Multi-Purpose Avionics Core Element (M-PACE): Using Advanced Manufacturing to Rapidly Develop CubeSat Subsystems and Components

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M-PACE (Improved TechEdSat)

- TechEdSat Space Plug-and-play Avionics (SPA) hardware and software – Complex and Expensive
  - Complex wiring and interconnects
  - Payload Volume – not optimized
  - Difficult to troubleshoot

- M-PACE reduces cost and complexity for CubeSats for a number of reasons
  - Use of Open Source hardware and software
  - Replaces the need for wires and wiring harnesses with snap-fit connectors
  - Able to maximize payload volume by leaving the availability for any PC104-like board with spacecraft subsystem components to connect to a backplane panel for power and avionics
  - No need for fasteners or standoffs due to the Advanced Manufacturing technologies and techniques used
Goal and Objectives

GOAL: To lower the cost, complexity, and development time of CubeSats

OBJECTIVES:
1. Use Advanced Manufacturing to develop engineering hardware for an integrated “smart” avionics panel
2. Develop modular hardware to support the next generation of CubeSat missions
3. Demonstrate the rapid development of CubeSat subsystems and components
4. Investigate slide-fit card technology for spacecraft subsystems and components so that payload volume is maximized
5. Demonstrate the ability to rapidly move from project concept to fully-tested prototype
What is Advanced Manufacturing?

- Advanced Manufacturing
  - Use of state-of-the-art and emerging technologies and materials to create high fidelity products
  - Types of machines used in this process include 3D printers, laser cutters, desktop milling machines, etc.
  - NASA Wide (ARC, MSFC, JSC)
Advanced Manufacturing Processes

- Wire EDM
- Die Stamping
- Extruded Aluminum
- Waterjet
NASA Ames SpaceShop

- Funded through NASA Ames Center Chief Technologist and Engineering Directorate under the Advanced Digital Materials and Manufacturing for Space Initiative (ADMMS)
- Hands-on training and Advanced Manufacturing facility to educate and train NASA employees and interns
- Modeled after Massachusetts Institute of Technology’s Fab Lab
- First of its kind within the Agency, but is considered an extension of an education framework aimed at providing people worldwide with the skills necessary to become their own inventors
NASA Ames SpaceShop

Chao Lao working on structure using Solidworks

Tung Dao working on software for avionics board

Sarah Hovsepian and Greenfield Trinh using the 3D Printer to print out Digital Material pieces
Materials that can be used in printer

- Plastic ie ABS, conductive ABS, PLA
- Metal – SLS (selective laser sintering)
  - Ti, Al, Stainless steel
Structure – Joint Concept

5 units = 1 Joint

Top View

Joint Assembled

Single Joint Assembly
3 Degrees of Freedom
5 Units Total
2 Types of Units

1. Rotate C Unit 90 deg
2. Rotate C Unit 180 deg
3. Rotate C Unit 270 deg
4. Rotate C Unit 360 deg
5. Insert T Unit
Structure Dimensions
Update

• **Structures**
  – Ran basic FEA and tensile tests
  – Currently experimenting with SpaceShop machines (3D printers, Modela milling machine, laser cutter) to manufacture these materials

• **Power**
  – Li-Po Batteries w/ TASC solar panels

• **Avionics**
  – “Smart Panel”
    • Arduino Uno
    • Gyro
    • Magnetometer
    • Radio
    • Antenna

• **Communications**
  – TI CC1101 Radio

• **Software**
  – Arduino Open Source Programming software
Conclusion

• By demonstrating this Advanced Manufacturing capability, one can greatly reduce cost and time to design, build, prototype, and test CubeSats.

• Also, with open source hardware and software, we can design and build our own spacecraft subsystems using information already researched and developed.

• Combining both of those together, a CubeSat that takes several months to build can now take
  – several weeks…
  – or days…
  – or hours
Printed Micro-Fluidics Card