



SMD Class D Standard MAR

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Outline

- Class D principles
- Significant departures from common practices
- Parts and radiation
- What risks are acceptable for Class D?
- Summary

Class D Principles: Dos & Don'ts

- **Do:**

- Streamline processes (less formal documentation, e.g., spreadsheet vs. formal software system for waivers, etc.)
- Focus on tall poles and critical items from a focused reliability analysis
- Tolerate more risk than A, B, or C (particularly schedule risk)
- Capture and communicate risks diligently
- Rely more on knowledge than *indirect* requirements
- Put more decisions into the hands of the engineers on the floor.
- Have significant margin on mass, volume, power (not always possible, but strongly desirable)*
- Have significant flexibility on performance (level 1/level 2) requirements (not always possible, but strongly* *desirable)

- **Don't:**

- **Ignore risks!**
- Reduce reliability efforts (but do be more focused and less formal)
- Assume nonconforming means unacceptable or risky
- Blindly eliminate processes

While the impression may be that a Class D is higher risk from the outside, if implemented correctly (and consistent with the intention), in reality the extra engineering thought about risk may actually reduce the practical risk of implementation.

Significant departures from common practices (1/3)

- Inherited items process
 - Allows a holistic, risk-based process based on
 - Prior history
 - Changes from previous (in H/W, S/W, operation, environment)
 - Past anomalies
 - Allows prior processes to be used without waivers
 - Decisions to use or impose additional tests, etc., based on risk
- GMIPs (consistent with NPR 8735.2B)
 - No predefined set of GMIPs
 - Based on upfront negotiation considering
 - assessment of developer's own inspection points
 - developer identified risks
 - project identified risks; and furthermore in response to events, such as failures, anomalies, and process shortfalls that prompt a need for further inspection.
 - Will be coordinated with the project to maximize efficiency and minimize schedule impact

Inherited items process principles

(apply to products used within their bounds and qualification ranges)

- Changing processes for a proven product is unlikely to improve, but more likely to degrade the product
- Changing processes for a proven product is most often not possible to do and doing so or attempting to do so will not only increase risk, but will substantially increase cost and development time
- GMIPs inserted into a standard build only cause a distraction from the standard build process and should only be attempted if there is a history of quality escapes that have entailed mission risk that GMIPs have caught for the product. Review of records for common standard components has not revealed any such escapes.
- Changing parts or part screening practices for a proven design or system will add both risk and cost to the system and likely will not be feasible
- Reliability analyses are needed only if a design is unproven
- The MAR requirements can be categorized as safety, quality, or reliability, but the purpose of quality requirements is to achieve reliability
 - Established standard products are already proven reliable and thus should not be assessed from a piece-part, one-of-a-kind design perspective

Significant departures from common practices (2/3)

- Workmanship
 - Workmanship standards (industry and NASA) provided as guidance, developer standard practices allowed
- EEE parts
 - Follows NASA-STD-8739.10 for Class D: Level 4 = COTS parts with no additional screening
 - Guidance provided to consider:
 - Prior usage of the part and qualification for the specific application
 - Manufacturing variability within lots and from lot to lot for parts
 - Traceability and pedigree of parts
 - Reliability basis for parts.
 - Parts stress/application conditions

Significant departures from common practices (3/3)

- Radiation
 - Emphasis on radiation-tolerant design
 - Part-by-part analysis and testing (for susceptible* parts) otherwise
- Printed Wiring Boards
 - Use own preferred standard
 - Project retains coupons or spare boards until mission disposal

*susceptible parts are generally microcircuits and active semiconductors

Intelligent use of COTS parts

- Always use parts within the limits of their datasheets
 - Respect the datasheet!
- AEC-qualified parts (not just “for automotive use”) from leading manufacturers, produced under IATF 16949 will maximize reliability
- Use familiar parts when possible
- Avoid an approach that prompts you to use more parts as often happens with capacitors
- Conservative derating is good practice, but excessive and forced derating may result in need for many extra parts, a mass or space problem, or a weaker design with less margins.
- Use parts that the manufacturer declares to be for reliable use
- Use parts that have been established for over a year and in high volume production
- Buy parts from authorized distributors
 - There is no purpose in MIL-SPEC distributor restrictions when buying COTS parts
- There are many great options for “enhanced space” COTS parts for microcircuits and discretes
- Avoid requiring the tightest performance and tolerances from passive parts
- Strive for flexible resistance values (ranges) in current sensing applications
- Be sure that parts only offered with pure tin have matte tin finish, when available.
 - Give preference to manufacturers that use JEDEC tin whisker acceptance testing or similar approach
- Often increased performance and modern design and manufacturing drive increased reliability
- In some cases, you can only use what’s available against the guidance – accordingly assess and acknowledge the risk and explore reasonable mitigations

Common approaches for addressing radiation

- Avoidance: dormancy of sensitive electronic elements in high stress regions such as SAA or Van Allen Belts
- RHBD: Proven rad-hard by design approach, applied to circuits and/or parts
- Traditional parts-centric: Use of RHA* parts with radiation-tolerant design to accommodate high stress region operation
- Modern parts-centric: Use of familiar sensitive** parts along with proven circuit designs in comparable environment, normally combined with select strategic parts testing outside of specific projects to characterize variability or parts changes in general
- Radiation-tolerant design: Use radiation-tolerant circuit design techniques including features such as MOSFET protection and overcurrent detection with reset capability, resettable processors, EDAC, derating beyond EEE-INST-002 recommendations, etc.
- Risk-based approach combining past on-orbit experiences in similar stressing environments.
- System fault-tolerance (including redundancy): This may include new, unproven approaches, with backup proven systems.

* RHA = radiation-hardness assured, with lot-specific testing and accompanying paperwork

**Sensitive parts include memory, processors, CMOS devices, MOSFETs, etc.

Will use of COTS cause a radiation nightmare?

- It certainly can if you're in a radiation environment and you pretend it's not there, but that has **nothing** to do with COTS.
- Typically, about 90% of the part count even for large missions are not radiation-hardness-assured (because they don't need to be).
 - The majority of places where COTS are really needed are for non-susceptible parts
- The problem is no different from that of using a 5962-XXX microcircuit or a JANS2NXXXX BJT (neither of which is radiation hardness assured)
- For reference, an IRHM58160 is a COTS part (and it is radiation hardness assured).
- No matter whether you use COTS, MIL-SPEC or “special drawing” parts, radiation should be addressed in the same way
- As we transition to newer technologies and higher performance, we will have to think about radiation mitigation in different ways because parts with RHA will almost always be multiple generations behind
 - However, some of the new technology parts will be less susceptible to radiation by the nature of their designs (thinner gate oxides, etc)

Radiation and on-orbit non-RHA performance data sources

- Test data:
 - Traditional: radhome.gsfc.nasa.gov, transitioned to <https://nepp.nasa.gov/pages/pubs.cfm>
 - New: esarad.esa.int
 - New: pmpedia.space
- On-orbit experiences (“fact of” - some info available)
 - Spacecube data (LEO on-orbit – extensive non-RHA and COTS – 10+ yr)
 - Aerocube data (LEO on-orbit – 100% non-RHA COTS – 10+ yr) (Aerospace Corporation)
 - Swift data (585km x 604km, 20.6 deg - extensive COTS ~ 19 yrs)
 - Ascent (GEO cubesat – launched 12/2021) (AFRL)
 - Biosentinel (deep space cubesat – launched with Artemis)
 - Newspace – extensive, limited data availability

What kinds of risks are acceptable?

- Those tied to compressed schedules and tight development constraints as long as there is a solid plan and acknowledgement of the challenging elements
- The use of new, modern, innovative approaches at development
- The use of yet-to-be-established standard or COTS components that are the only solution
 - Use of standard and COTS components outside of their qualified environment, or that are as of yet unproven when they constitute the only viable solution
 - Risk should be acknowledged with a plan for addressing or accepting
 - Note: Use of standard and COTS components that have been proven in the same environment for same time frame is lower risk than any piece-part assured approach
- The use of new select new technologies when necessary to advance science, with a viable plan for maturation and incorporation

Summary

- A Standard Mission Assurance Requirements document has been produced to represent the general set of requirements to impose on SMD Class D missions
- This is the first such document that truly addresses significant costs and programmatic risks that were not really addressed in the past.
- The document is baselined as a formal SMD document

Minor departures from common practices

- ARB/MRB/FRB
 - Government notified and invited to participate in type I (form, fit, function)
 - Type II – Government given access to, but timely notification not required
- Reliability
 - Project completes reliability analysis (e.g., FTA, FMEA) for faults that may lead to injury to personnel or the public, or produce orbital debris, or that may affect host platforms
 - Parts stress and derating analysis per EEE-INST-002 or comparable
- Software assurance
 - NASA-STD-8739.8 required
- Software safety
 - Safety critical elements determined from the hazard analysis and range requirements
- GIDEP: project shall take action to mitigate the effects of alerts on the project

Agency Team

- GSFC: Jesse Leitner (lead), Ron Perison
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Background

- Numerous activities have taken place over the past several years to address the fact that Class D practices across the agency have differed little from those for Class A, B, or C missions
- Most of these activities have not resulted in substantial efforts to tangibly change how we perform Class D developments
- The result is that we have been limited in our ability to push the boundaries for moderate-risk/high-payoff missions
- This development effort has taken a very detailed view of the practices that are in place to ensure safety and mission success, and tunes them into risk-driven activities that accept developers' approaches in contrast to the current "do it the way we always have" approaches that have been difficult to depart from.
- This approach emphasizes the processes that provide the most risk reduction payoff and avoids the "feel-good" types of requirements that are abundant for Class A and Class B missions, where there is significant tolerance for overrun.
- This approach further emphasizes developer standard practices as opposed to prescriptive "do it our way" practices.
- At this point, there will be no choice, no matter what the risk posture, but to implement a "true Class D" for the new wave of highly resource-constrained missions that are abundantly emerging

Other elements

- Lifting
 - Vendor practices if command media exist
 - NASA-STD-8719.9 for all others
- ESD: ANSI/ESD S20.20-2007
- Lead-free and whisker controls required
- Assurance Plan for new digital electronic designs (FPGAs, ASICs, etc)
- Planetary Protection for outside of earth orbit
- Cybersecurity and Command Link Protection
 - FIPS 140-2 compliance (being superseded by NIST 800-171)
 - NASA-STD-1006A