster of high (COTS) processors to >24
- •Peak throughput density of 300 million (MOPS)/watt
- •Fault tolerant DM Middleware (DMM) + 8 Processors mitigate high-current SEFIs and will be resilient to total radiation doses expected in the lunar environment
- •8 Processor version: mass = 0.24 U and weight =350 g

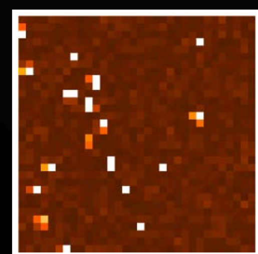
Processor Architecture	Clock Rate	Memory	Max Power Usage	Digital Interface Types	Mode	Manufacturer
Cluster Nodes: ARM Cortex A8	61.4 GHz	512 MB RAM 512 MB Flash	1.5 Watt	UART, I2C, USB, SPI, CAN, PHY	Network Node	Gumstix™
Cluster Backbone	24 MHz	1 MB	2.0 Watts	PHY, UART, SPI	Network Backbone & Management Interface	MSU

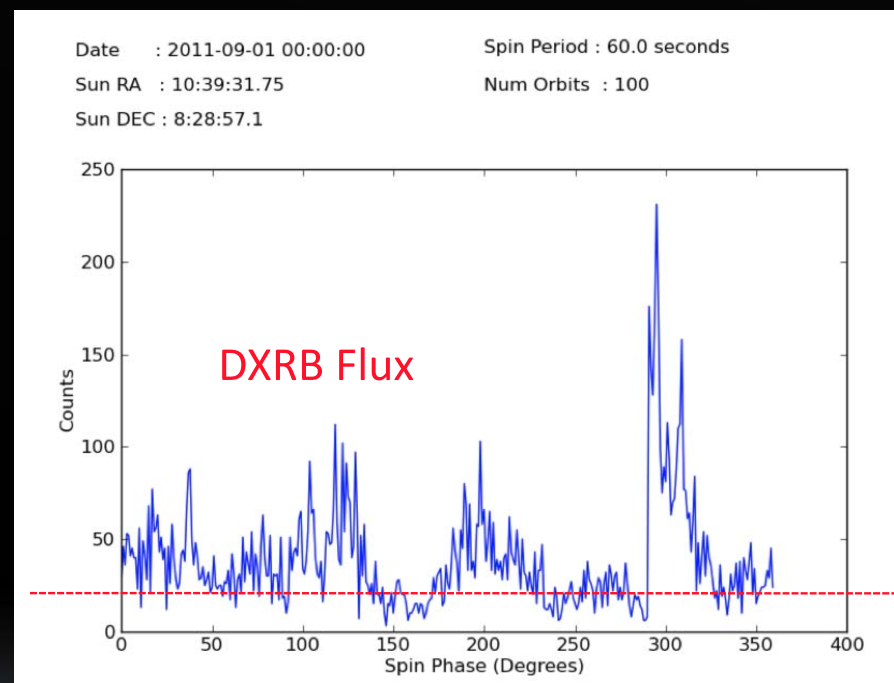
CXBN ConOps

MEASURING DXRB WITH CZT

- Spacecraft will spin about the sun pointing axis, allowing the detector to sweep out its Field of View (FOV) over 360 degrees with each rotation

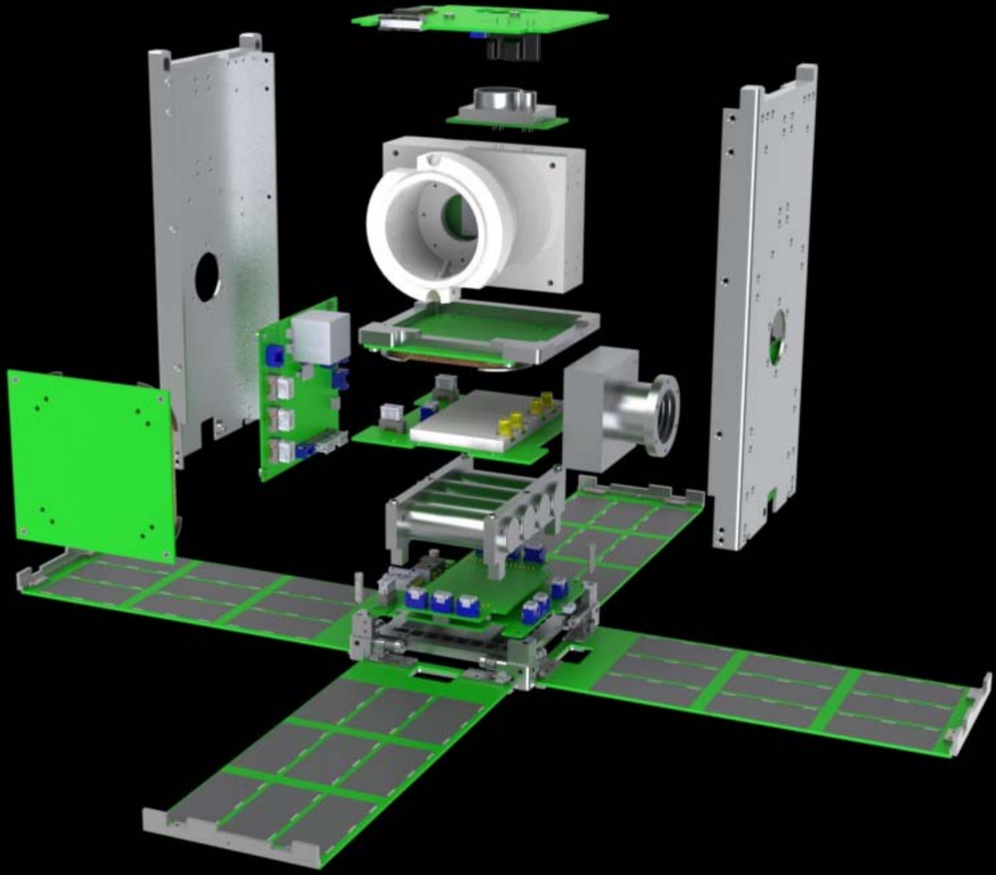






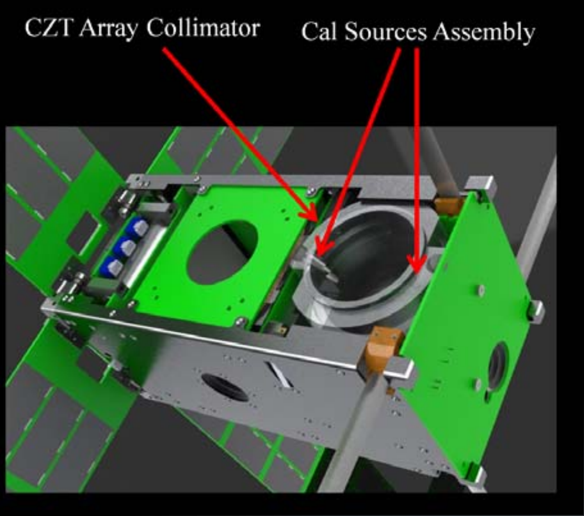
CXBN- COMPARATIVELY SOPHISTICATED CUBESAT

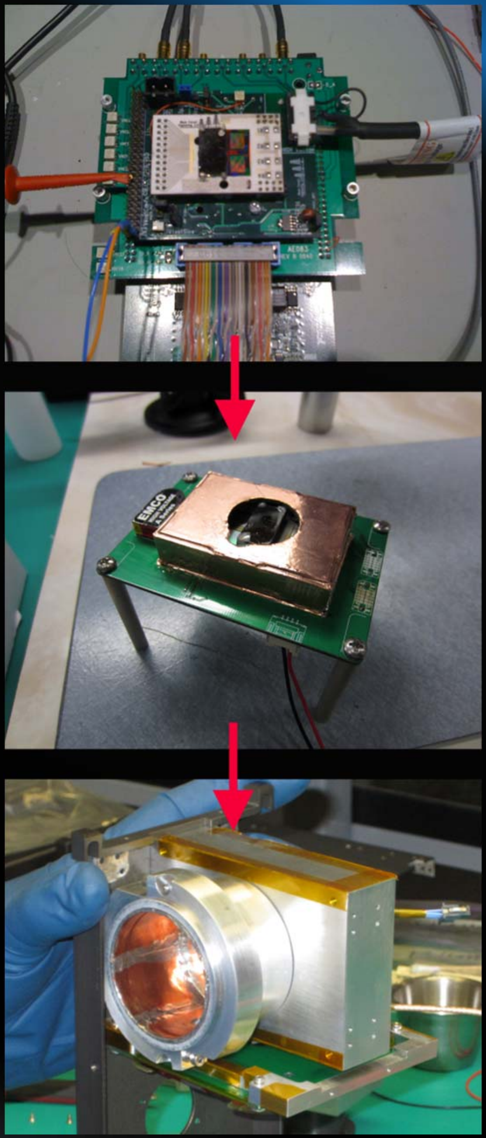
- ADCS
  - MEMS-Based Gyros
  - Tri-Axis Magnetometers
  - Dual Sun Sensor
  - Star Pipper
  - Magnetorquers
- Power Systems
  - Deployable Solar Panels (
  - 15 W Continous
  - Direct Energy Transfer
- Comms
- VHF and S-Band
- C&DH
  - Distributed MSP 430s
  - 40 MHz Clock Speed
  - RTC
  - Watchdog Timers



CZT ARRAY

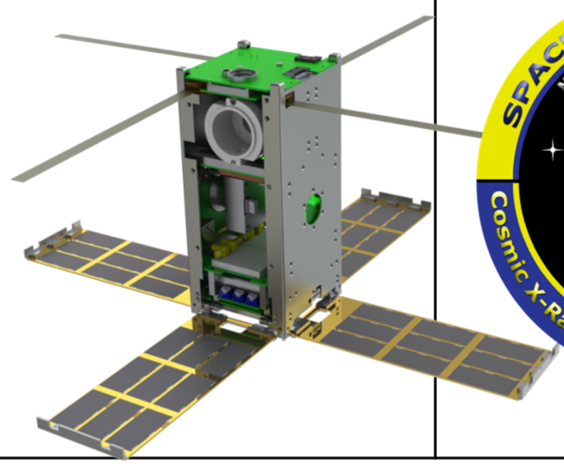
- Direct Bandgap Semiconductor
- 600x600 micron pixels and 1keV energy resolution at an energy of 60keV
- Extreme Sensitivity in the 10 – 100 KeV Range
- Calibrated with Am-241 Sources





Cosmic X-Ray Background Nanosatellite-2
Morehead State University and Kentucky Space

CXBN-2



Mission Description/Goal

•Increase the precision of measurements of the Cosmic X-Ray Background in the 30-50 keV range
•Constrain models that explain the relative contribution of cosmic X-Ray sources to the CXRB
•Produce data that will lend insight into the underlying physics of the Diffuse X-Ray Background
•Provide flight heritage for innovative CubeSat technologies
•Provide flight heritage for CZT-based X-Ray-Gamma Ray Detector

Major Milestones

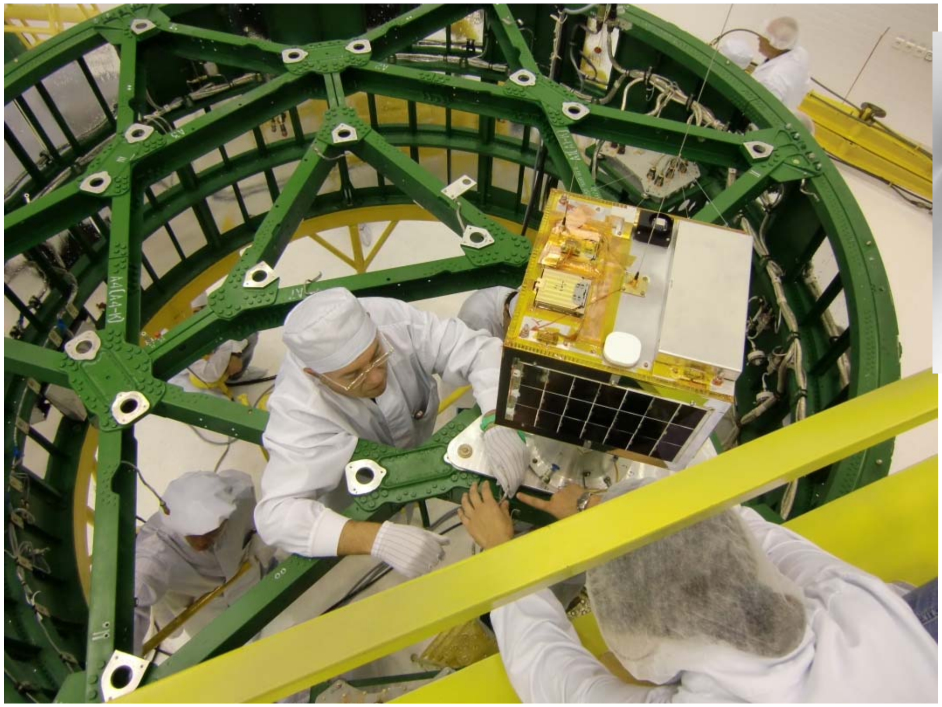
- Completion of requirements, design, and mission/flight readiness reviews
- Completion of fabrication benchmarks
- Completion of pre-flight testing
- Integration, Launch, and LEOP—contact established and subsystems operating nominally
- Science objectives:
    - 3 million seconds of data
    - ~1 year of operation
    - broadband S/N ~250
- End of mission de-orbit in 15 years

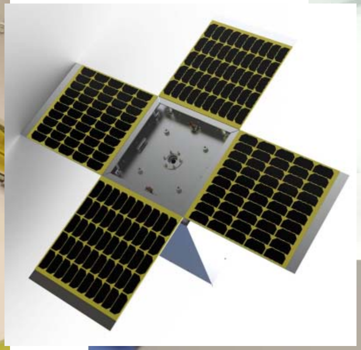
Spacecraft Specifications

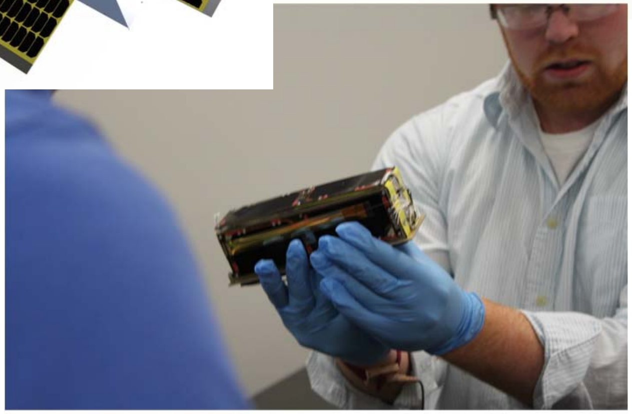
- Spacecraft Developers: Morehead State University Space Science Center, Kentucky Space, Univ. of California Berkeley
- Integration & Test Location: Morehead State University Space Science Center (Kentucky USA)
- Mass: 2.6 kg
- Power: 15 W max generated; Regulated Power to Subsystems at 3.3VDC, 5VDC, 12VDC
- Size: 2U = 10 cm x 10 cm x 20 cm
- Dynamics: Sun Pointing, Rotation Rate = 1/6 Hz

UniSat Series: 25-40 Kg Microsatellite

- GAUSS Project with Morehead Collaboration
- 6 Ph.D. Students worked/working at MSU
- MSU Designed and Build FemtoSatellite Orbital Deployers
- EduSat and UniSat-1 -5
- Deploys CubeSats and PocketQubs (femtosats)
- To Be Launched by Kosmotras in 2013

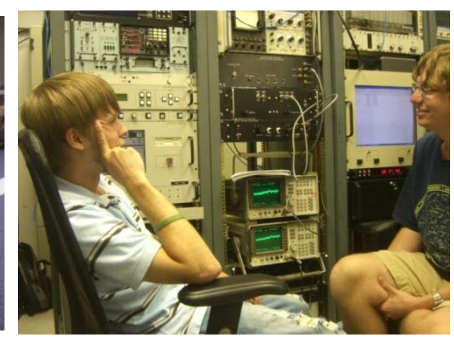






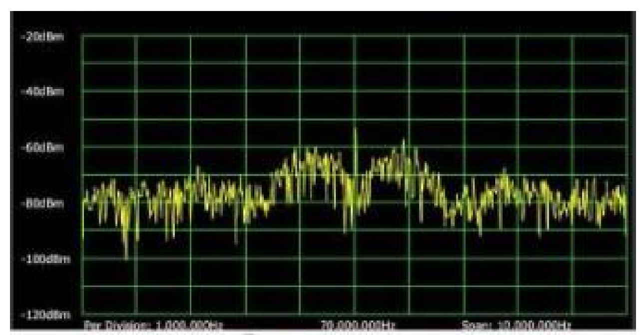
Ground Segment: University-Based Earth Stations

- 21 Meter at Morehead State: Full-Motion, High Precision Dish
- Designed and Built with NASA assistance
- Replaceable feeds including L-band, S-band, C-band,and Ku-band
- Provides Experimental and IOAG Compatible TT&C Services
- Operated Largely by Cost-effective Undergraduate Students
- High Gain and Extreme Accuracy reduce comms link with small, low power, distant S/C
- Station is ideal for LEO and lunar spacecraft experiments and operations



2012 Station Upgrade

- Major Upgrade Supported by NASA HEOMD and Johns Hopkins APL, included:
  - Full Remote Control of All Systems
  - All equipment required to process spacecraft data
  - Timing and frequency references
  - Uplink capability implemented
  - SLE Compliance
  - NASA NEN Compatible
  - IOAG Compatible
  - Software-Defined TT&C Processor (SoftFEP)
  - T400 Modem
  - High Data Rate Digitizer for Experimental Missions



TIMED Spacecraft FFT

Benefits

- Cost-Effectiveness
- Launch Opportunities as Secondaries
- Greater Risk Tolerance
- Short Development Time
- Standardized Form Factor
- Standardized Acceptance Testing
- COTS Subsystems
- Flight Heritage
- Potential for Student Involvement

Technical Challenges

- Mass: < 1.3 kg per U
- Volume < 10 x 10 x 10 cm per U
- Bus Requirements (function of science requirements)
  - 1 U– Bus needs 0.75 U
  - 2 U – Bus needs 1.5 U
  - 3 U – Bus needs 1.5-2 U
  - 6 U Lunar- Bus, Propulsion, ADCS, leaves 1-2 U payload
- Power
  - 1 U ≈ 1-1.5 W Continuous
  - 2 U ≈ 15 W
  - 3 U ≈ 40-70 + W
  - 12 U ≈ 150 + W
- Propulsion/ADCS

Student Research Supported Provide By

- NASA (GSFC, MSFC, WFF)
- KY NASA EPSCoR
- NSF
- DoD
- Kentucky Space Grants Consortium
- Kentucky Space
- Johns Hopkins APL