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SmallSat/CubeSat TIM Observations and Takeaways

- **EEE Parts**
  - There was universal agreement that the use of COTS EEE parts was acceptable for all classifications of CubeSats with mitigating factors. The mitigating factors included the following:
    - Robust electrical, thermal and mechanical design to reduce the stress experienced by the EEE parts. Many spoke about significantly limiting the thermal excursions experienced by EEE parts and the different ways to achieve this for example sealing in 1 atm and selecting parts with at least the industrial grade temperature range. One participant mentioned that his company would place its electronics in the propulsion tanks to keep the temperatures down. There was also talk of derating as much as possible and paying attention to mechanical stress.
    - Radiation effects must be carefully considered and taken into account, sometimes testing should be performed. Most participants preferred to have radiation tolerant designs that could tolerate some level of upsets and avoid destructive effects. We discussed the need for additional scrutiny on power parts with regards to radiation effects because they have a higher likelihood of experiencing an event that causes system failure.
    - Qualified assembly technicians were recommended to prevent workmanship issues during board assembly. Many have experienced failures and issues as a result of poor board workmanship.
    - Independent QA inspection was recommended to check the work of the assembly technicians.
    - Most of the CubeSat mission profiles are 3 years or less. A suggestion was made to use Automotive grade COTS for missions over 3 years due to the qualification basis they have established in the AEC Q specifications. Some suggested viewing pure COTS EEE parts as limited lifetime items.
    - Deployment switches (uswitches) have caused problems for many CubeSat missions. NASA Ames recommended using an F18 hornet switch.
    - NASA Ames also recommends the PIC processor which is rad tolerant by design and ~$20.
    - The underlying belief is that sound design and system level testing is effective at flushing out parts quality issues. This brought out a recommendation to create a GEVS equivalent for CubeSats.
- **Printed Circuit Boards (PCB's)**
  - Many recommended using Class 3 PCB's
- **CubeSat Launch Services**
  - Many agreed that launch services needs to be engaged in these conversations.

    - There was a lot of concern with the current PPOD dispenser because it exposes the satellite to mechanical loads which cannot be modeled or reasonably modeled. There is a PPOD 2.0 dispenser which is designed to eliminate this issue by adding clamping rails. CubeSats using this dispenser will need to add rails to be compatible.
- **Collaboration and Knowledge Sharing**
    - AFRL has a SPOON database that includes CubeSat/SmallSat subsystem information. Access to the database is not yet available to all interested users.
    - There was a great deal of discussion regarding the need for a radiation test results database. NASA GSFC currently has a database that can be used by the community however most parts included are preferred for traditional missions and not CubeSats. Creating a database for the CubeSat community will require significant coordination and government investment.
- **Alpha-Delta Risk Classification**
    - Many did not agree with this approach for different reasons
        - Felt it had too many or not enough bins
        - Felt that different parts of a mission may follow different classification requirements
    - Most agreed with a menu style approach where all of the requirements across the different disciplines are tailored
    - Different disciplines may require different numbers of reliability (or confidence) bins. For example, EEE parts may have 5 different recommended activities per mission risk posture and systems level testing may have 3.
    - Significant thought must be put into how this translates into the proposal world
    - Confidence intervals are preferred over risk
- **Design approach/risk posture**
    - Iterative design was a word frequently used. Design, build, launch using best practices and iterate the design and approach based on lessons learned. This is done for traditional missions to a degree but is a cornerstone of SmallSat/CubeSat missions. It requires a good understanding of risk tolerance.

Recommendations

- I'm in agreement with Linda and Jesse. The subcommittee should continue to meet and work on confidence based approaches for the different disciplines needed to address SmallSat/CubeSat reliability.
    - SmallSat/CubeSat launch services should be engaged as part of this effort.
- Collaboration opportunities should be thoroughly explored for all areas where it is advantageous to the community (i.e. radiation and EEE parts database, failure and anomaly database, etc).
- We should engage contract award/proposal representatives on the feasibility of a menu based approach that allows significant requirements tailoring.