Highly-Integrated Design Approach for High-Performance CubeSats

Austin Williams

Tyvak Nano-Satellite Systems

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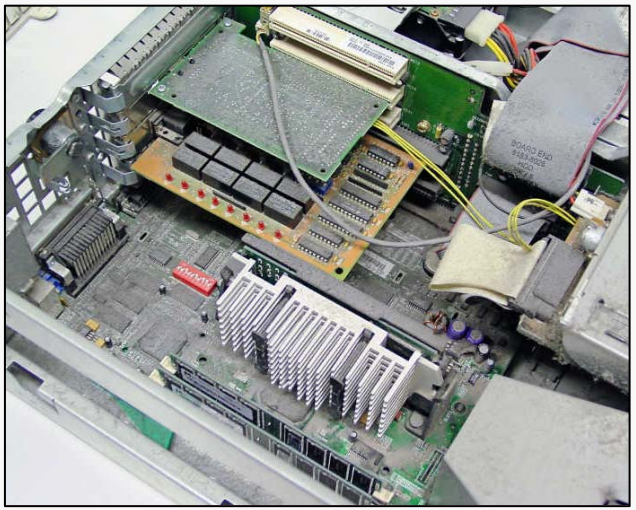
Commercial Electronics Evolution

Tyvak Nano-Satellite Systems LLC ™

- **In last 10 years, computers have transitioned from Desktops, to Laptops, to Smart Phones and Tablets.**
  - **Performance per Kg, Performance per Watt continues to increase.**
  - **Transition from single function per board, to multifunctional boards.**
  - **Bulky, standardized connectors replaced in favor of much smaller solutions.**
  - **Volume initially was not a constraint, now device size is major design driver.**
- **Will CubeSats follow this trend?**
  - **Pumpkin PC104 based architecture, with a single subsystem per board mentality was a great starter for University CubeSat developers 10 years ago.**
  - **Following the mobile devices trend *will* bring the same benefits to CubeSats.**

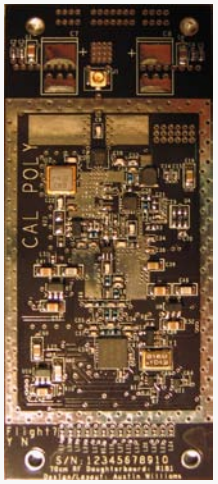


Radiation Concerns

- **KEY TRADE: Is RadHard worth it on CubeSats?**
  - **RadHard takes an order of magnitude more power, for an order of magnitude less capability…**
  - **For 98% of CubeSat activities, RadHard is not worth the price paid**
- **Mass, Volume, and Power are at a Premium**
- **High Power Components Compound the Problem.**
  - **More Power => More Solar Panels => Increases Complexity in EPS, ADCS (disturbances), Thermal, while eating into available mass and volume for payload.**
- **Low Power Components *Reduce* the problem.**
  - **Less Power =>Less Solar Panels =>Less complex EPS, Thermal, while providing more mass and volume to the payload.**

Tyvak's Approach: Ride the Coat-Tails of Mobile Device Boom

- **Power and Volume are King.**
  - **A CubeSat's inability to generate significant power can be offset by using less of it!**
  - **Central, Low Power, High Performance processor running Linux.**
    - **The PC104 architecture typically implements a dedicated MCU per board, requiring more power, and complicating software with more inter-processor communication.**
- **Multi-Function boards. Combine Electrical Power System, with Communication and Data Handling Boards. Blur subsystems.**



Tyvak's Approach Continued

- **Miniaturized Connectors. Fight for every mm.**
- **Radiation Mitigation**
  - **Use naturally Rad-Hard parts where it makes sense (Phase Change Memory for Linux Image storage)**
  - **Many Watch-Dog Layers (SW and HW)**
  - **Smart Fuses**
  - **Design the system to Reboot.**
- **Consider the Battery Pack part of the Payload**
  - **Custom battery pack design goes a long way towards optimizing volume. (see Orange cylindrical batteries on CP7 below)**

Cal Poly CP7 Payload for 1U CubeSat. (Bus not shown)

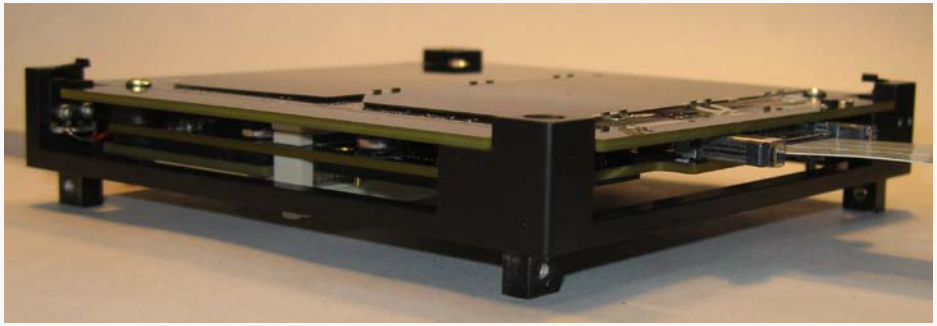
Results: Tyvak's Intrepid CubeSat System

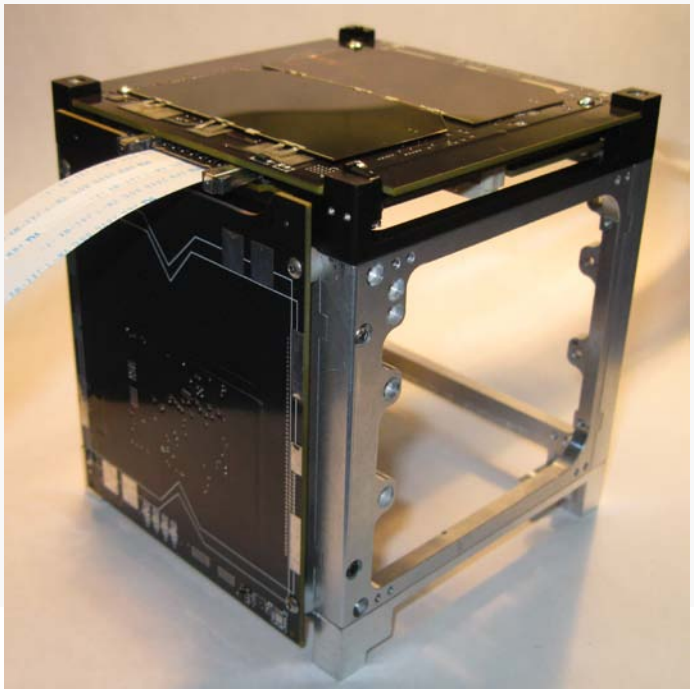
- **SystemBoard**
  - 400Mhz Linux Computer, 128MB SDRAM, 512MB NAND, 32MB PCM, MicroSD
  - Electrical Power System (4 Regulated Rails, 8W each)
  - RTC, 3-Axis Gyro, 3-Axis Accel, 3-Axis Magnetometer
  - Umbilical Development (Ethernet, Full signal diagnostics)
  - Basic Bus functionality only utilizes a few % of the systems full capability (lots of room to grow for ADCS algorithms, Image capture, Payload Software, etc)

- **UHF Half-Duplex Comm**
  - 2.4 to 250kbps
  - FSK, GMSK, BPSK, OQPSK
  - Up to 1.5W RF Out
  - 9.6kbps packet reception down to -118 dBm

- **Multi-Functional Side Panels**
  - 3-Axis Magnetometers, 2-Axis Sun Sensors
  - Solar Cells
  - Magnetic Torquers

SystemBoard and UHF (in receive mode) peak power draw: <400mW





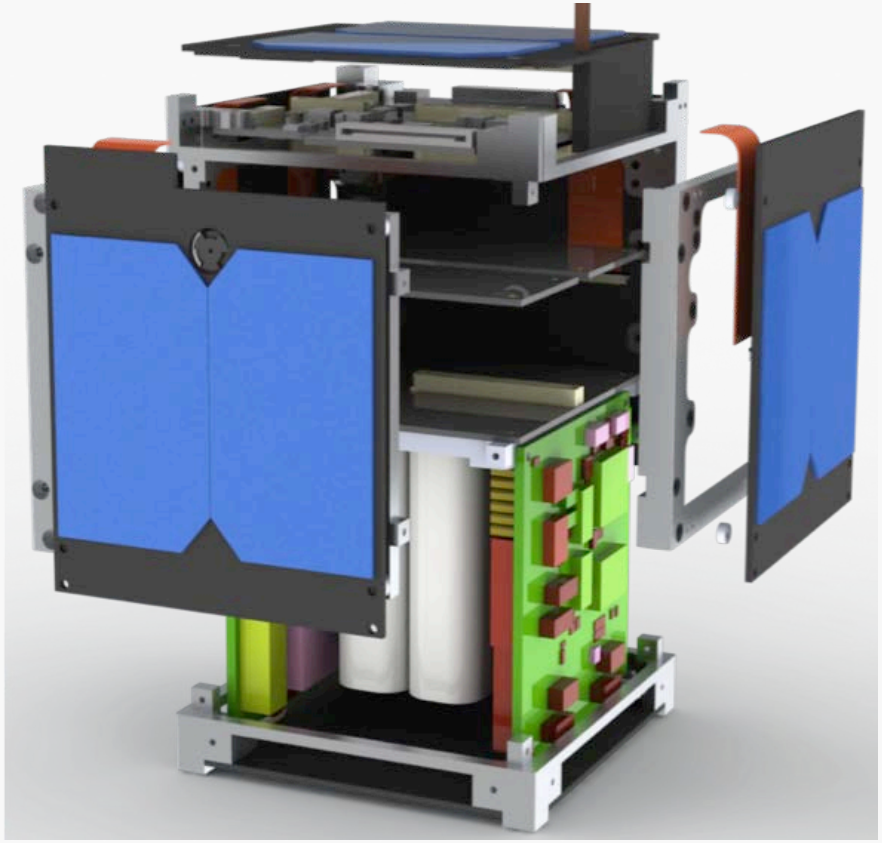
Implications for CubeSat Developers

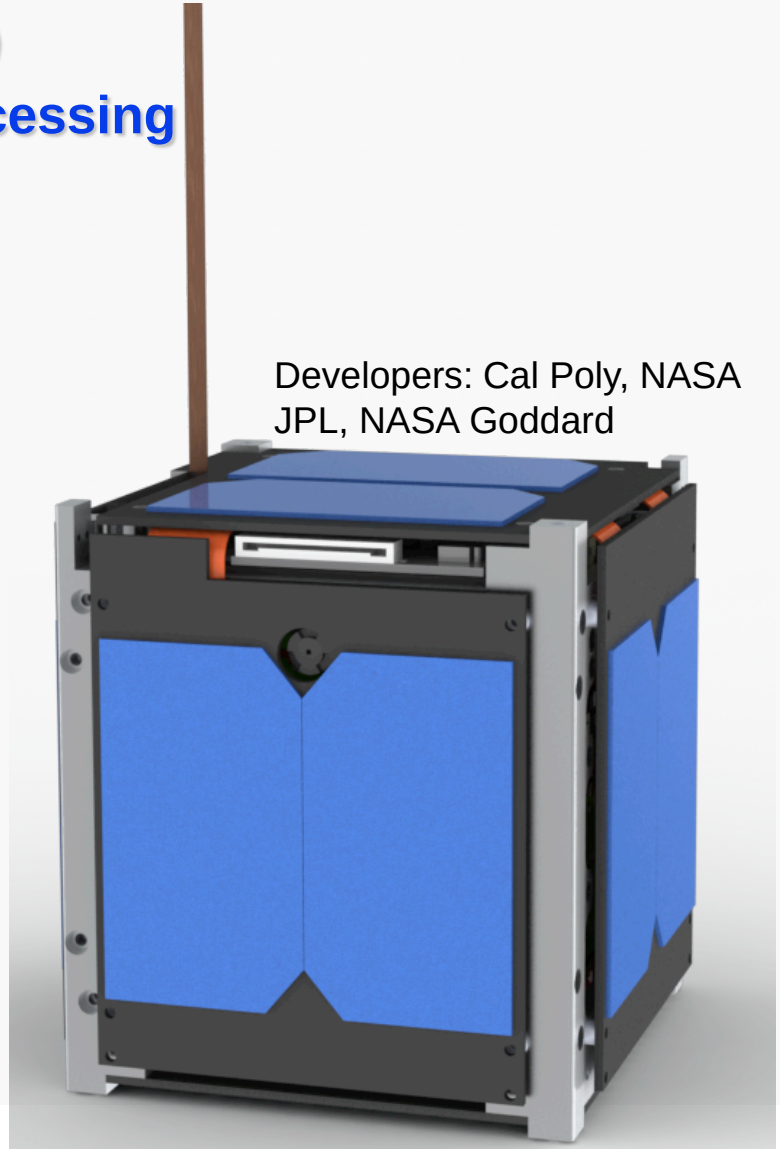
- **Low Power Complete Bus Solution (<400mW)**
- **Take advantage of ample spare processing and memory**
- **Volume Optimization for 1U translates to dramatically increased payload volume for 2U and 3U systems.**
- **Tight HW and SW integration provides considerable functionality out of the box.**
- **Free Development Tools (Linux)**
- **Remote Development (Linux + Ethernet!)**
- **Take advantage of open source drivers**

1U Configuration **2U Configuration** **3U Configuration**

Missions Enabled by Intrepid: CP8 - IPEX

- **Intelligent Payload Experiment (IPEX)**
- **~10W FPGA for intelligent image processing**
- **Autonomous Operations Algorithms**





Developers: Cal Poly, NASA JPL, NASA Goddard

Parting Words…

- **Orders for the Intrepid System are being filled, for pricing check out the website, or contact us directly**
- **Visit us for an Info Session on the Intrepid System from 5:30 to 6:30 today in Bld 192, Room 331**

For more information go to

www.tyvak.com