# Radiation-Aware Design for CubeSat Form-Factor Experiment using Goal Structuring Notation

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## NASA Mission Assurance

NASA classifies spacecraft missions by cost, significance, priority, lifetime, and launch constraints.

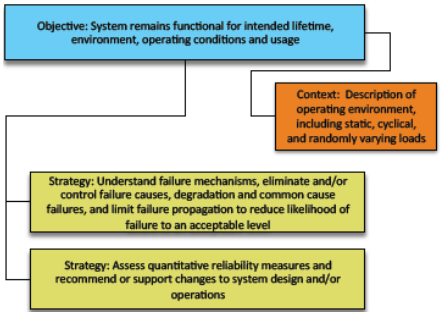
- Class A: High-cost, highly significant like a space telescope, low risk tolerance, use radiation hardened (rad-hard) parts
- (Sub) Class D: Low-cost, short lifetime like CubeSats, high risk tolerance, use commercial off-the-shelf (COTS) parts
  - Unknown radiation hardness of COTS parts is a reliability issue

Mission assurance is moving toward a model-centric paradigm where model-based representations of the spacecraft replace requirement and interface documents.

## NASA Reliability & Maintainability Template

NASA's Reliability & Maintainability (R&M) template uses a modified GSN structure to graphically present an objectives-based approach to reliability and maintainability.

R&M template was used to create general structure for top-level goals for GSN example assurance case.

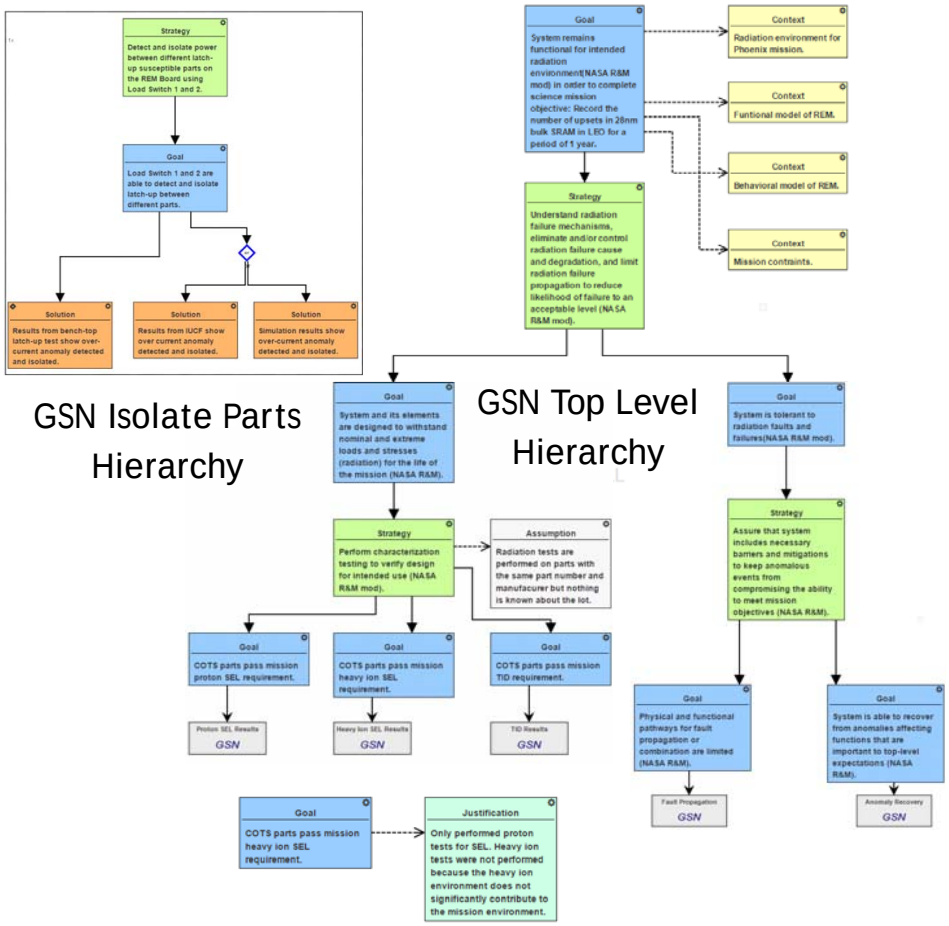



[2] Groen, F.J.; Evans, J.W.; Hall, A.J., "A Vision for Spaceflight Reliability: NASA's Objectives Based Strategy," RAMS, 2015, 26-29 Jan. 2015

## Preliminary Results

- Graphically describe mitigation strategies
- Graphical model can be used as a deliverable for reviews
- Makes assumptions and justifications explicit
- Shows what lack of evidence does to the argument

## GSN Model for REM




## Parts of GSN [1]

**Goal** (blue boxes): Claims of the argument
Solution (orange boxes): Items of evidence
**Strategy** (green boxes): Reasoning step, nature of argument
**Context** (yellow boxes): How the claim or reasoning step should be interpreted
**Assumption** (white boxes): Needed for goal or strategy to be valid
**Justification** (teal boxes): Explain why a claim or argument is acceptable
**In Context of** (dotted lines): Contextual relationships
**Supported by** (solid lines): Inferential or evidential relationships
**M of N options** (diamond): M out of N paths can be completed to prove goal

[1] GSN Community Standard Version 1 2011

## Goal Structuring Notation

Goal Structuring Notation (GSN): Graphic argumentation notation used to explicit document an argument and relationshi between elements

- Created at the University of York in the 1990
- First used in safety and security applications

## CubeSats

Created in 1999 by Cal-Poly and Stanford provide easy access to space for universities

- CubeSats are 10cm cubes that weigh no mo than 1.33kg
- Come in various sizes that are multiples of t 10cm cubes: 1U, 2U, 3U, 6U
- The cost for a single unit is about $65,00 $80,000 to make and launch
- They can be launched in large groups, usua timed with larger satellite launches

## WebGME

WebGME used to develop modeling framewo for GSN.

**WebGME**: Web-based Generic Modelin Environment for collaborative domain specif modeling platforms https://webgme.org/

- Customizable modeling rules specify th syntax and semantics of the model
- Support for model interpretation algorithms
- Developed by Vanderbilt's Institute f Software Integrated Systems

https://github.com/webgme

## Single-Event Latch-up Testing

Single-event latch-up (SEL) testing investigat the energy of a particle that causes the part latch into a sustained high-current state.

## Total Ionizing Dose Testing

Total ionizing dose (TID) testing investigat parametric changes in a packaged semiconduct device as a result of cumulative ionizi radiation over a period of time.

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