National Aeronautics and Space Administration

EEE Parts Bulletin

Electrical, Electronic, and Electromechanical

A periodic newsletter of the JPL/OSMS Assurance Technology Program Office (ATPO), NASA EEE Parts Assurance Group (NEPAG), and Section 514, of the Jet Propulsion Laboratory.

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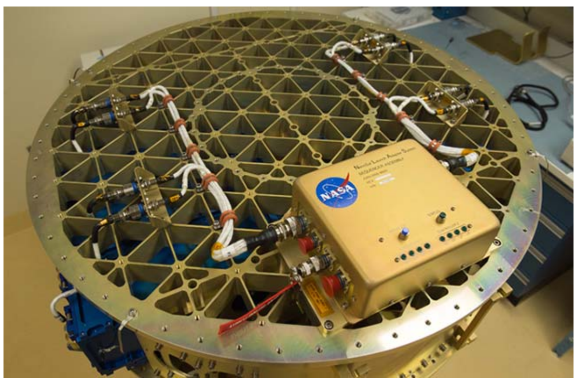
Figure 1: LADEE integrated spacecraft (left) and PhoneSAT 1U CubeSAT (right)



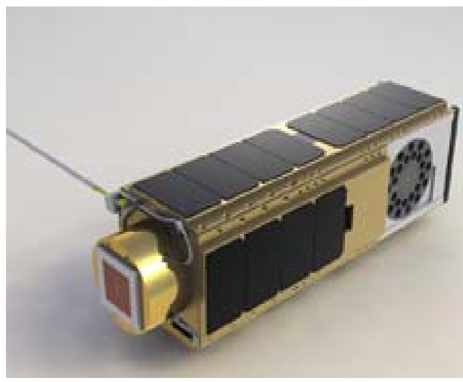


Figure 2: NLAS CubeSAT dispenser (left) and O/OREOS 3U (3000 cc) nano-satellite (right)

Introduction from Michael Sampson:

While not utilizing the traditional high-reliability approach to electronics, missions that are cost-conscious may be willing to accept additional levels of risk. As such, non-traditional approaches to EEE parts are being developed across the Agency. Ames Research Center provides one such concept here.

EEE Parts Selection for Class D Missions: NASA Ames Research Center Philosophy

NASA Ames Research Center (ARC) focuses its expertise on low-cost, risk-tolerant small and nano-spacecraft (Figures 1 and 2). These spacecraft range in size from 10 centimeters cubed (1000 cc or 1U) CubeSats to satellites taller than a basketball hoop. The typical ARC mission carries a Class C or D risk posture, per NASA Procedural Requirement (NPR) 8705.4 (Risk Classification for NASA Payloads, Safety and Mission Assurance). In general, missions of this class tend to have moderate to low complexity, cost, and lifetime—but high value, flexibility, and innovation. Therefore, they are often able to accept a moderate to high degree of risk with respect to parts selection. Per the NASA parts policy (NPD 8730.2), each center is authorized to develop local, customized requirements appropriate for that center. NASA ARC has developed an electrical, electronic, and electromechanical (EEE) parts-focused Ames Procedural Requirement (APR 8730.2) that incorporates flexibility for the wide variety of missions it develops under the risk-tolerant umbrella. Traditional, risk-averse missions mandate a clear-cut pool of radiation tolerant and high-reliability parts available to the electronics designer. Commercial and industrial grade components are generally discouraged, and when used, such parts require substantial amounts of testing to become qualified for use. The typical ARC program necessitates a bit more nuance and tailoring to the application. Factors such as cost, schedule, and consequences of failure mean every mission must be considered individually. Parts policy for a $280M mission such as Lunar Atmosphere and Dust Environment Explorer (LADEE) would only hinder a streamlined, technology demonstration such as PhoneSAT (Figure 1).

Small size does not necessarily imply risk tolerance—24 PhoneSATs could fit inside the Nanosatellite Launch Adapter System (NLAS). An NLAS dispenser lifetime is measured in hours, so why not operate its sequencer from well-written code operating on an industrial microcontroller? ARC also specializes in astrobiology experiments such as the Organism/Organic Exposure to Orbital Stresses (O/OREOS) nano-satellite (Figure 2). O/OREOS packs 1U of electronics with 2U of biological payload, all sealed inside a 12 pound pressurized vessel. The electronics experience benign environmental conditions and therefore COTS hardware was an appropriate choice for that application. Technical factors such as size, power, and functionality preclude using traditional radiation-tolerant (rad tolerant) components in space-constrained, small satellites. Some ARC programs make heavy use of commercial off-the-shelf (COTS) and industrial-grade components. These programs either accept risk, or they design in reliability measures at the system level. Others use more traditional, rad-tolerant and heavily screened components. The common threads across Ames missions are tried-and-true risk management and a heavy emphasis on environmental testing.

Traditional aerospace thinking holds that commercial parts are inherently unreliable, uncontrolled, radiation sensitive, and generally unsuitable for use in the space environment. The ARC philosophy is based on the understanding that high-volume semiconductor manufacturers must control reliability in order to survive. There exists a "sweet spot" of reliability for those parts which are neither obsolete nor fresh to the product line. Competition forces low profit margins; and therefore, these components receive an ample amount of quality assurance. For short-to-moderate duration applications, their reliability is often sufficient for the space environment. The current crop of commercial parts, manufactured on deep sub-micron processing, carry surprisingly high total ionizing dose ratings. The silicon on insulator (SOI) ceramic metal oxide semiconductor (CMOS) manufacturing process finds frequent commercial use and is inherently single-event latchup (SEL) immune. COTS components also carry strong thermal benefits for the space environment. Industry trends towards low-power integrated circuit (IC) design have made it possible to build a satellite operating on less than 10 W. Modern surface-mount (SMT) packages such as the Dual-Flat No-leads (DFN) and Mini Small Outline Package (MSOP) offer belly pads that allow conduction cooling of an IC's junction directly to the printed circuit board (PCB). From a vibration perspective, small parts make it possible to build small rigid circuit boards, thereby raising resonant frequencies and compatibility with the typical launch environment.

The central authority in the NASA ARC EEE parts management process is a Parts Control Board (PCB). Strongly tied to the Chief Engineer's office, the PCB reviews and approves individual projects' Parts Control Plans (PCPs) and waiver requests for non-standard parts. The novel elements in NASA ARC's Parts Control Requirement (APR 8730.2) are the provisions for tailoring and the addition of a COTS EEE parts level, which is available to Class D programs. These two aspects set a quality control policy without undue burden on the numerous small spacecraft projects at ARC. The addition of a COTS category to the center's EEE parts requirements releases small programs from the high materials cost of high-reliability, multi-year design-life parts. System designers may instead selectively purchase space-grade parts, or design-in reliability controls at the system or mission level. For example, watchdog timers and system-level fault detection can ensure that single event effects (SEE) only have temporary consequences. Pushing reliability controls to higher levels of abstraction often facilitates use of key components unavailable from high-reliability manufacturers.

The NASA Ames' approach has been in place for nearly a decade and has proven successful across dozens of small-satellite missions. The notion of risk assessment and tolerance in spacecraft development also extends to EEE parts. Modern integrated circuits are surprisingly well-suited to short-duration, low-cost missions, and they offer numerous advantages. Simply using COTS parts does not imply ignorance or lack of coordination, and ARC's central requirements ensure that projects continue to make the right decisions. NASA Ames will continue to re-think established methods of satellite design and set the trend for small-satellite applications in the aerospace industry.

(Article supplied by J. Forgione and K. Ling, Ames Research Center.)

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Interdigitated Capacitors and the Draft Specification for Thin-Dielectric Multilayer Ceramic Chip Capacitors

The NASA and aerospace community has been working on a DLA Land and Maritime military performance specification to cover thin dielectric multilayer ceramic chip capacitors (informally entitled MIL-PRF-THIN). Both precious metal electrodes (PMEs) and base metal electrodes (BMEs) will be included in the specification. The general requirements specification is derived from MIL-PRF-123. The working group expects the document to be distributed to the wider community through G11 prior to the end of December 2014 for review and comment.

The specification criteria will cover standard multilayer ceramic capacitor designs and will not address interdigitated capacitors (IDCs) such as those used on Xilinx's V4 and V5 field-programmable gate array (FPGA) packages. The IDCs are more aggressively designed and will not survive the standard +125°C life test at twice the rated voltage. Similarly, burning them in at twice rated voltage and +125°C would use up too much of their useful life. For IDCs, burn-in and life test at +125°C are typically performed at a maximum of 1.5x rated voltage, and sometimes as low as rated voltage for some designs.

Manufacturers currently do not have the capability to perform burn-in for IDCs without soldering them to test cards. Manufacturers are investigating a new 10-terminal capacitor design to be able to perform 100% burn in using standard fixtures. Any changes to the existing design will need to be carefully evaluated and will take at least a year. Feedback is requested from the community as to whether burn-in is needed for their particular applications.

Besides life test and burn-in, additional differences for the aggressively designed IDCs exist. MIL-PRF-THIN also specifies temperature humidity bias at rated voltage instead of low voltage. Manufacturers currently do not have any data history for temperature humidity biasing at rated temperature for IDCs. There will most likely need to be changes to the destructive physical analysis (DPA) and visual inspection criteria. Some options being discussed are creation of an IDC slash sheet with test modifications for MIL-PRF-THIN, a new performance specification, or a DLA Land and Maritime drawing.

For more information, contact

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NASA Counterfeit Parts Awareness and Inspection Training

Enrollment is currently ongoing for the 2015 NASA Counterfeit Parts Awareness and Inspection Training. For more details, to schedule training at your facility, or to send attendees to training at JPL contact:

Carlo Abesamis 626-298-2667

RHA (Radiation Hardness Assurance) Program

There are 19 vendors who are qualified to provide RHA Standard Microcircuit Drawing (SMD) products:

1. Aeroflex Colorado Springs
2. Aeroflex Plainview Inc.
3. Analog Devices
4. Atmel Nantes
5. BAE Systems
6. Crane Electronics
7. Honeywell
8. Interpoint
9. Intersil
10. International Rectifier
11. Linear Technology
12. MS Kennedy
13. ST Microelectronics
14. TI
15. TI SVA (doing business as National Semiconductor)
16. Xilinx
17. Rochester Electronics
18. VPT
19. Microsemi

There are 907 active SMD (and this number is increasing) with RHA requirements, 8361 RHA devices available, and 968 RHA die.

This RHA information was derived from a Defense Logistics Agency (DLA) Land and Maritime presentation at the space parts meeting in Columbus, Ohio (Sept. 17, 2014). For more details, consult the DLA website at

http://www.landandmaritime.dla.mil/Programs/Smcr/

NASA Parts Specialists Recent Support for DLA Land and Maritime Audits:

Audits performed at

- Aeroflex Colorado Springs, CO
- AVX Corp., Myrtle Beach, FL
- AVX Corp., Conway, SC
- Bourns Ltd., Bedford, UK
- Flip Chip International (Aeroflex), Phoenix, AZ
- International Rectifier, Leominster, MA
- Microsemi Ireland, Ennis, IE

Upcoming Meetings

JC-13 / G-12 / G-11 Committee Meetings; Columbus Renaissance, San Antonio, TX, Jan. 12–15, 2015

Microelectronics Reliability and Qualification Working Meeting (MRQW), Aerospace Corporation, El Segundo, CA, Jan. 27–28, 2015

Space Parts Working Group (SPWG), Los Angeles, CA, week of April 20, 2015

Single Event Effects (SEE) Symposium/Military and Aerospace Programmable Logic Devices (MAPLD) Workshop, La Jolla, CA, May 18–21, 2015

NEPP Electronics Technology Workshop and CubeSat EEE Parts Workshop, Greenbelt, MD (US only on-site, all access via the web), June 23–25, 2015

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http://atpo.jpl.nasa.gov/nepag/index.html

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