Single-Event Transient Case Study for System-Level Radiation Effects Analysis

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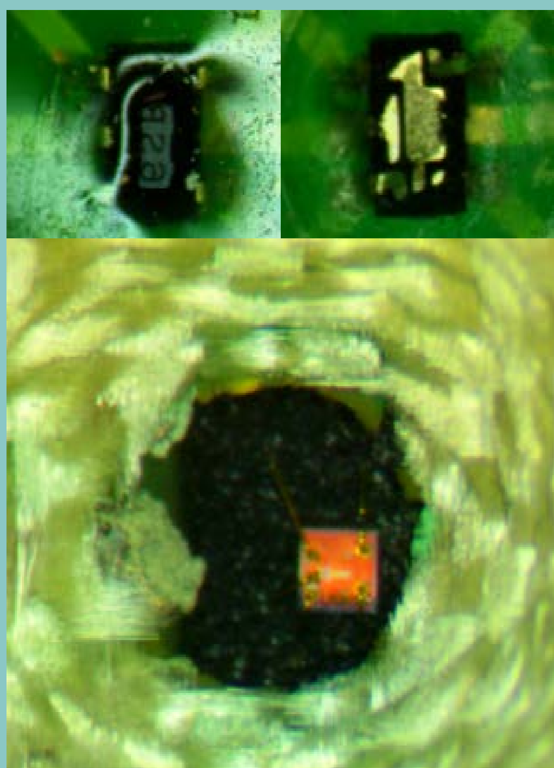
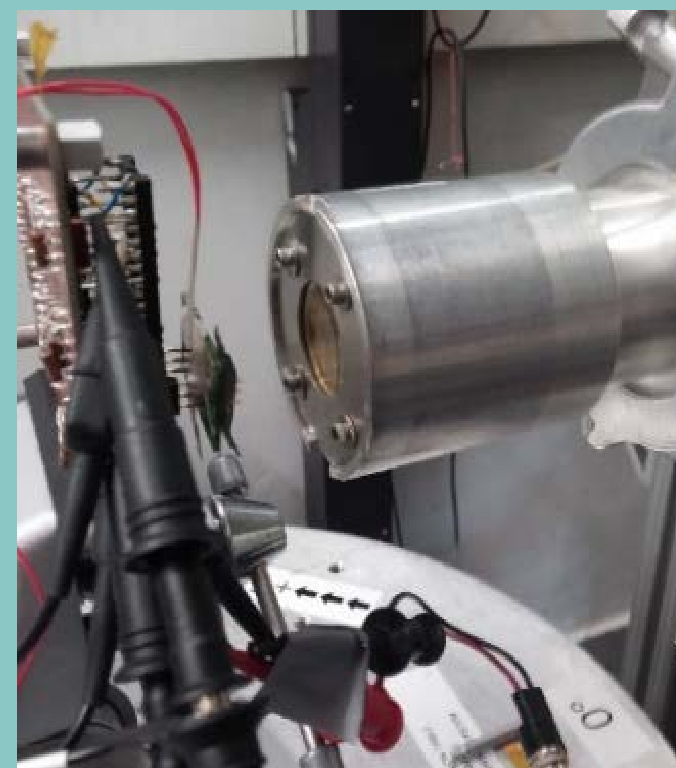
Abstract: Analog single-event transient results are analyzed for two different applications within one system architecture. Application-specific analyses are presented on the MAX4595 commercial device using single-event effects criticality and goal structuring notation.

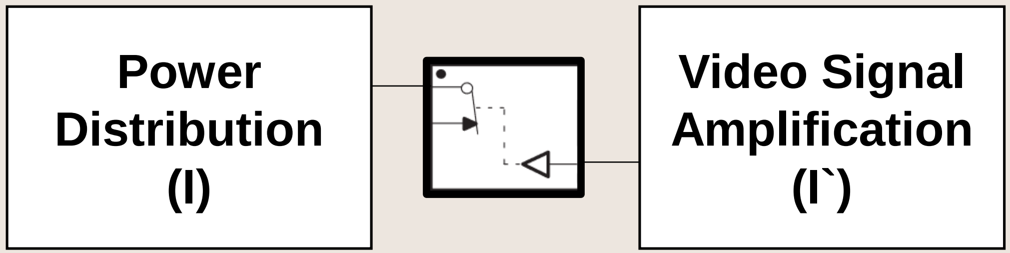
Device Preparation



Heavy Ion Testing
TAMU Cyclotron

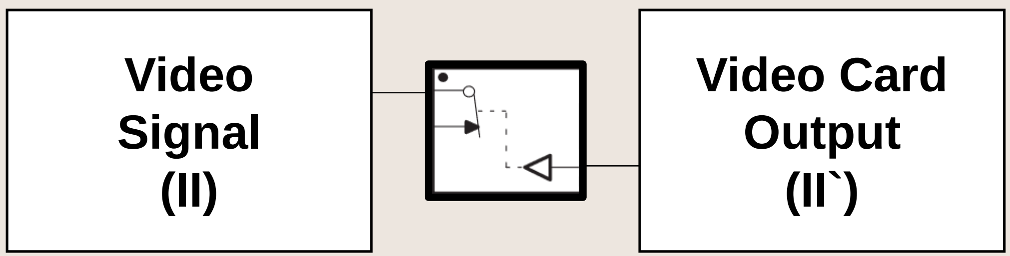


Application I - Interruption on the power supply to the video signal amplifiers has sensitivity to transient duration, if the SET is long enough in duration the power to the amplifiers will be suppressed which changes the amplifier output and could effectively turn the amplification off.



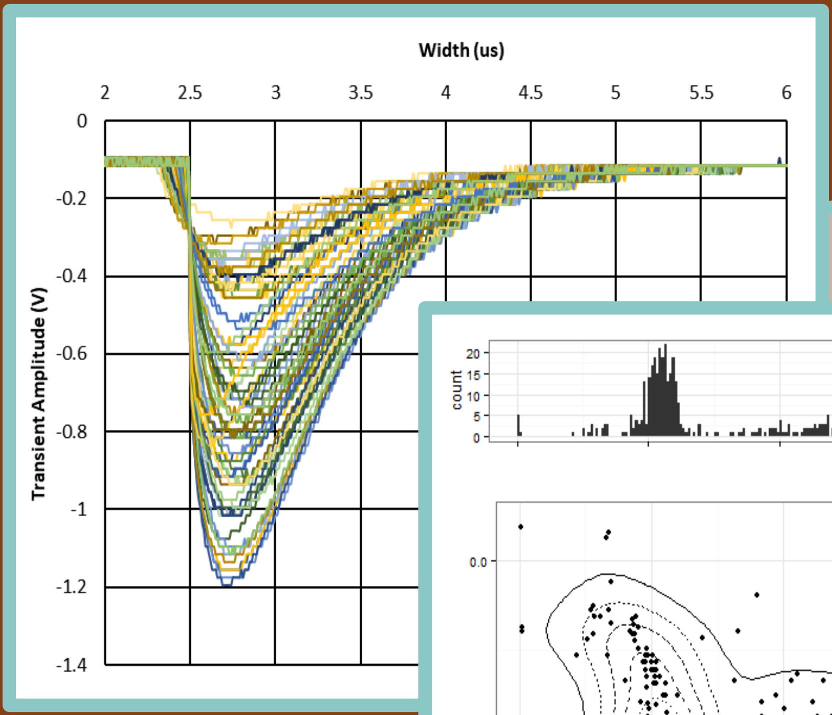
Concern with pulse width (PW)

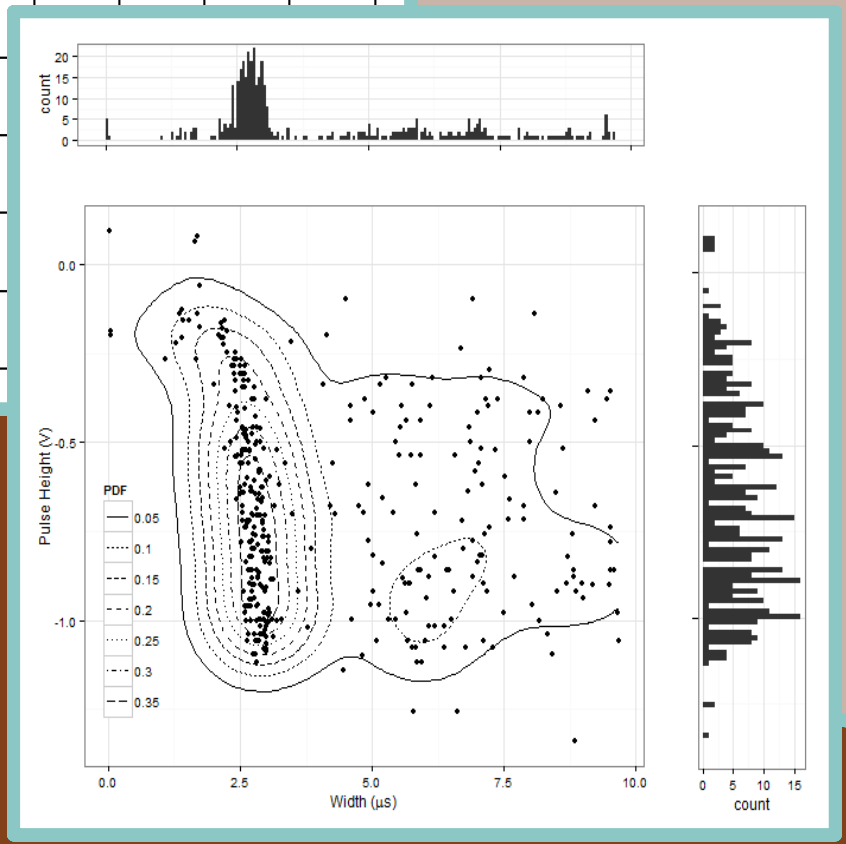
Concern with pulse height (PH)

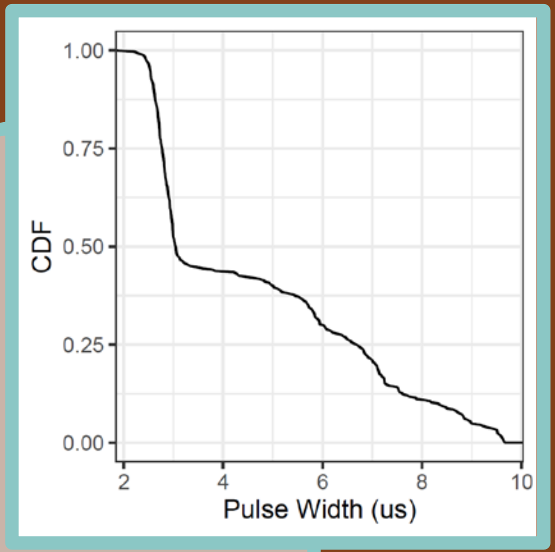


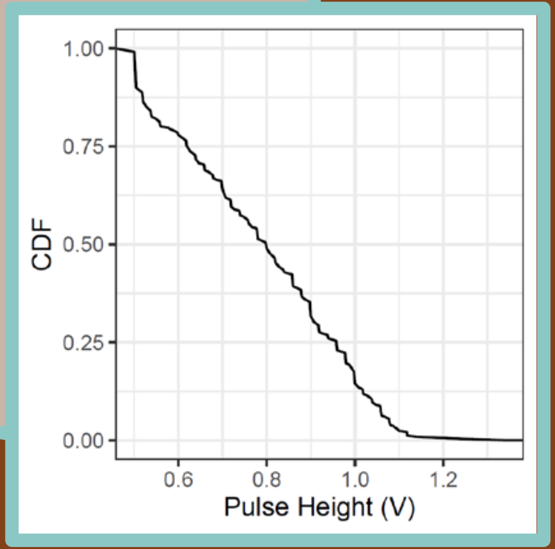
Application II - Disruptions on the transmission of the video signal output has sensitivity to transient peak values. If the peak-to-peak values are outside of the expected output range at a high rate, the average measurements would change, disrupting science data.

Data Collection and Analysis



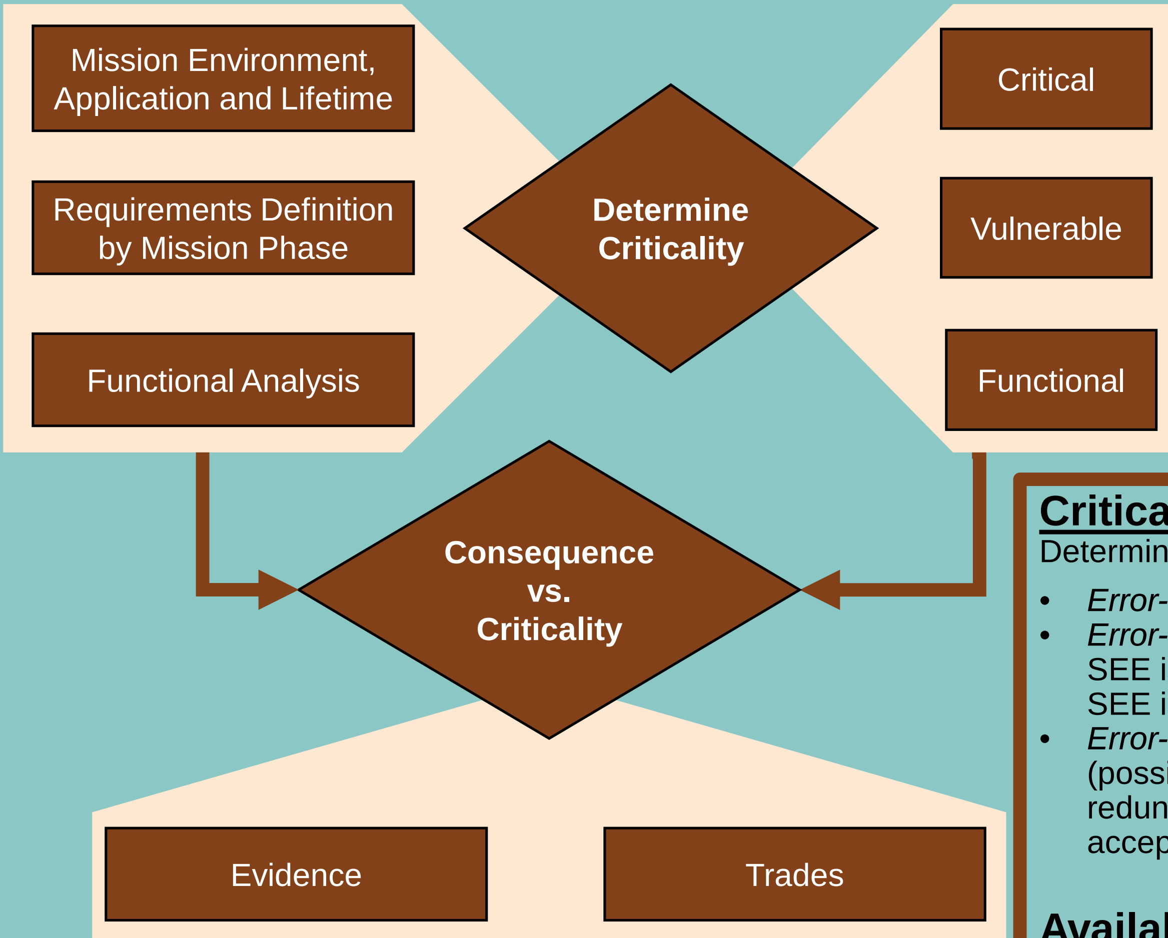






Single-Event Transient (SET) capture and pulse width and pulse height (PWPH) analyses, done to determine results vs. application

Single-Event Effects Criticality Analysis (SEECA)



Use Case	Mission Concern/ CONSTRAINT	SEE Severity Assessment
Power to Amplifiers (I)	Duration of transient cannot cut power to amplifiers during measurement, rate cannot exceed 1 every 30 minutes (I`)	Error-Vulnerable
Video Signal Chain (II)	Rate cannot exceed 1 every 120 seconds, duration cannot exceed 1 second for integration/ averaging (II`)	Error-Functional

Weibull Fit Parameters	Environment	Estimated Rate (transients /device/day)
LET threshold = 32.1 MeV·cm^2/mg Limiting Cross-Section = 2 x 10^{-3}	Geostationary	1.55 x 10^{-4}
Shape = 2.5 Width =71	October 1989 Worst Day	4.80 x 10^{-1}

Criticality Classes:

Determined by potential impact to function

- *Error-Critical* – function where SEE are unacceptable.
- *Error-Vulnerable* – function where low probability for SEE is required, response with mitigation or risk of SEE is permissible.
- *Error-Functional* – function may be unaffected by SEE (possibly by error-corrections scheme, mitigation, or redundancy), large probability of events may be acceptable.

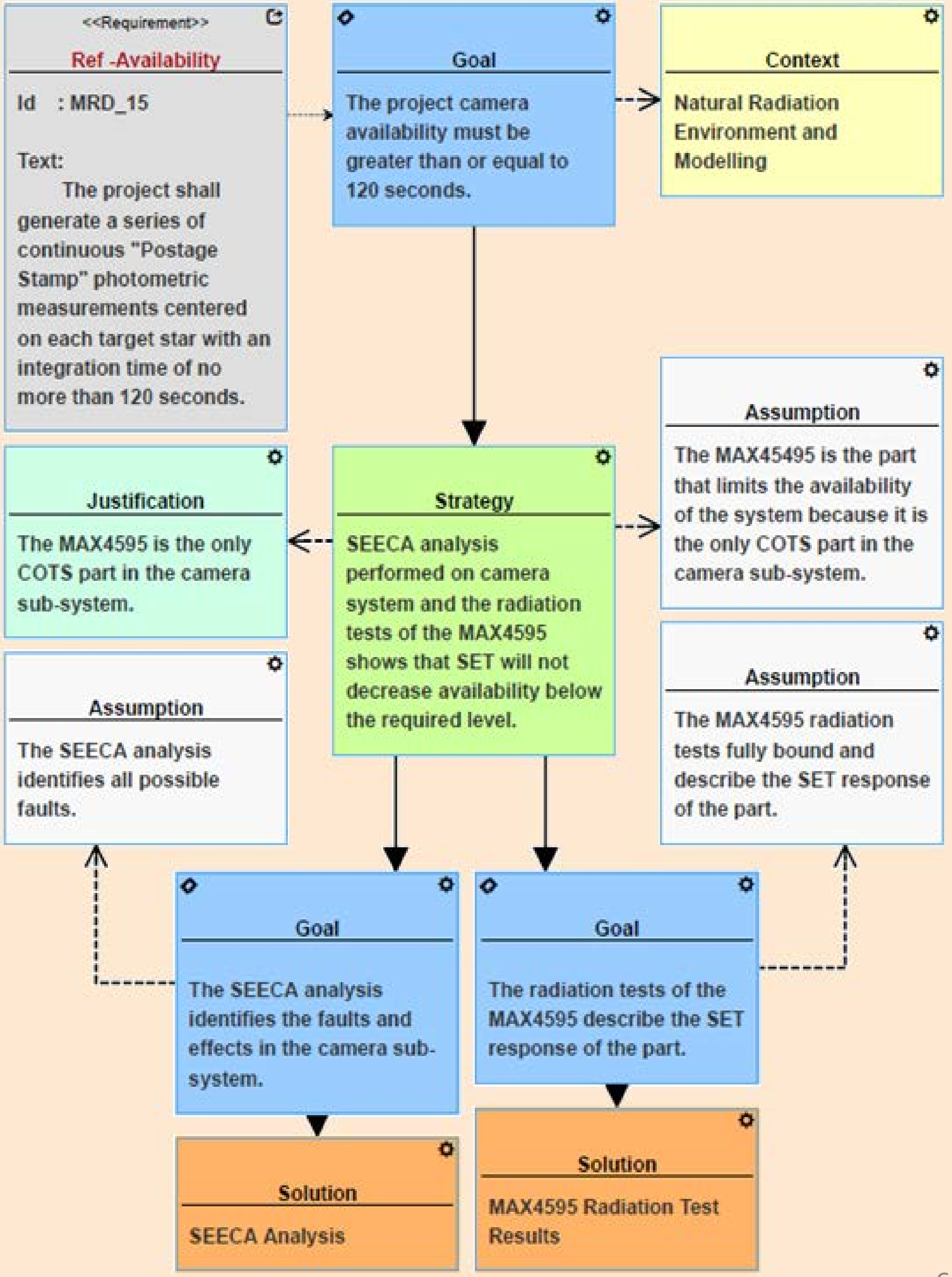
Availability Requirements:

Event consequences translated from requirements

- *Application I* - Pulse width greater than 5 microseconds will cause power off condition, some transients recorded were greater. Availability is 30 minutes.
- *Application II* - One pulse height measurement greater than 1V during integration would be sufficient to throw away measurement, some transients recorded exceeded that limitation. Availability is 120 seconds.

Goal Structuring Notation (GSN) –

- A visual argument
- Links mission requirements (like availability) to the analysis for verification
- Provides clear goals and sub-goals
- Tracks assumptions and context
- Links justification to strategies and mission architecture
- Feeds into Model-Based Mission Assurance (MBMA)
- Impacts from changes in Mission Environment, Application and Lifetime (MEAL) can be identified quickly



Conclusions: The results of SEE testing on the MAX4595 were application-specific and show the device susceptibility to SETs. A system-level analysis can allow for the use of COTS parts in spaceflight missions if used to capture and verify requirements. In some use cases, limited data or lack thereof, functional operation of the device in systems with mitigation, or in non-critical applications can be justified; in order to do so, traceability and documentation of assumptions are paramount.

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