Dellingr: NASA GSFC’s first 6U CubeSat
Larry Kepko, Space Weather Laboratory
(Just the spokesperson for an incredible team)

+ many, many others
SmallSats are at the **interface** between “suborbital” and flight missions a **focal point for tension**

Depending on application, CubeSats fall into different categories

How does a place like GSFC incorporate this disruption and leverage capabilities at both campuses?
Enter Dellingr
A Collaborative Project
Heliophysics Science Division and the Applied Engineering and Technology Directorate
GSFC Greenbelt + WFF

GSFC could build a $20M LEO cubesat that works (pointless). But can we build one for <$3M, have it survive 2 years (95%), AND leverage commercial and academic innovation?

Key objectives:
1. Develop a cost-effective model
2. Develop “lean” & scalable end-to-end systems
3. Determine what works & what doesn’t, and keep moving forward

Approach:
- Small, tight-knit team
- “Build, test, fix” to find problems quickly vs. analysis & process
- **Smartly** apply GSFC knowledge & (tailored) procedures
- “Table-top reviews” when needed – no gates
Dellingr also does science!

Ion-Neutral Mass Spectrometer (INMS)

Measures the ion and neutral composition of Earth’s upper atmosphere

Miniature fluxgate magnetometers

Flown on “Auroral Jets” sounding rocket.
Dellingr overview

• COTS:
  - Flight computer, EPS, batteries, UHF radio, reaction wheels, GPS, IMU, FSS, camera, CSS

• In-house
  - Special Services Card, solar panels, UHF antenna, FSS, release mechanisms, magnetometer boom, GPS splitter & antenna, flight software, instruments

~3U of payload

baseplate facilitated integration
Flight Software, C&DH, electrical bus

- Gomspace Nanomind for flight computer
  - 40 MHz Amtel ARM, 2 MB SRAM, 8 MB flash
  - FreeRTOS

- Core Flight Software
  - Open source framework, available via SourceForge
  - Used on LRO, GPM, MMS, etc.
  - Abstracts software architecture from hardware
  - Publish/subscribe messaging framework, event reporting, FDC, scheduling

- Mission specific applications
  - ACS, spacecraft housekeeping, instrument interface, and radio control

- NanoMind included I2C, SPI and 3 UARTS
  - Supplemented on SSC with A2D, general purpose I/O pins, and additional UARTS
Solar Panels

Power

- ClydeSpace 3rd generation EPS
- Two ClydeSpace 40 Wh ISS approved batteries
  - Originally three 30 Wh; did not meet ISS requirements
- In-house solar panels
  - SolAero ZTJ Triple Junction CIC cells (GPM spares)
  - Mounted to PCB substrate with double-sided kapton tape (thanks Aerospace!)
  - Embedded torquers for momentum dumping
  - Formed closeout panels
- SSC added fuses, switches and current regulation for release mechanisms

Kapton tape

Closeout

Solar Panels
Attitude Determination and Control System

- Sensors - Combination of magnetometer, sun sensors (fine and coarse), and IMU
- Actuators - Reaction wheels and torquers for momentum control
- ACS software developed in-house, based off Solar Dynamics Observatory (SDO)
  - Software written as cFS apps
- Verified in 42 and with hang and spin test
  - 42 simulates all 6 DoF, all sensors and actuators, including the reaction wheels and the torquers
Testing

• Initial environmental
  - TVAC bakeout, 8 TVAC cycles, thermal balance, day in life, random vibe (9.47 GRMS) & sine-burst (14.5g)

• Magnetics
  - Calibrated magnetometers and characterized spacecraft interference; validated phasing

• End-to-end comm at WFF
  - L3 Cadet, half-duplex up to 3 Mbps downlink
  - SDL TITAN ground software

• ITOS (I&T and MOC)
  - Enables “Test as you fly”
  - Developed for original SMEX program
  - Commands initiated at MOC (Greenbelt), sent to WFF

• Final NR vibe, 2 cycle TVac, regression testing, final mag cal. → delivery!
Take-aways

- Dellingr delivered to NanoRacks May 31.
- August 13 Launch via Falcon-9 to ISS

**Lessons Learned**

- FSW reuse and core-flight are key to keeping costs down, and need a flatsat for software development work
- The PC104 card stack does not disassemble easily
- Harness Mockup – A 3D printed or similar physical model is needed for wire harness development
- Dellingr invested in detailed I&T procedures and documentation as part of the pathfinder ("build, test, fix") approach
- Component level performance tests should be completed before integration, as cubesat hardware is less mature

**The future for GSFC**

- Future focus is on rad-hard, high performance SmallSats for Decadal Survey science.
- Dellingr experience and capabilities leveraged for GSFC SmallSat science missions - changing the culture.

*Dellingr is already a success!*