

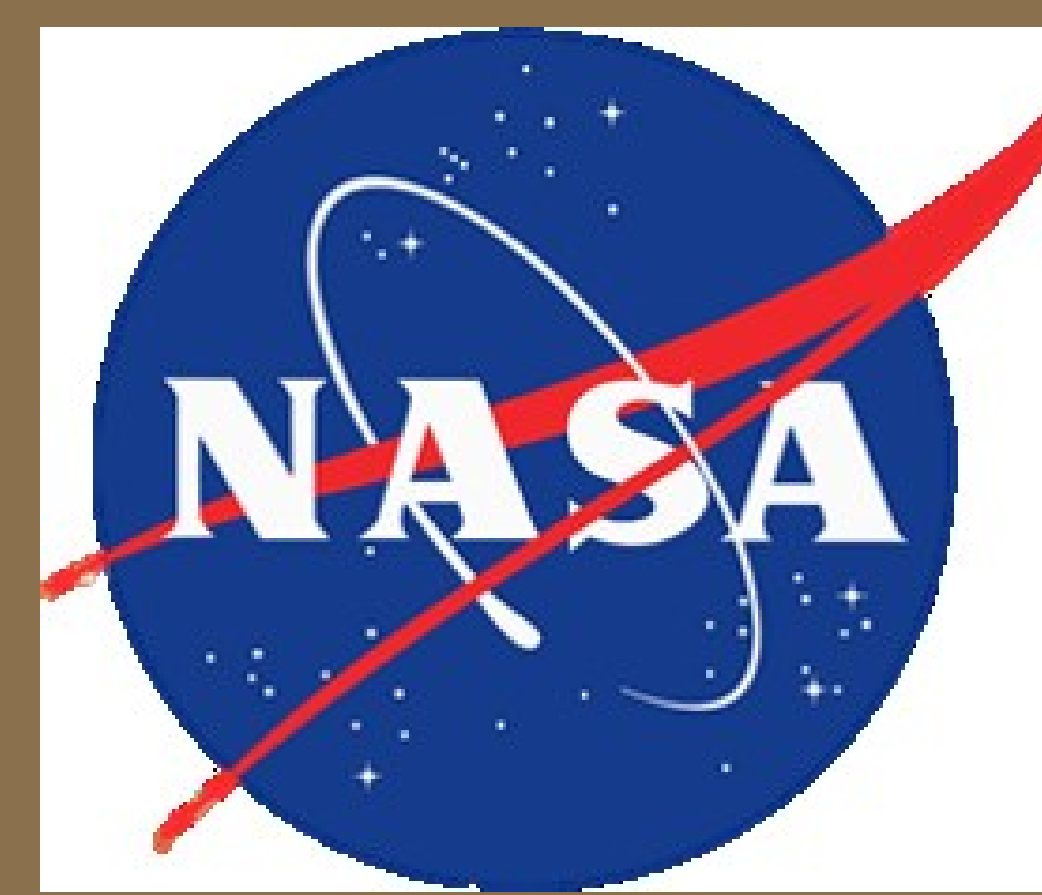


# Effective Small-Satellite Radiation Assurance for Non-Specialists

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## What is radiation hardness assurance (RHA)?

- Analysis of the expected ionizing radiation environment and its impact on the system
  - Effects cause part degradation and random events from energy deposition of the ionizing particles

## How do designers know the effect of radiation on parts?

- Use R-GENTIC
- Should be addressed early in design phase, before PDR
- Do not need to know specific part numbers, just general part types

### R-GENTIC

- Select representative environment
  - Orbit, Altitude, Sun Cycle, Class, Lifetime, Architecture
- Select representative parts
  - Designator, Family, Function, Process, Criticality
- Outputs of tool
  - Description of radiation for similar environments
  - For each part: Typical line of questioning, Radiation concerns, Greatest system concern

<https://vanguard.isde.vanderbilt.edu/RGentic/>

Notional radiation risks: What are we dealing with?

### Select Environment

Mission Description:

Orbit: LEO (Polar) Type in Altitude(km): 800

Sun Cycle: Solar Max Class: Do No Harm

Lifetime: Short (< 1 Year) Single spacecraft, no redundancy

How do similar devices react?

### Select Part

Device: U4

Assign a Reference Designator or Unique ID

Family: Analog Function: Voltage Regulator

Considered for Low criticality component on a Single spacecraft, no redundancy ...

Your Part	Radiation concerns	Greatest System Rad Concern	As-is Risk	Post Recommendation Risk
U4	TID, DDD, ELDRS, SET, SEB	Degradation & Single Event	Low	Low

### Output of tool

Recommendation and Guidelines:

Transients of all shapes and sizes, make sure you filter where appropriate on your output. Downstream circuitry limits should not be exceeded.

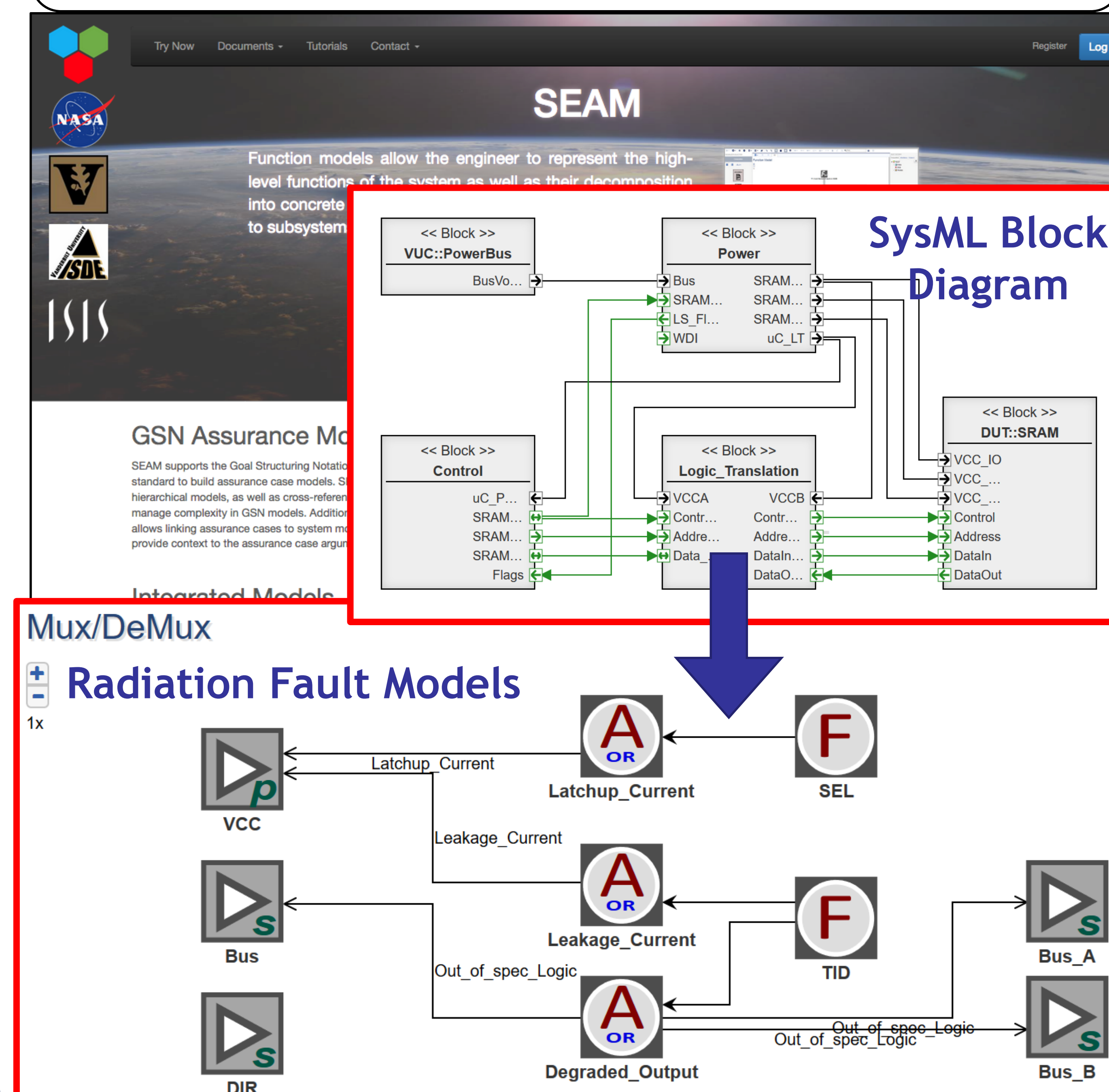
## How do designers model how the radiation-induced faults propagate through the systems?

- Use SEAM
- Radiation fault models for different part types
- Analyze how faults in parts propagate through the system

### SEAM

- Contains the following functionalities:
  - System Modeling Language (SysML)
    - Requirement Diagrams
    - Block Diagrams
  - Fault modeling (within SysML block diagrams)
  - Functional Decomposition
  - Graphical Argument Structure (GSN)
- Exports via XML
  - Bayes Nets
  - Fault Trees
- Radiation-related tools
  - CRÈME
  - R-GENTIC

<https://modelbasedassurance.org>



## Why use a model-based approach for RHA?

- Captures a “digital copy”
  - Enables knowledge capture, sharing, and continuity
- Radiation effects and reliability ultimately need to be analyzed at the system level
  - Knowledge about the system is needed
  - Complements and uses model-based system engineering processes and languages

## How do designers capture and analyze radiation hardness assurance activities?

- Use graphical arguments like Goal Structuring Notation to link arguments with models of the system

