CubeSat Buses and Architectures

Dellingr-X: GSFC's solution to enable planetary science missions

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Do today's CubeSat systems meet the unique needs of planetary science missions?

Mission Concepts

- Hitchhiker
  - Relies on primary spacecraft for transportation, then operates independently
- Daughtership
  - Relies on primary spacecraft for transportation, communication relay, and sometimes navigation
- Free flyer
  - Makes its own way from launch vehicle
- Probe/Lander/Penetrator
  - Interacts with planetary body in a way deemed too risky for primary spacecraft

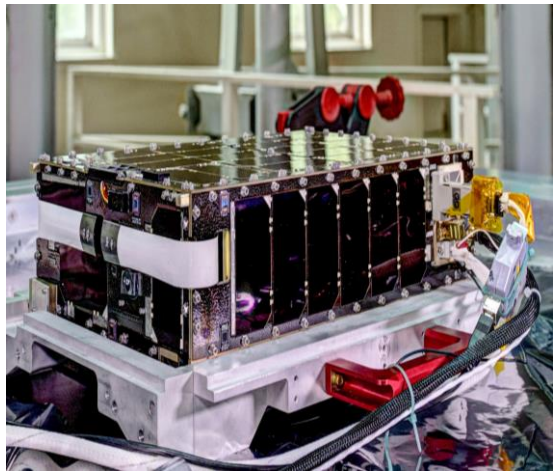
Planetary CubeSat Mission Challenges	
Radiation	Surviving and performing in high radiation environments
Lifetime	Surviving long duration cruises
Ride opportunities	Achieving higher reliability because the fly-learn-refly philosophy doesn't hold
Power	Generating solar power beyond 1 AU Increasing capability for telecom and propulsion
Thermal	Dissipating increased power from subsystems, inside 1AU, or near high albedo planetary bodies
Telecom	Closing direct to earth links over large distances Crosslinking to relay mothership
GN&C	Tracking and navigating outside GPS Desaturating wheels
Propulsion	Increasing delta-V for orbit insertions and exploration

Bus Options -> Dellingr-X

- COTS – e.g. Blue Canyon, Clyde Space, Pumpkin, Tyvak, GomSpace
  - Primarily designed for LEO, shorter mission lifetimes, and lower reliability/robustness
  - Evolving but big jump needed for typical planetary mission architectures
- Fully customized new build
  - Most optimal technical solution for a particular mission but usually expensive
- Dellingr – GSFC standard architecture to control cost/schedule
  - Dellingr-S – designed for LEO using primarily COTS (available)
  - Dellingr-X – high reliability bus for harsher environments (in development)

Credits: Blue Canyon Technologies
http://bluecanyontech.com/xb6-spacecraft/

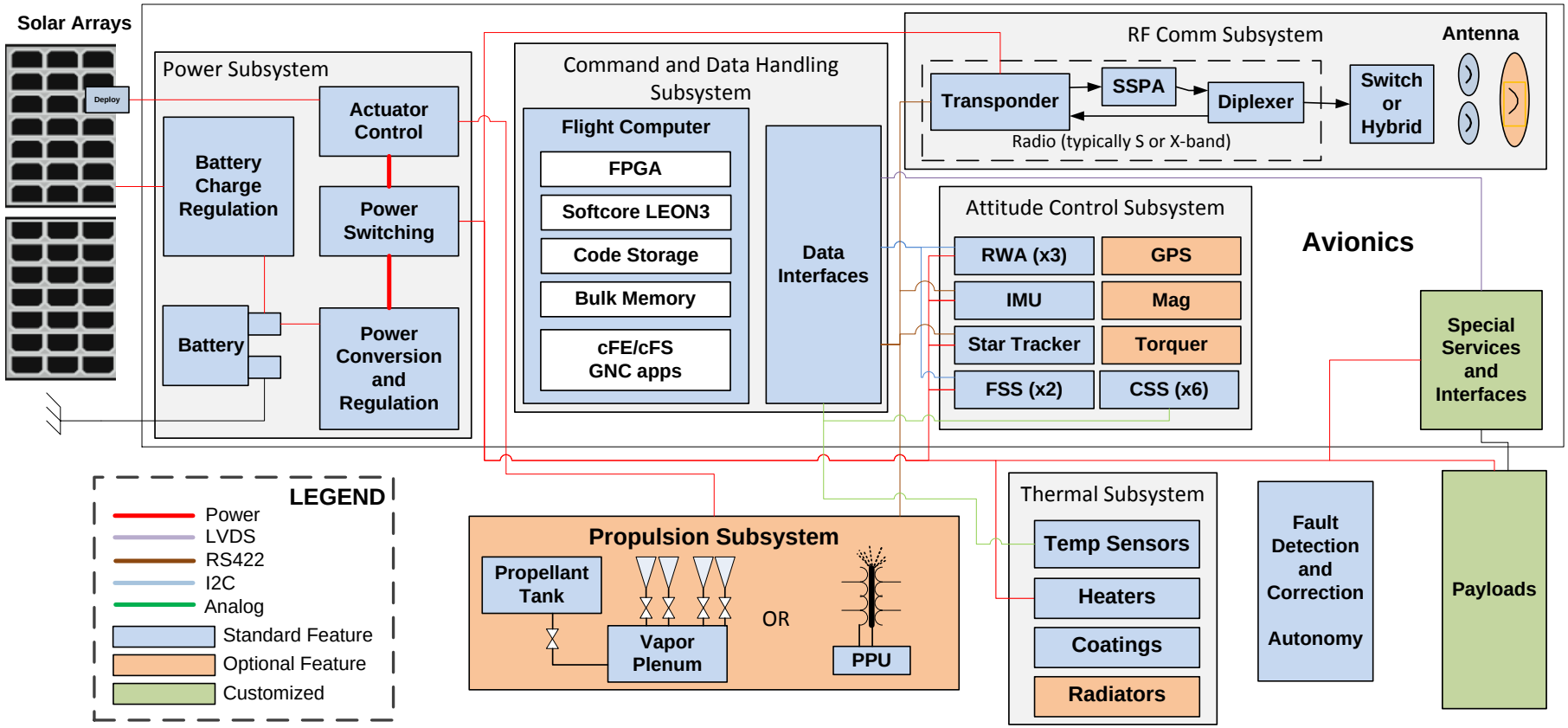
Dellingr



Dellingr-X Simplified System Architecture

Expected performance enables a significant portion of planetary missions while balancing cost

Radiation	Lifetime	Power	Thermal	Telecom	GN&C	Propulsion
> 80krad	3+ years	50-100W	Optional radiators	S or X band DSN compatible	Optical navigation Autonomous maneuver planning and execution	<100m/s cold gas, >1000m/s electric



Development Flow and Mission Infusion

Funded Missions
Dellingr, BurstCube, IceCube, STF-1, HaloSat, CeREs, petitSat

Internal Research and Development
C&DH, PSE, S-band Radio, star tracker, deployable solar panels, propulsion, sun sensor, ACS algorithm and test bed

Proposals
GTOSat, BOWTIE, ELMO, Aether, Spiral, HYDROX, OLE, PROVE, M4, Mariner 11

Science Community

Mission Concepts Requirements

Systems Architecture

Detailed Design

Dellingr-X
+ Flexible, reusable bus deign, processes, plans, infrastructure, and flatsat
+ Reference cost and schedule

Customized Implementation

Mission(s)

Lessons Learned

Dellingr Based
Planetary

Summary and Key Takeaway

- GSFC is addressing the unique challenges of planetary science missions with Dellingr-X
  - Extended capabilities meet the most common performance requirements
  - High reliability and robust design built from the ground up to perform in harsh environments
- Controlling cost
  - Flexible, reusable bus design
  - Tailored and standardized processes and testing
  - Investments in infrastructure and a flatsat
- Efficient customization for unique mission needs taking advantage of GSFC expertise
- We really want your feedback and engagement to make sure we hit the mark and meet your needs

Contacts and Acronyms

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- ACS – Attitude Control System
- AETD - Applied Engineering & Technology Directorate
- AU – Astronomical Unit
- BOWTIE – Bubbles Observed Within The IonospherE
- C&DH – Command and Data Handling
- CeREs – Compact Radiation Belt Explorer
- cFE/cFS – core Flight Executive/core Flight Software
- COTS – Commercial Off the Shelf
- CSS – Coarse Sun Sensor
- FPGA – Field Programmable Gate Array
- FSS – Fine Sun Sensor
- GN&C – Guidance, Navigation, & Control
- GPS – Global Positioning System
- GSFC – Goddard Space Flight Center
- GTO – Geostationary Transfer Orbit
- LEO – Low Earth Orbit
- PSE – Power Supply Electronics
- RWA – Reaction Wheel Assembly
- SSPA – Solid State Power Amplifier
- SSPO – Small Satellite Project Office
- STF-1 – Simulation To Flight 1