NASA Perspective on Radiation Hardness Assurance (RHA) for Hybrid Devices†

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Outline

- **Introduction/Problem Statement**
- **RHA Issues**
- **Hybrid RHA at NASA**
- **Test Issues**
- **Data Analysis Issues**
- **COTS**
- **Summary**

Problem Statement

- To understand the radiation hardness level of a hybrid device that typically consists of many technologies, detailed testing and analysis is required.
- The current budgetary conditions of most NASA flight projects is in direct conflict with these requirements.

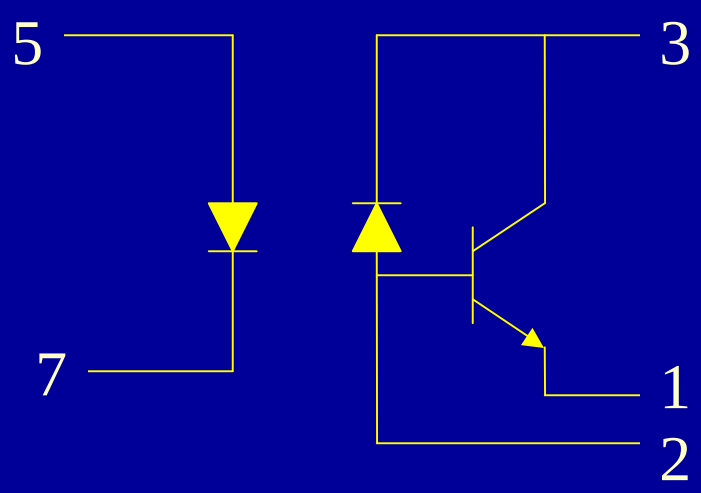
Sample RHA Issues

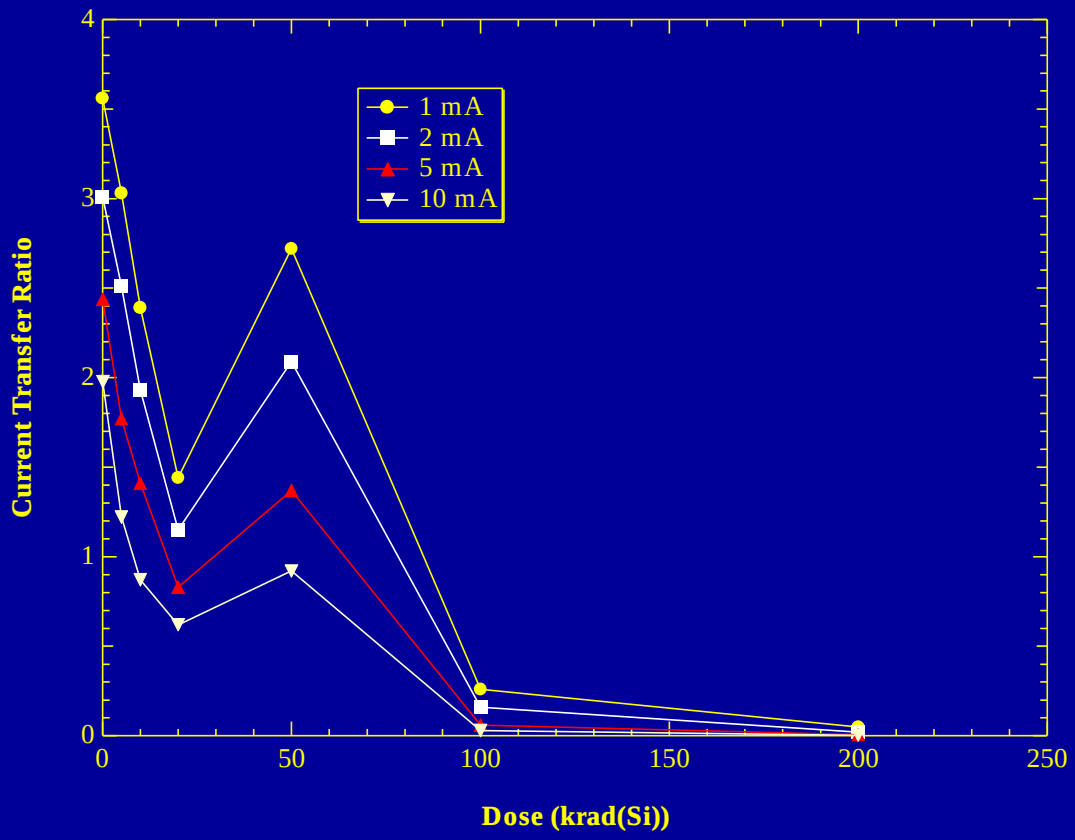
- Cost and Procurement Lead Time
- Traceability
- Everything can possibly go wrong
  - CMOS low dose rate, ELDRS, Displacement Damage, SEL, SEB, SEGR, SEU, SET, SEFI, etc.
- Worst Case vs. Application Specific

Hybrid RHA at NASA

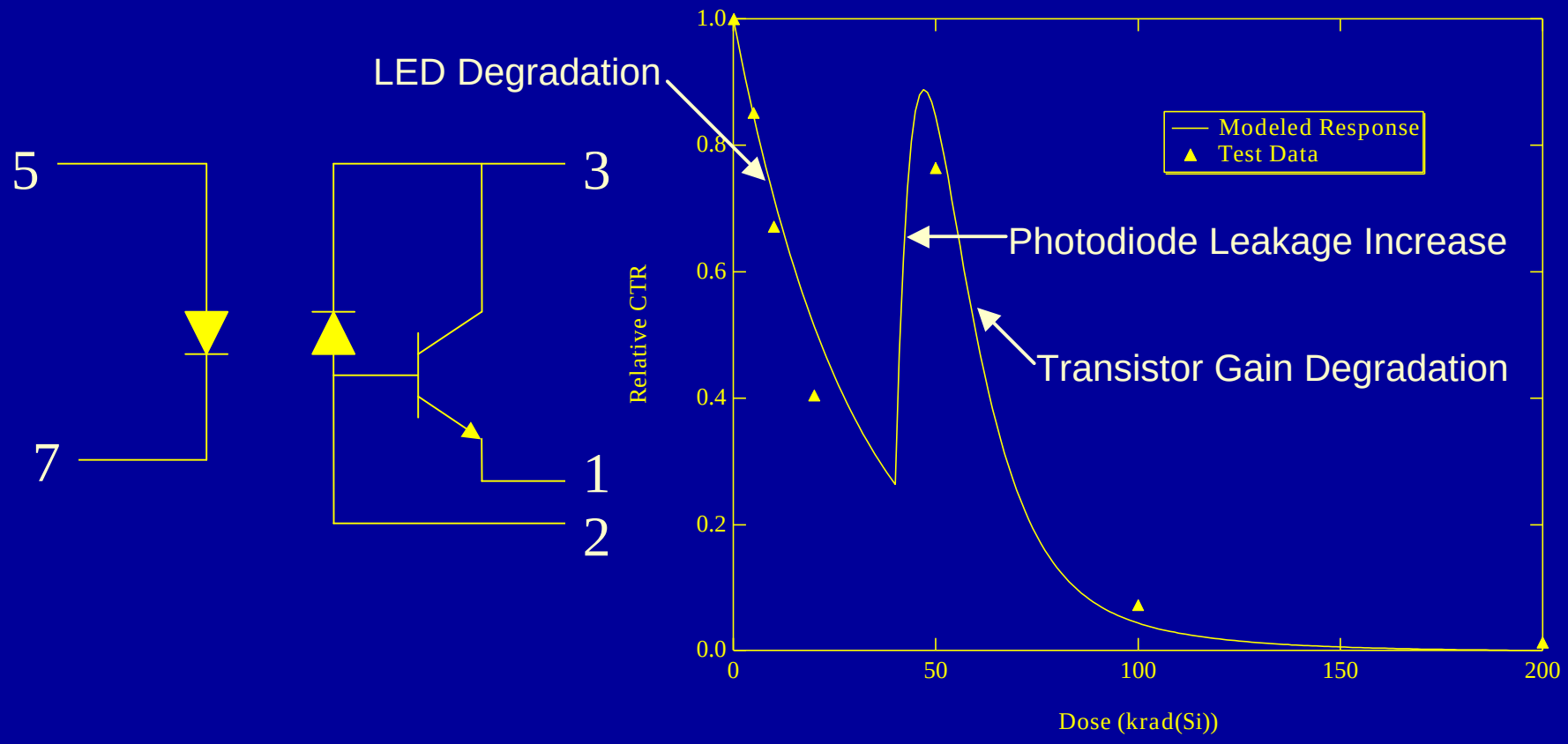
- Working with the Vendor
  - Information
  - Cooperative investigations
  - Design modifications
- Testing
- Analysis
  - Piece-part Analysis
  - Test Data Analysis
  - System Level Impact Analysis

Cooperative Investigation with Micropac



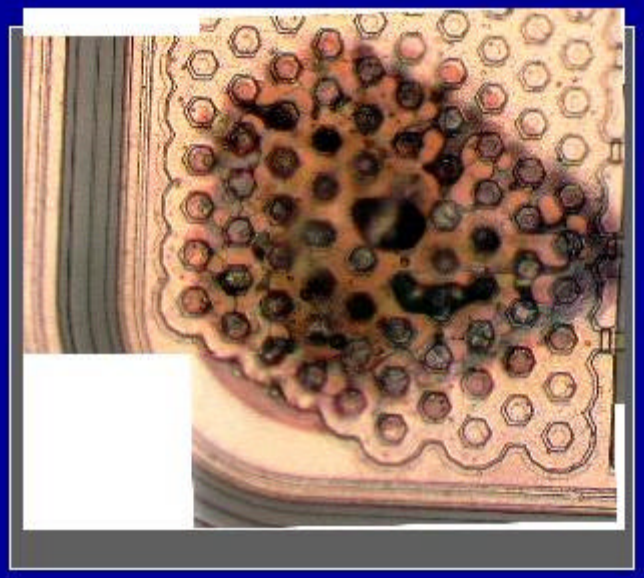


Cooperative Investigation with Micropac



Space Station (ISS) DC/DC Converters

- High Voltage DC/DC converters from Modular Devices, Inc. (MDI) were tested to examine the possibility of their use on ISS. A mixture of devices with 120 volt inputs and single or dual 5, 12, or 15 volt outputs were used.
- Initial testing showed a low LET threshold for destructive burnout of the power MOSFET (see photo below).
- MDI cooperated in this effort by replacing the “very good” power MOSFET used in the original design with a RADHARD equivalent.
- Follow-on tests of these new devices showed a higher LET threshold for failure but not considered RADHARD.
- Could indicate a circuit-induced failure mode that is not solved by RADHARD part selection.



Space Station DC/DC Converter Results Summary

Part Number	Volts	Load	LET	Pass/Fail
MDI3051RES05ZF	126 113	10% 50%	12 12	Pass Fail
MDI3051RES12ZF	120 126 120 120	25 -100% 25 -100% 25 -75% 100%	12 12 28 28	Pass Pass Pass Fail
MDI3051RES15ZF	120 120	25 -100% 75%	28 28	Pass Fail
MDI3051RES05ZF_A	126 126 126	50% 50% 75%	28 37 37	Pass Pass Fail
MDI3051RED12ZF_A	120, 126 120 120 120	75% 75% 25% 75%	28 37 60 60	Pass Pass Pass Fail
MDI3051RED15ZF_A	120, 126 120 120	75% 25% 75%	37 60 60	Pass Pass Fail

Parts with RadHard MOSFET

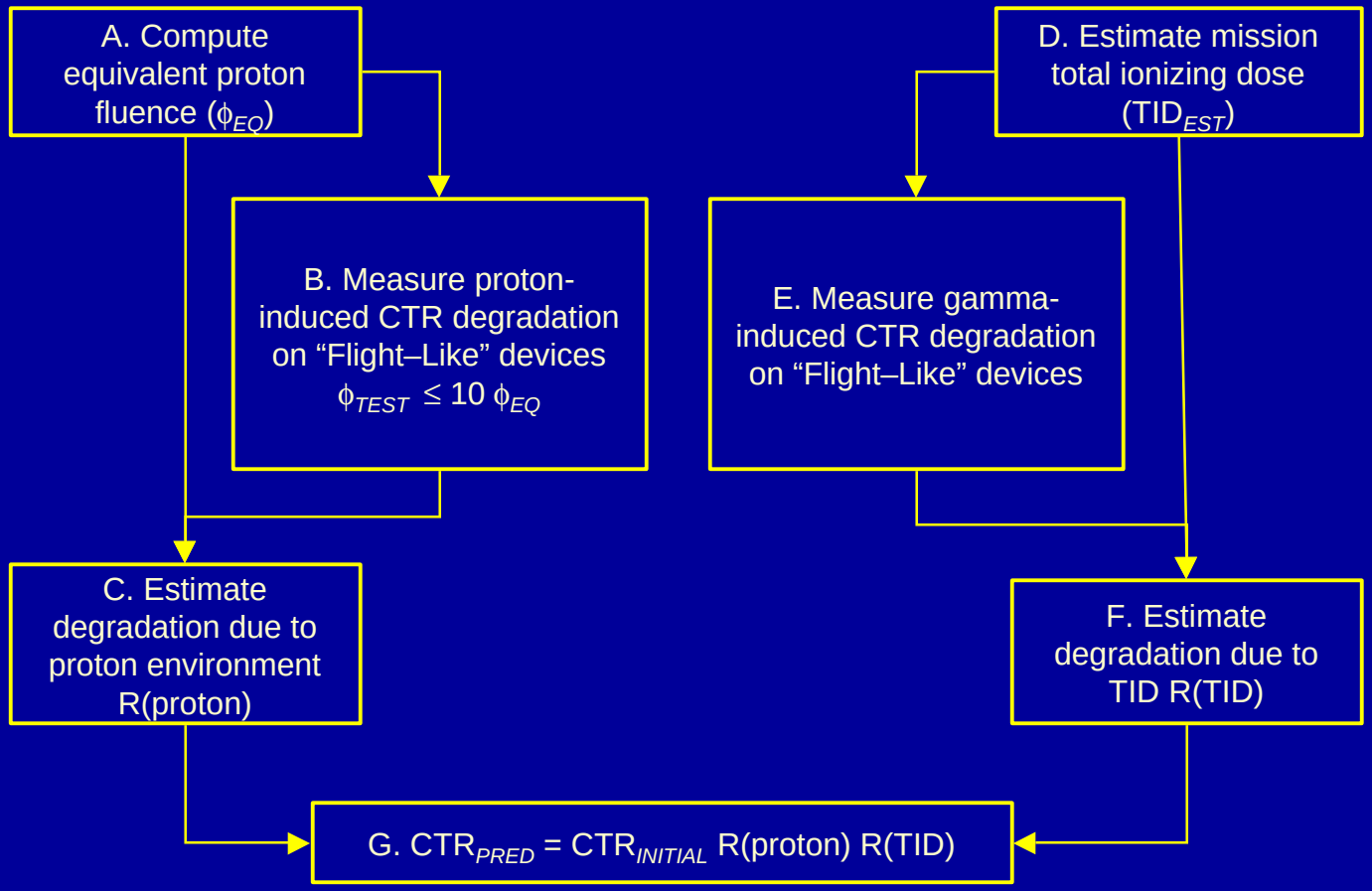
Testing Issues

- Cost and Procurement Lead Time
  - Extremely Small Sample Size
  - Can lead to “late in the game” testing
- Everything can possibly go wrong
  - With the small sample size, testing has to be prioritized/combined
- Worst Case vs. Application Specific
  - With small sample size, testing is generally done application specific
  - Multiple applications within a project may force more generic testing
    - Can worst case conditions really be determined
    - Test parameter space can be extremely large for generic testing
- High Voltages and Currents
  - Care in testing due to destructive events and constrained sample size
  - Cooling of test structures often required which can be problematic when working in a vacuum
- Multiple devices exposed simultaneously
  - Don’t know which device may be the problem
  - May have some multiple event interactions
- Packaging can restrict device access

Data Analysis Issues

- Piece-part Analysis
  - If complete parts list and radiation data available, can treat as any other system analysis
  - Main issues are:
    - Rarely are both items available
    - The “system” designer is usually not available
- Test Data Analysis
  - Must go from test data to in-flight predictions
    - Multiple data sets
    - Multiple space environments
- System Level Impact Analysis
  - In-flight predictions for hybrid are then analyzed for system-level impact, mitigation options and risk assessment
  - Trades between mitigation, risk assessment and risk acceptance are at the system and project manager levels

Optocoupler Flight Predictions



Taken from Reed, et al., "Guideline for Optocoupler Ground Radiation Testing and Optocoupler Usage in the Space Radiation Environment"

Commercial-Off-The-Shelf (COTS) Issues

- COTS Hybrids
  - Traceability is the real issue
  - Part-to-part variability can be significant
    - COTS parts are used
    - Various vendor parts may be used in same location
    - In general, no such thing as lot control
- COTS Printed Circuit Boards as “Hybrids”
  - COTS PCB can be treated as a hybrid on a larger scale
  - All the same issues apply as noted above
  - Often the PCB is integral to larger system and the observed effects can only be seen at that level
  - Heavy ion testing is often impossible

Summary

- There are numerous issues when dealing with hybrid devices
- NASA takes a system-level-down approach to RHA
- It cannot be overstated how critical radiation testing, how the devices are tested, to good RHA
- NASA also works to make the vendor an integral part of the RHA process, as much as the vendor is willing to participate
- Test data analysis to flight risk assessments can be a very complex business, especially when dealing with many applications within a flight project
- COTS is COTS