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

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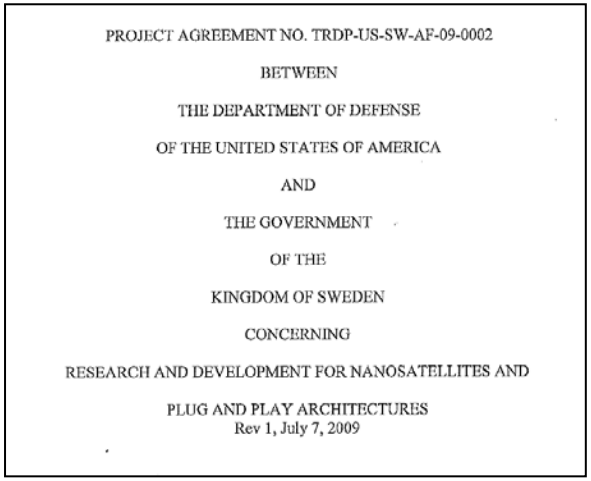
Civil domain

DoD domain

ARKIVEXEMPLAR

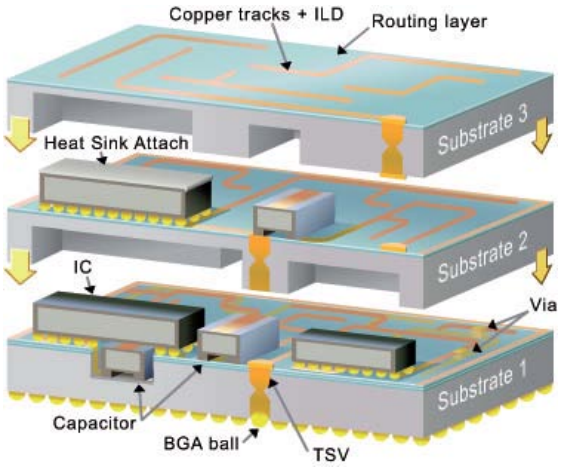
IMPLEMENTING ARRANGEMENT
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OF THE UNITED STATES OF AMERICA
AND
THE SWEDISH NATIONAL SPACE BOARD
OF THE KINGDOM OF SWEDEN
FOR
COOPERATION IN AERONAUTIC AND SPACE RESEARCH
USING NANOSATELLITE TECHNOLOGIES

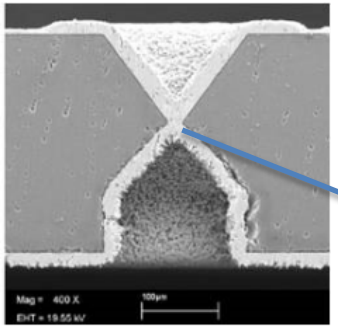


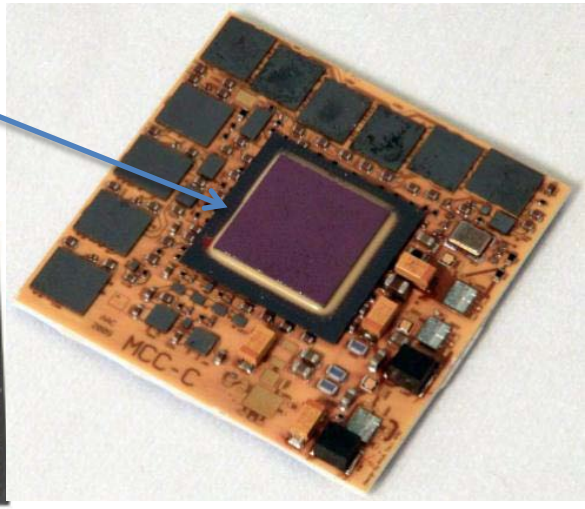
PROJECT AGREEMENT NO. TRDP-US-SW-AF-09-0002
BETWEEN
THE DEPARTMENT OF DEFENSE
OF THE UNITED STATES OF AMERICA
AND
THE GOVERNMENT
OF THE
KINGDOM OF SWEDEN
CONCERNING
RESEARCH AND DEVELOPMENT FOR NANOSATELLITES AND
PLUG AND PLAY ARCHITECTURES
Rev 1, July 7, 2009

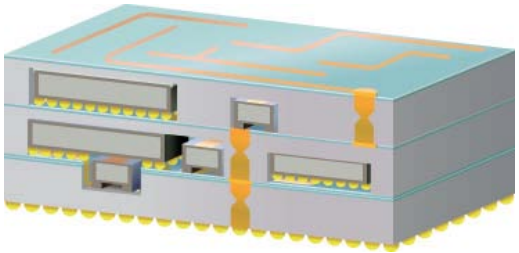
Advanced Packaging Si-interposer Technology Featuring XiVIA™

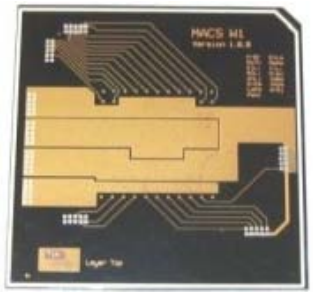
- ✓ Ruggedized for space temperature range
- ✓ Under qualification with ESA as ”harmonized” packaging technology for 3D integrated electronics including high-IO count circuit flip-chip
- ✓ Demonstrated for ESA Motion Control Chip (MCC) motor controller for interplanetary exploration (-120 °C → +70 °C)

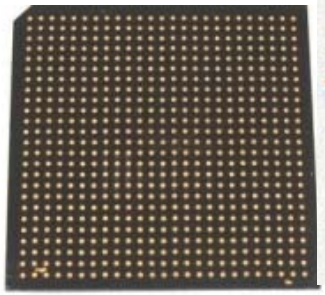












Space Plug-and-Play Avionics in short

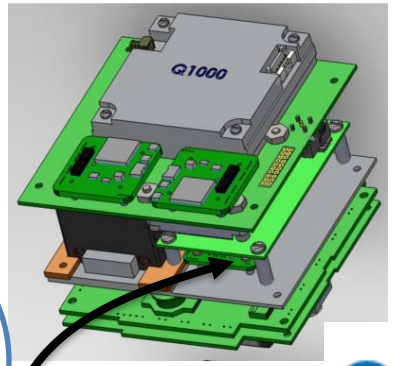
Personal Computer platform

driver

Driver loaded by Operating system based on matching unique device ID

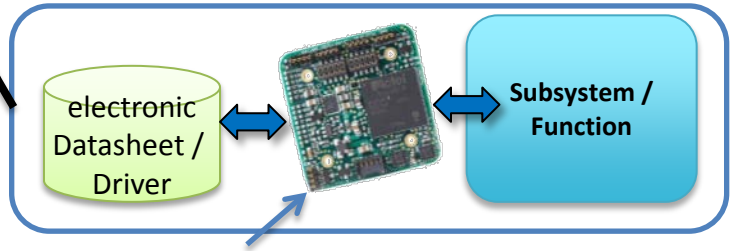
plug-and-play Component with Unique ID

USB interface chip



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

SPA enabled component

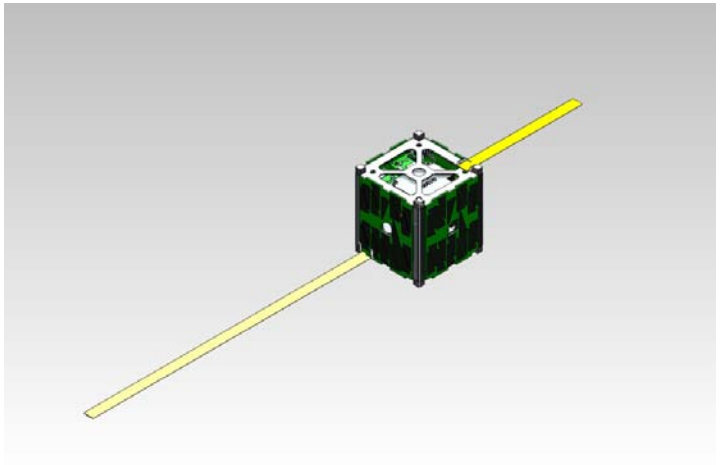


Remote Terminal Unit (RTU)

SPA Component with Distributed datasheet / driver (XTEDS)

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

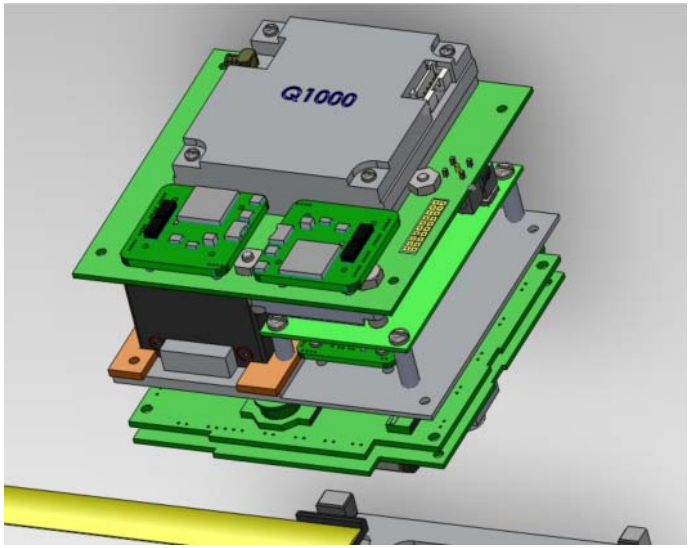


TechEdSat mission objectives

- 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

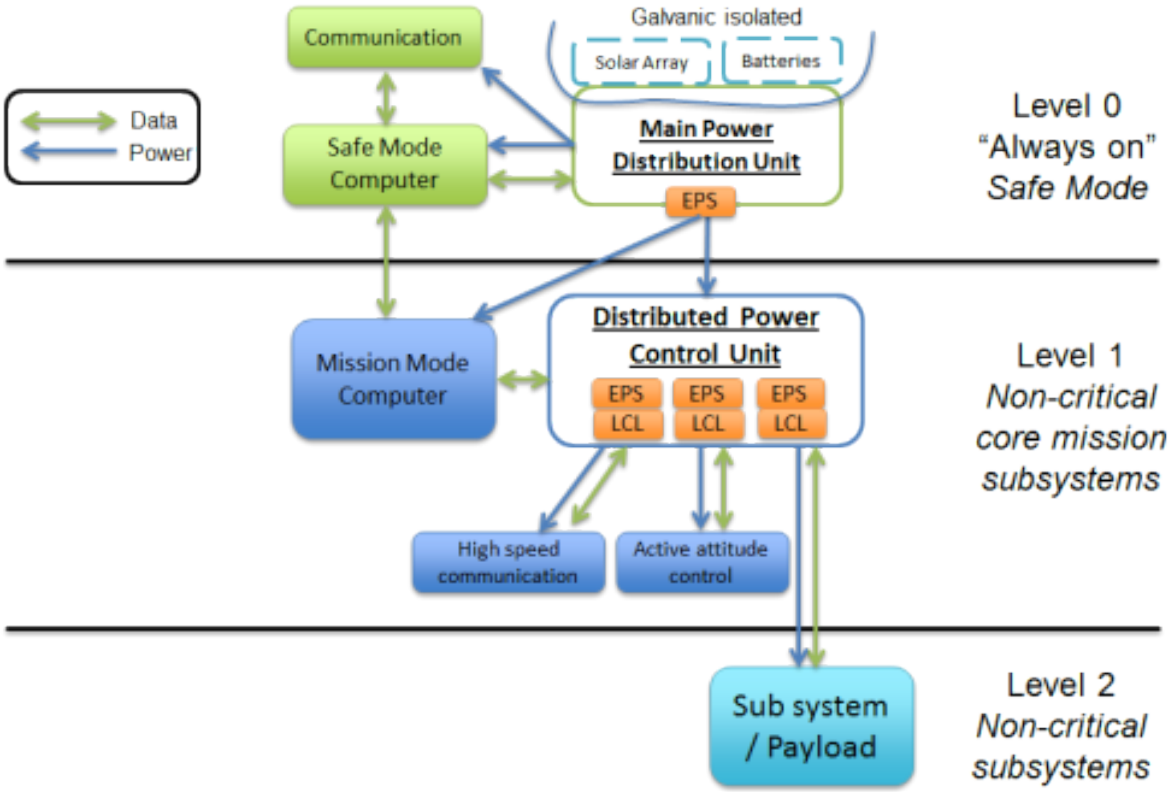
TechEdSat technology overview

- 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



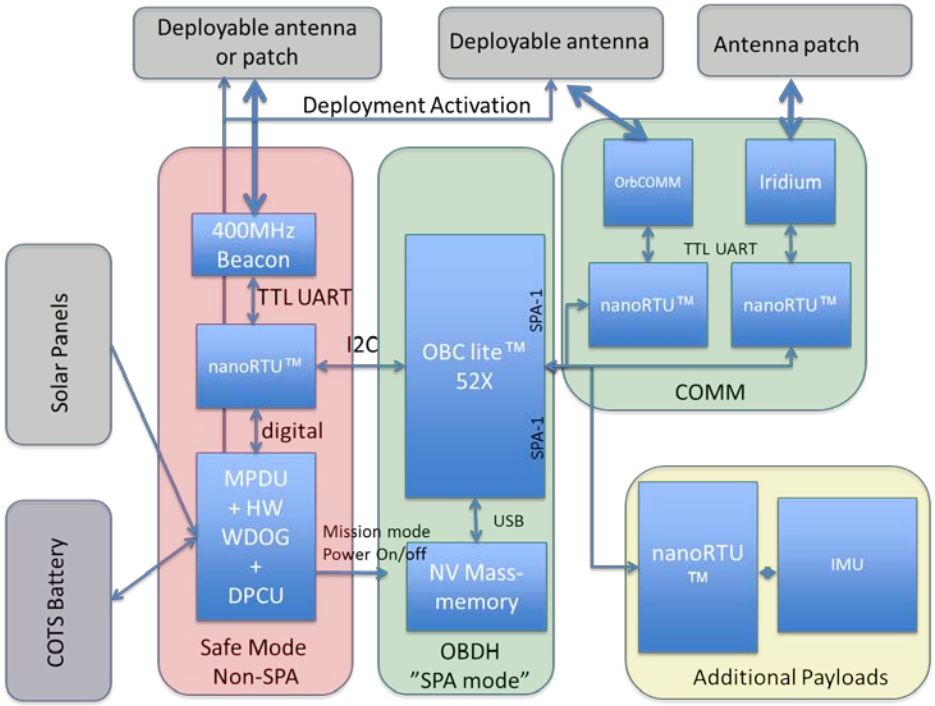
PnP Scalable power architecture

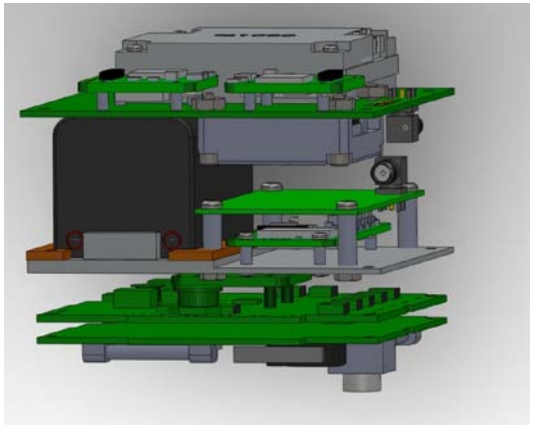
- Space Plug-and-Play Avionics compatible
- RadHard with short circuit protections (Latch-up Current Limiters, LCL)
- Galvanic isolation
- Li-Ion Battery Charge/Discharge
- Solar Array management
- Safe mode and mission mode



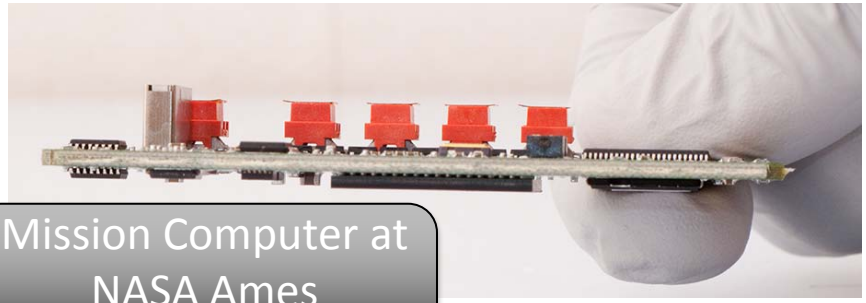
TechEdSat block diagram

- 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 chache 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



Mission Computer at NASA Ames integration facility

Running PnP Data Manger on Linux kernel 3.2

Internet / LAN

Removes the need of:

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

Location 2

PnP Subsystem / Payload

Location 1

PnP Subsystem / Payload

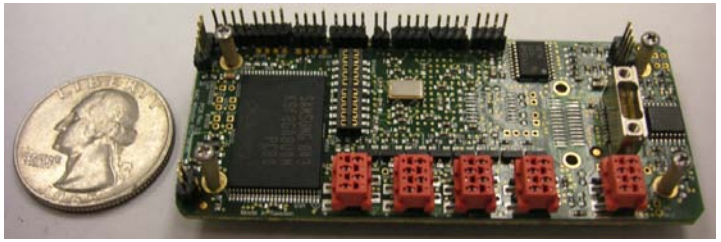
PnP Subsystem / Payload

VSI equipment

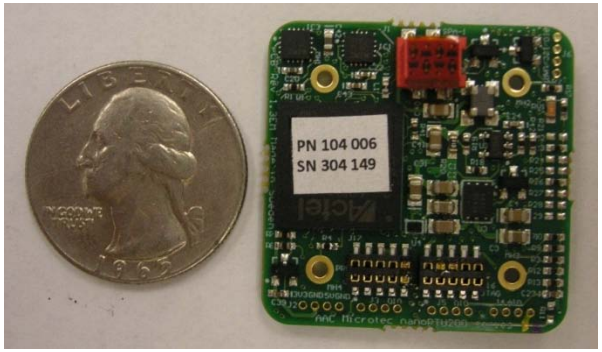
- LV-SPA-U
- SPA-1
- LV-SPA-S
- Gb-Ethernet

Radiation hardening work

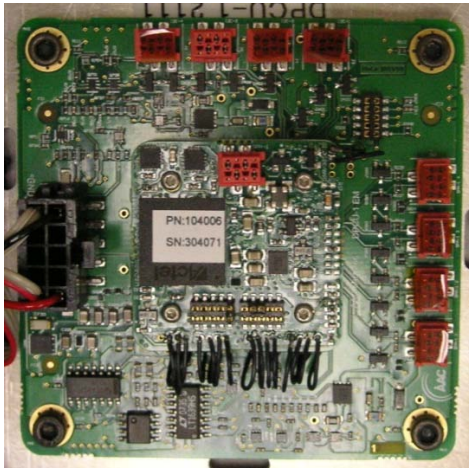
- All parts radiation screened, selected jointly with AFRL
- nanoRTU™ tested by AFRL to 70 krad component level (AD/DA died at 40 krad) > 100 krad missions
- Derating of passive components and connectors according to MIL/ECSS standards
- Advanced SEU protection using soft core processors with
  - ECC 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



OBC lite™



nanoRTU™



MPDU

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

ÅAC Microtec

Thank you for your attention!

Acknowledgements

San Jose State University

NCASST

JAXA

Agi

Space Systems Loral