CYGNSS Lessons Learned

Small Satellite Reliability Initiative TIM-4

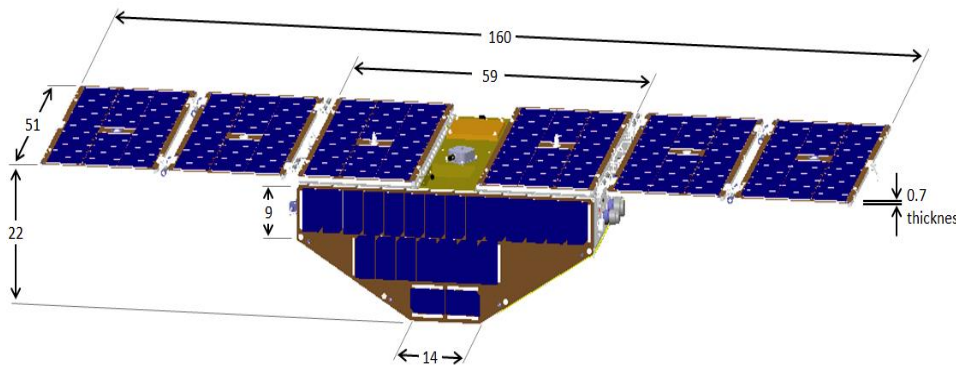
Southwest Research Institute®

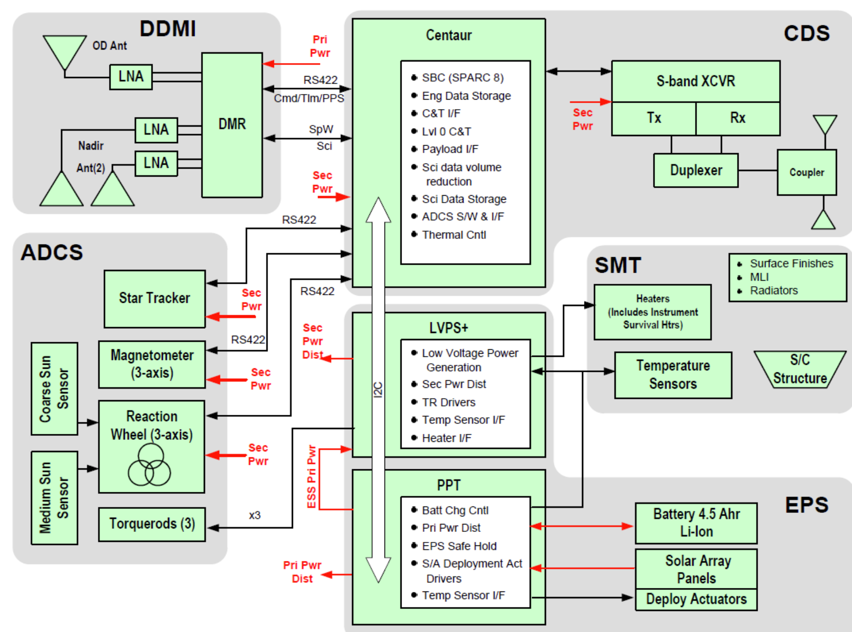
San Antonio, Texas

7-8 November 2018

CYGNSS Background

- **Constellation of 8 uSats**
- **Measures surface winds via reflected GPS**
- **Class D mission, Earth Venture Mission**
- **Launched December 2016**
  - Mission SRR/MDR in June 2013
  - Mission PDR Jan 2014
  - Mission CDR Jan 2015





Lessons Learned Themes

- Risks Associated with Cubesat Vendors/Suppliers
- Traditional Suppliers may have issues too
- Constellations
- Systems Engineering Challenges & Successes
- NASA “Standard Processes” Do Not Always Reduce Risk
- LV Interface may be the toughest
- Thorough Testing is Even More Important for Class D Missions
- Project Relationships
- PI Engagement

See document #17790-LL-01, CYGNSS Lessons Learned, for detailed write-up

Vendor Issues

- **CubeSat**
  - Dynamic business nature
  - Processes not well established
  - “Subsystem in a box” vs. component
  - Develop a vendor vetting plan
- **Traditional**
  - Business practices adjusted to “old space”
  - Using Class D missions to establish a US presence
  - Established business practices do not always translate to a quality product

Constellations & Systems Engineering

- **Constellations**
  - Configuration Management for multiple builds
  - Automation of test and operations
  - Parallel vs. serial operations in AI&T
  - Personnel management for commissioning
  - Configuration management for operations (i.e. different look-up tables, command sequences, etc)
- **Systems Engineering**
  - Class D mission budget had lean systems engineering team resulted in over-subscribed staff
  - Had to take a higher level of risk while maintaining same required margins as traditional missions
  - High fidelity Engineering Model helped with smooth integration

NASA Standard Processes

- **Margin and Reserve Requirements**
  - Margin requirement should be based on system maturity, not a fixed percentage at each KDP
  - Resulted in significant ballast in flight that could have been used in design for redundant components, etc
  - Funding reserve requirements drove some decisions in a direction that did not reduce risk as much as possible
- **Earned Value Management**
  - Cost impact: ANSI-compliant EVM vs. “EVM-lite”
- **Standing Review Board (SRB) Reviews**
  - NASA requires five specific SRBs
    - Assumes combined SRR/MDR
  - With this burden, management team backfill will be required
  - Tiered milestone reviews (e.g. SRB review / CMC / KDP review, etc.) is a strain on project’s management team

Launch Vehicle & Testing

- **Launch Vehicle**
  - Contractual reporting and communications chain can be awkward
  - LV schedule & project schedule conflict
    - Design optimization if selected before PDR
    - LV needs a test-verified Finite Element Model, which is compressed due to fast-paced schedule
  - No such thing (yet) for a Class D LV: risk posture ideologies
- **Testing**
  - Delivered components need a much more involved level of acceptance testing compared to traditional space items
  - Short term vs. long term testing (orbits in the life)
  - Splitting tests into tiers of criticality
  - Consistent terminology and formatting across teams
  - Value of a test not fully realized until all data is analyzed

Project Relationships & PI Engagement

- **Project Relationships**
  - Good relationships, both internal to the team, and external to clients and supplier go a long way
  - Earth Venture Missions not a great training ground for key personnel, important to have experienced folks
- **PI Engagement**
  - PI must be fully engaged with the team for quick decision-making
    - Earth Venture Missions have neither the time or money to let issues go unresolved for long
    - CYGNSS had at least three instances where the engaged PI helped resolve problems
  - Coordinated science team with delegation of tasks

Questions

- **Thank you**
- **Happy to take questions back to the team at SwRI**