Root Causes of Avionics Can-Not-Duplicate Maintenance Burden & Solutions

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OVERVIEW

- Food for thought
- Eagle Century Study
- Avionics Intermittent Failure Root Causes
- Reliability Solutions – Then & Now
- Recommended Solutions
- Summary

Food for Thought

- Virtually all modern component technologies have no inherent wear out mechanisms – for at least 50 years
- Parts are the fundamental units of design, manufacture, failure, rework, repair, & obsolescence
- Systems don't fail, software doesn't really fail, parts fail and, over time, go obsolete
- If modern parts have virtually no inherent wear out mechanisms, why the high maintenance demand & why do we have obsolescence problems in logistics support?
- MISAPPLICATION?

Eagle Century Study

- Fire control & ground mapping radar
  - 40 Hrs MTBF (2 Hrs MTBF when all failure types considered)
  - 90% of maintenance actions CND, RTOK, BCS
  - Large factory rework burden (many SRUs reworked more than 12 times)
  - Brand new, just delivered LRUs required depot level repair before initial installation
- Study of CND, RTOK, BCS maintenance burden root causes
- Goal – reduce CND, RTOK, & BCS sufficiently to achieve 100 hrs MTBF
- Collected data from 6 USAF data bases, 13 radar contractor data bases, 7 prime contractor data bases
- Identified 5 “bad actor” BIT codes
- Performed circuit & failure analysis, simulations/modeling – identified critical parameters from system down to parts level

Eagle Century Study
(continued)

- Analyzed aircraft BIT (ground & in-flight), backshop and depot diagnostics (tested parameters, test conditions, pass/fail criteria, limits etc.)
- Studied manufacturing data, processes procedures, & acceptance testing for bad actor BIT code signal paths
- Studied parts and materials in bad actor signal paths (specifications, selection criteria, incoming test/inspection)
- Evaluated use environments for assemblies containing bad actor signal paths
- Evaluated design adequacy of bad actor signal paths
- Studied BIT philosophy, test verticality, lead and solder joint fatigue analysis
- Studied connectors

Eagle Century Study
(continued)

- Identified limiting factors to reliability
  - Designed for absolute maximum performance
    - Inadequate tolerances and margins for variability due supplier processes, operating environments, or aging
  - Unidentified / undocumented / uncontrolled key signal path and parts parameters and characteristics
    - circuit boards effectively being used as “test fixtures” for part sorting during production
  - Test commonality and verticality problems, undefined test requirements, and test conditions not matching operational performance demands/conditions
    - Factory acceptance testing
    - On-aircraft BIT
    - Backshop diagnostics & acceptance testing
    - Depot diagnostics & acceptance testing
  - Very high correlation between circuit locations causing factory rework & those causing depot repairs and CNDs/RTOKs/BCS

Failure Analysis Experience

- New reliability limiting factors
  - Cleanliness
  - Corrosion
    - COTS parts & materials more moisture & corrosion sensitive
  - "Uncontrollable" parametric / characteristic variability "INHERENT" in COTS parts when using vendor part number
    - Vendor Data sheet disclaimers
  - Uprating / upscreening = intentional misapplication – lot-to-lot variability?, accelerated aging?
  - Whiskers - tin, zinc
  - No-lead solders – processing temperatures, dwell times, highly activated fluxes, much stiffer joints + brittle parts…
  - Surface mount - VERY small solder joints, larger device outlines…
  - Contract assembly houses = "commercial grade" process controls – e.g., "20 year" highly stressed solder joints require more control / controls than "90 day" or "5 year" joints

Reliability

- Traditional approaches to reliabiltiy
  - Design & build to mil standards – many lessons learned specific to mil systems
  - Use mil grade parts & materials
  - Test, analyze, and fix
  - Qual testing
  - Mod programs
- Trends
  - Design and build to industry & contractor standards
  - Use COTS parts from world class vendors – 6 σ, ISO…
  - Uprate / upscreen
  - Modeling, simulation (little or no aging effects capability)
  - Some qual testing (commercial or FAA methods)

Reliability

- Did it work?
  - No, especially not for high performance and/or highly stressed equipment
  - In high performance circuits, Mil standard parts guaranteed uncontrolled key parameters/characteristics resulting in heavy factory rework and field maintenance burdens
    - Slash sheets, military drawings contained fewer parameters (most easily controlled) and wider limits when compared with COTS data sheets for the same parts
- Is it working?
  - My failure analysis experience suggests no.
  - Avoiding misapplication of COTS parts in high stress or high performance application requires much more engineering effort than was ever required by mil standards

What to do?

- For new acquisition
  - Create customer demand for control of ALL key/critical parameters & characteristics
    - Design processes demonstrated capable of identifying AND DOCUMENTING all key/critical parameters/characteristics of every part/material at each circuit location and ensuring limits and margin to account for variability and aging
      - Modern circuit modeling & simulation tools make this possible with very little added effort
    - Parts acquisition/control and manufacturing processes demonstrated capable of ensuring fully capable, un-degraded part at each circuit location
  - Field failures considered design and development or manufacturing process failures/escapes
    - Identify improperly controlled key parameters causing rework at affected circuit locations and re-specify parts
  - Benefits – little or no rework, few or no field failures, little or no maintenance demand, little or no obsolescence

COTS MICROCIRCUIT CONCERNS
continued

- For fielded equipment
  - When early field failures occur, perform circuit and failure analysis by circuit location to determine root causes
  - Modify part specifications and assembly drawings by circuit location to ensure spares have proper parametric limits and characteristics with sufficient margin so as to prevent further failures
  - Using spares matching originally installed parts ensures continuing maintenance burden and eventual parts obsolescence

Summary

- Eagle Century Study and failure analysis experience demonstrate most failures are due to misapplication of parts and uncontrolled key parameters.
- CND / RTOK / BCS intermittent failures
  - unstable circuit performance caused by parametric drift or interconnects
  - due to problems with test commonality and/or voids.
- Creating a customer demand for controllable and well controlled design, development, and manufacturing processes, capable of controlling key parameters by circuit location would substantially reduce maintenance burden and obsolescence
- Applying controllable, well controlled failure analysis and corrective action procedures to ensuring properly specified spares would improve reliability and reduce obsolescence of fielded systems
- Rework is an early indicator of future field failures – properly correcting rework would prevent future failures and obsolecence