TechEdSat – CubeSat Technology demonstration mission featuring Plug-and-play and radiation hardened electronics

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Advanced Packaging Si-interposer Technology
Featuring XiVIA™

✓ Ruggedized for space temperature range
✓ Under qualification with ESA as "harmonized" packaging technology for 3D integrated electronics including high-IO count circuit flip-chip
✓ Demonstrated for ESA Motion Control Chip (MCC) motor controller for interplanetary exploration (-120 °C → +70 °C)
Space Plug-and-Play Avionics in short

Personal Computer platform

USB interface chip
driver

Driver loaded by Operating system based on matching unique device ID

plug-and-play Component with Unique ID

Driver stored locally in subsystem and sent to On-board Computer for parsing

SPA enabled component

SPA Component with Distributed datasheet / driver (XTEDS)

Remote Terminal Unit (RTU)
**TechEdSat background**

- TechEdSat is a 1 U CubeSat designed and built by San Jose State students/NASA Ames/AAC Microtec

- The satellite will be a part of the first mission to be launched from the Japanese Experimental Module on the International Space Station.

- This mission will demonstrate space plug-and-play hardware, new communication hardware and be a part of ISS history

- Introduce open source on all levels including hardware
TechEdSat mission objectives

- Demonstrate the SPA hardware and software from ÅAC Microtec.

- Investigate both IRIDIUM and ORBCOMM satellite to satellite communication as a method of eliminating the requirement for a physical ground station in Nano satellite missions.

- Demonstrate the capabilities of the JAXA J-SSOD aboard the ISS, and be one of the first cubesats to be deployed from the ISS.
TechEdSat technology overview

- 1U Cubesat (10x10x10 cm volume, 1.3kg mass)
- Secondary battery recharged using PV cells
- Radiation tolerant Space Plug and Play Avionics from ÅAC Microtec
- Amateur band radio beacon for safe mode operation
- IRIDIUM and ORBCOMM intersatellite links
- Two deployable whip antennas (VHF/UHF), one L-band patch antenna
- Off the shelf Pumpkin structure
PnP Scalable power architecture

- Space Plug-and-Play Avionics compatible
- RadHard with short circuit protections (Latch-up Current Limiters, LCL)
- Galvanic isolation
- Li-Ion Battery Charge/Discharge
- Solar Array management
- Safe mode and mission mode
• Safe mode running ÅAC fault tolerant soft core “OpenPIC MCU” (compatible with PIC16F84) at 16 MIPS
  – 4 kWord instruction ROM with ECC
  – MCU instruction execution with ECC
  – 128 kB boot EEPROM
  – HW wdog

• Mission mode running ÅAC fault tolerant soft core “Fault Tolerant OpenRISC Model-R” with Linux 3.2 kernel at 25 DMIPS
  – CPU instruction execution with ECC
  – 8 kB instruction cache with ECC
  – 8 kB data cache with ECC
  – 40 MB RAM with hw scrubbing ECC
  – 8 Gbit boot flash
  – Advanced house keeping
  – USB host
  – 4 x I2C master / slave
PnP Virtual System Integration concept

Removes the need of:
- Shipping engineering models
- Sending updated mission software
- Allow testing of classified payloads (xTEDS driver open, data stream encrypted)

Running PnP Data Manager on Linux kernel 3.2

VSI equipment
- LV-SPA-U
- SPA-1
- LV-SPA-S
- Gb-Ethernet
Radiation hardening work

- All parts radiation screened, selected jointly with AFRL
- nanoRTU™ tested by AFRL to 70 krad component level (AD/DA died at 40 krad) > 100 krad missions
- Derating of passive components and connectors according to MIL/ECSS standards
- Advanced SEU protection using soft core processors with
  - ECC from flash, through cache, to instruction execution
  - External memory scrubbing ECC
  - FPGA bank IO flip detection
  - 3 voting of boot flash firmware
  - Peripheral FIFO EDAC
  - DMA transfers
  - HW watch dog
Conclusions

- A low-cost full blown, radiation tolerant and scalable nanosatellite architecture have been integrated for missions up to 100 krad (including Geostationary and interplanetary)

- Added PnP interface support to ORBCOMM and IRIDUM inter-satellite communication payloads

- Shown to be compatible with ORS 6-day concept (actually AIT can be done under two days)

- Scales to a wide range of satellite sizes

- Demonstrated Virtual System Integration for global rapid integration and development

- Started studying a 6U technology demonstrator mission together with NASA Ames/Swedish National Space Board
Thank you for your attention!

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