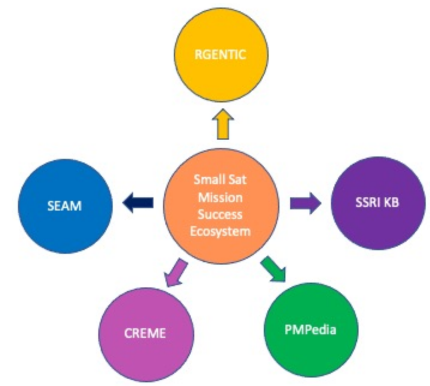
SSC21-WKI-04



Online Small-Sat Knowledge Repositories and Modeling Tools for Risk Reduction and Enhanced Mission Success

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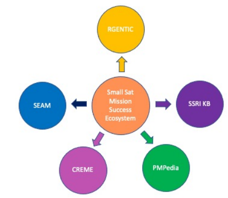
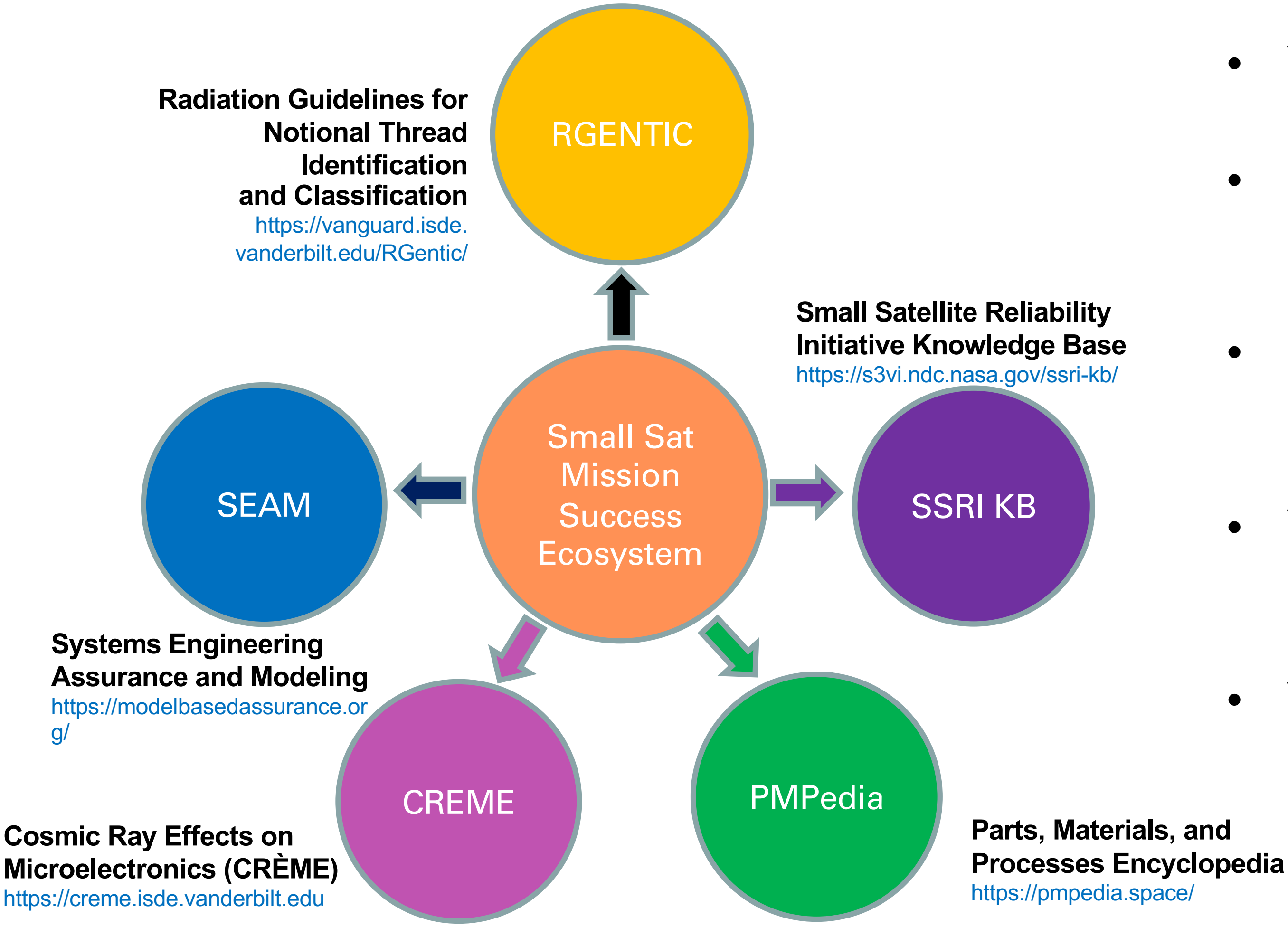
[1]Vanderbilt University, [2]The Aerospace Corporation, [3]Laboratory for Atmospheric and Space Physics (LASP), [4]Goddard Space Flight Center (GSFC), NASA, [5]Ames Research Center (ARC), NASA, [6]Sedaro Technologies

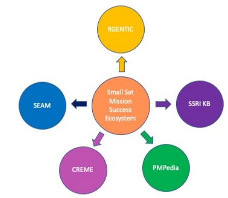
Small Sat Mission Success Online Ecosystem





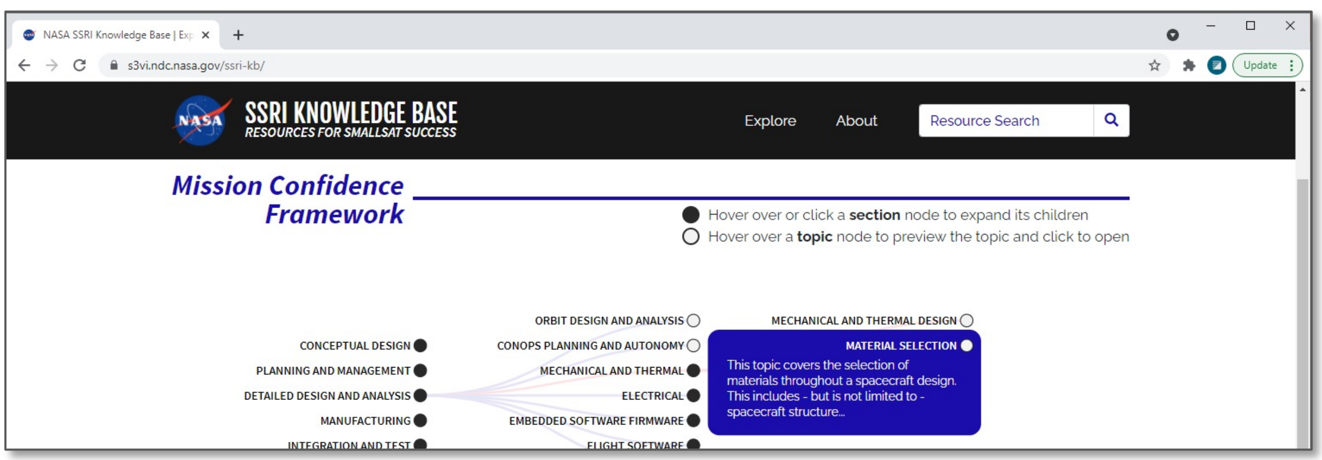
- What are Small-Sat best practices?
- How do I know the radiation vulnerabilities of electronic parts?
- How can I construct a radiation assurance case?
- What is the radiation environment in my orbit?
- Where can I find radiation test data for parts?

SSRI Knowledge Base: Overview

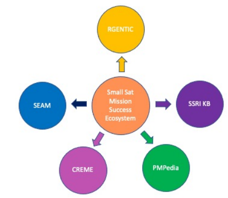


SSRI KNOWLEDGE BASE
RESOURCES FOR SMALLSAT SUCCESS

- Public-private collaboration led by the SSRI and NASA's S3VI
- Crowdsourced website providing resources and guidance on a broad range of smallsat topics
- Final moderation of all content by the SSRI, not the user community
- Publicly available now at **https://s3vi.ndc.nasa.gov/ssri-kb/**



SSRI Knowledge Base: Structure

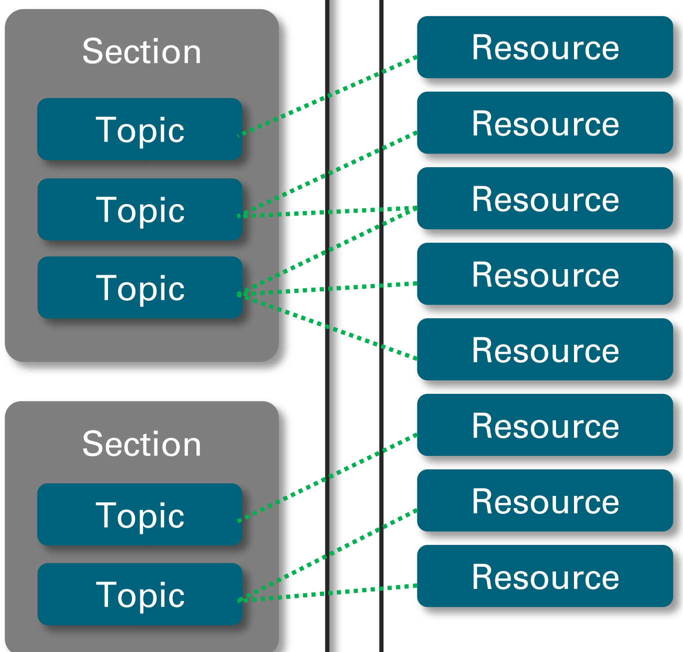


SSRI KNOWLEDGE BASE

RESOURCES FOR SMALLSAT SUCCESS

Mission Confidence Framework

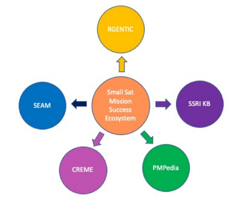
- Order, structure, context
- Best practices & lessons learned
- User interfaces for submitting feedback and recommendations



Resource Library

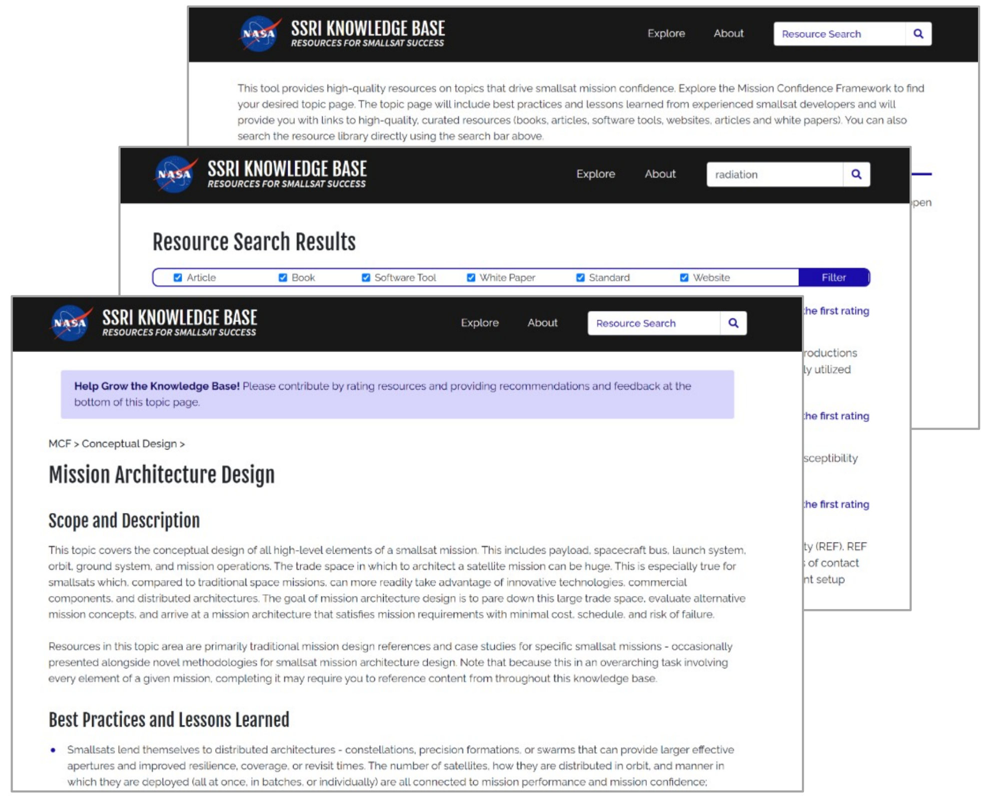
- Third-party content
  - Articles, books, software tools, white papers, standards, and websites
- Access to resource
- Smallsat context
- Ratings

SSRI Knowledge Base: Upcoming Enhancements

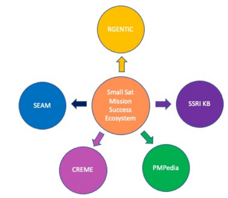


SSRI KNOWLEDGE BASE
RESOURCES FOR SMALLSAT SUCCESS

- Expanded content - additional 18 topic pages and 180 unique resource items
- Application Programming Interface (API) - to allow access from other software programs & websites
- Improved interfaces for user input



R-GENTIC: Overview



“RADIATION GUIDELINES FOR NOTIONAL THREAT IDENTIFICATION AND CLASSIFICATION (R-GENTIC)”

R-GENTIC

Tool Guide:

This tool is meant to be used as guidance for understanding the radiation risks that apply to a specific set of circumstances, not to replace modeling one's own environment or replacing the need to test a device. When used from start to finish you can get guidelines to help mitigate radiation effects and understand where you can avoid risks, based on simplified inputs, for a parts list in question.

Each Navigation Tab is a step in the process:

1. User Mission - Begin with selecting the options that apply to you for an intended mission, each input will directly impact the output of the tool that is to follow. At any time, you can choose to begin again, or follow the path for a new mission design under question. By selecting a mission class, lifetime, orbit, and architecture you are returned an environment severity with contributions and the EEE threats the tool will focus on.

2. Environment Comparison - Using the inputs from section 1, the tool displays past mission modeling efforts that have been done. It returns the details of a mission that has been calculated to be close to yours when normalized for one year. This panel allows selection of multiple missions to compare and explore. It should be noted that the Solar cycle has an impact on the dose based on the launch year, and the normalization is for approximation. This piece of the tool is to show how shielding can be used to mitigate dose levels, and how mission characteristics impact your SEE concerns. Two plots are available, the TID vs. shielding depth curve and the GCR spectra. The tool also returns data tables for all plots rendered.

3. Device Response -Using the top level selections from section 1, the device susceptibility and basic radiation concerns are called out when the user inputs the device information. Here the tool returns examples of the most prevalent radiation concerns through plots and references of similar components where possible.

4. Guidelines -The final step captures radiation line of questioning that is tailored to the user inputs, the major concerns are clarified and the user is presented with mitigation strategies. You can also see a listing of class guidelines with respect to radiation using the dropdown. In an effort to document failure modes and reduce the threat/risk to the system from a radiation standpoint, a line of risk pre and post mitigation is returned. This output can be saved and added to a table in the summary.

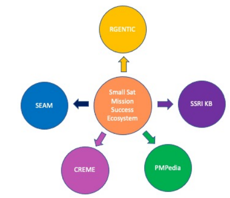
Due to the fact that radiation effects are application specific, this guidance is notional, generalizations cannot cover the entire state-space and the user will benefit from a more detailed analysis.

Proceed with Notional Guidance

- User inputs Mission Info
  - Length
  - Orbit, etc.
- Output is basic guidance on radiation risks

Publicly available: https://vanguard.isde.vanderbilt.edu/RGentic/

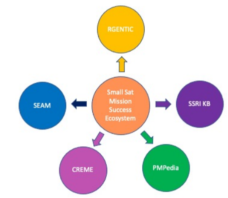
R-GENTIC: Typical Use Case



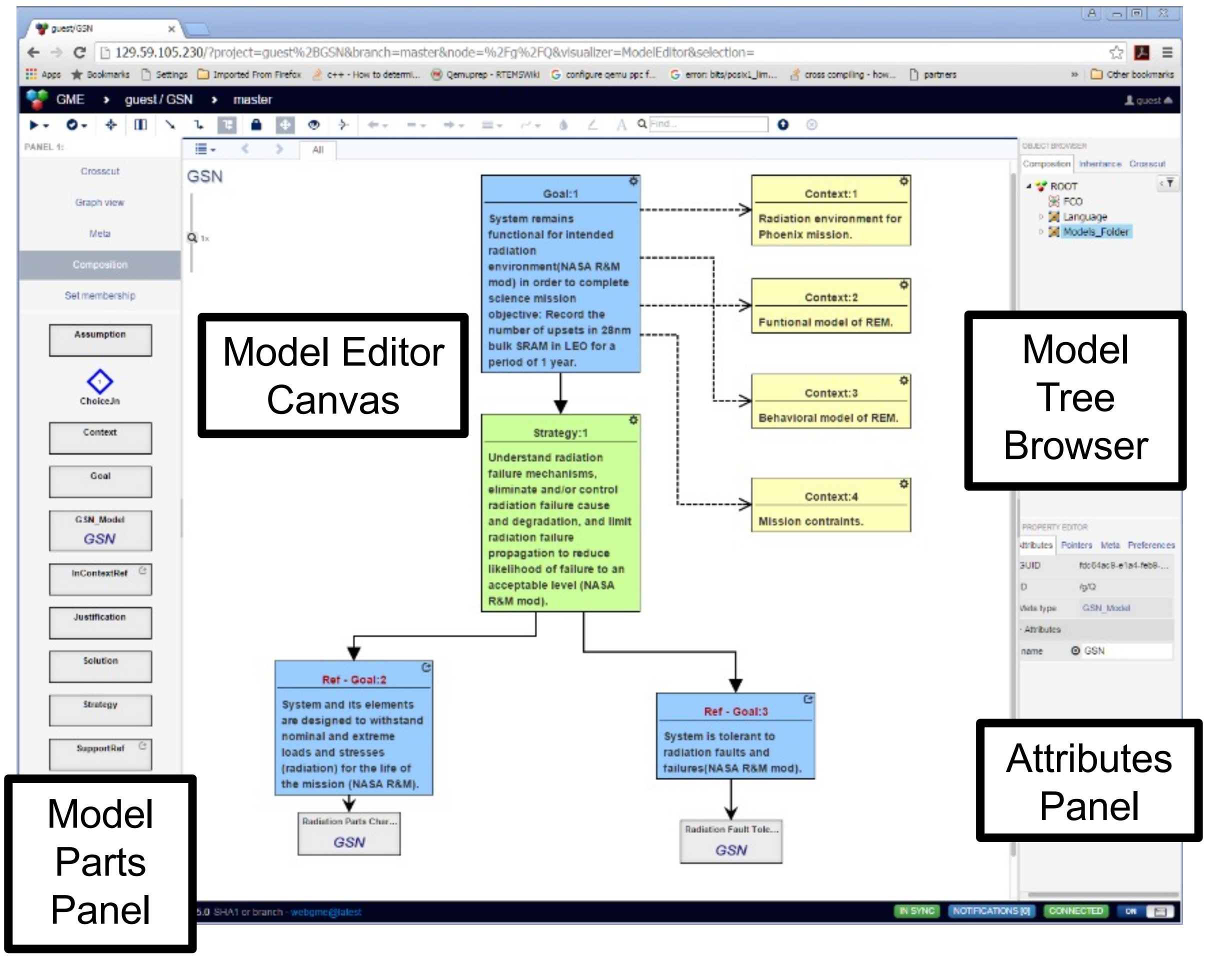
R-GENTIC Flow:

1. User Mission – input orbit, mission lifetime, risk tolerance
2. Environment Comparison – radiation environments from known missions with similar orbits
3. Device Response – input electronics device types of interest, basic radiation concerns are given
4. Guidelines – major concerns are clarified, radiation specific class guidelines are given

SEAM Details
Modeling paradigm and tool



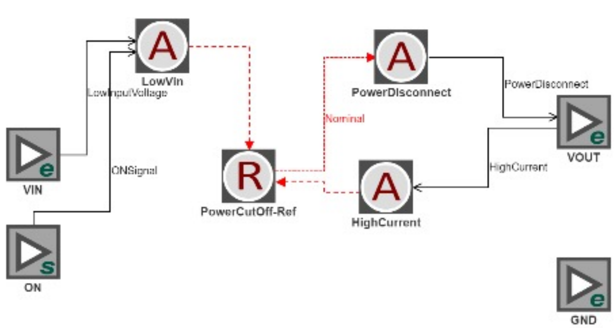
- Web-based collaborative platform
- A set of linked modeling languages to evaluate impact of part-level radiation effects on system functions
- Integrates Radiation Hardness Assurance activities into overall system design process

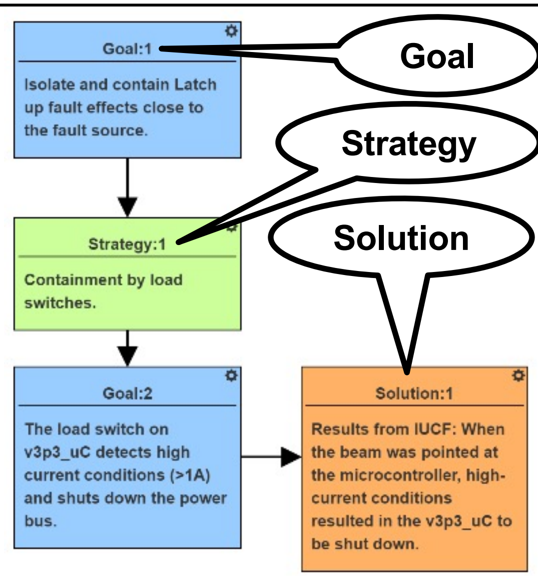


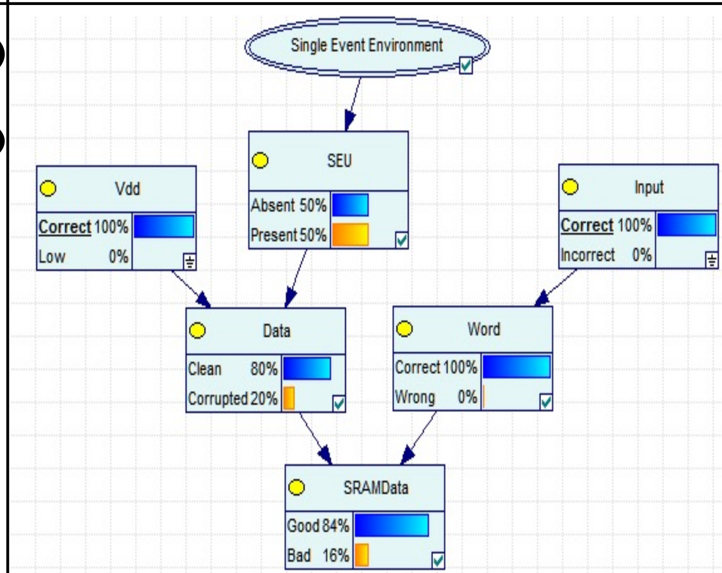
modelbasedassurance.org

SEAM
Overview of Modeling Languages Used

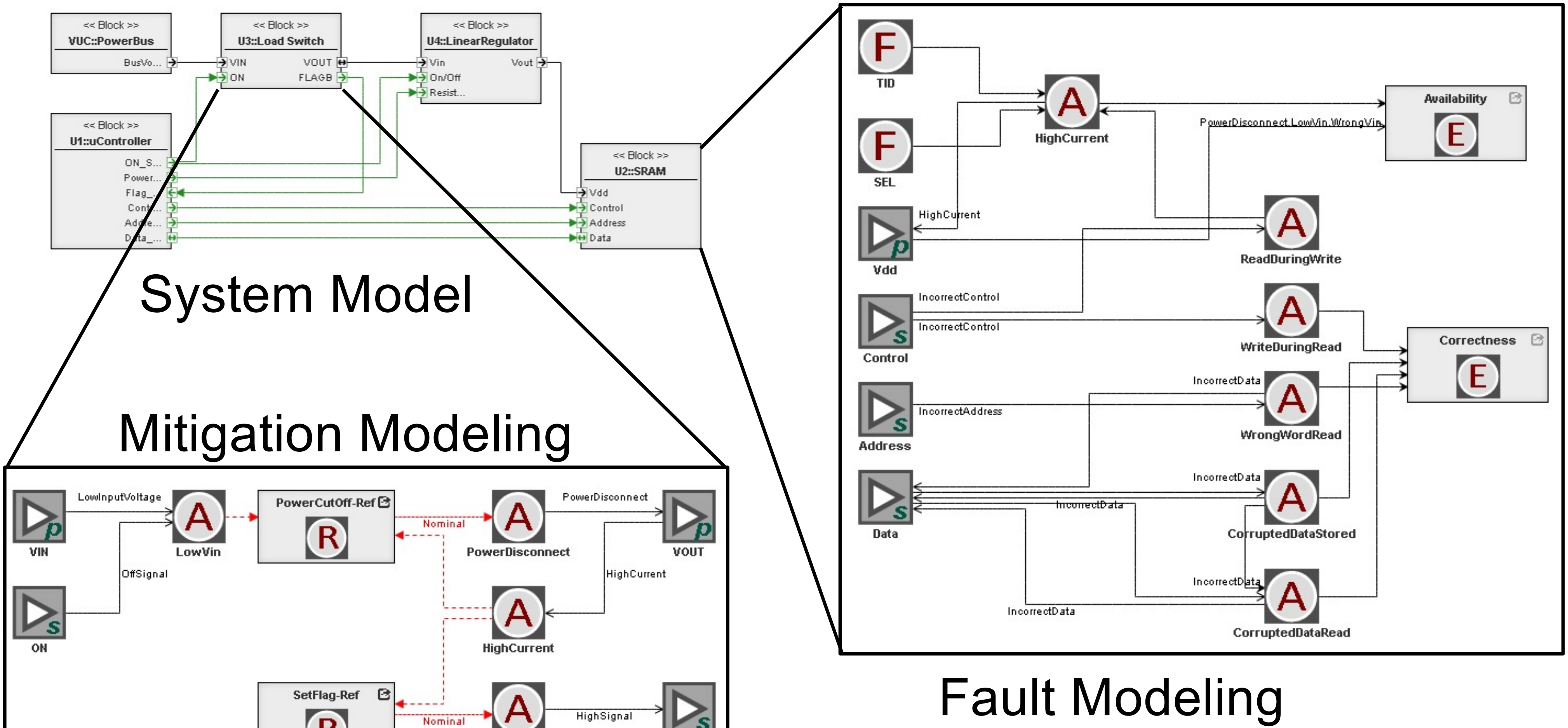
System Mod.	GSN	Bayes Net or FT
• Specification of systems through standard notation • Added fault propagation paths	• Visual representation of argument • Goals, Strategies, and Solutions	• Nodes describe probabilities of states • Calculate conditional probabilities from observations



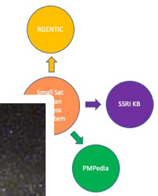




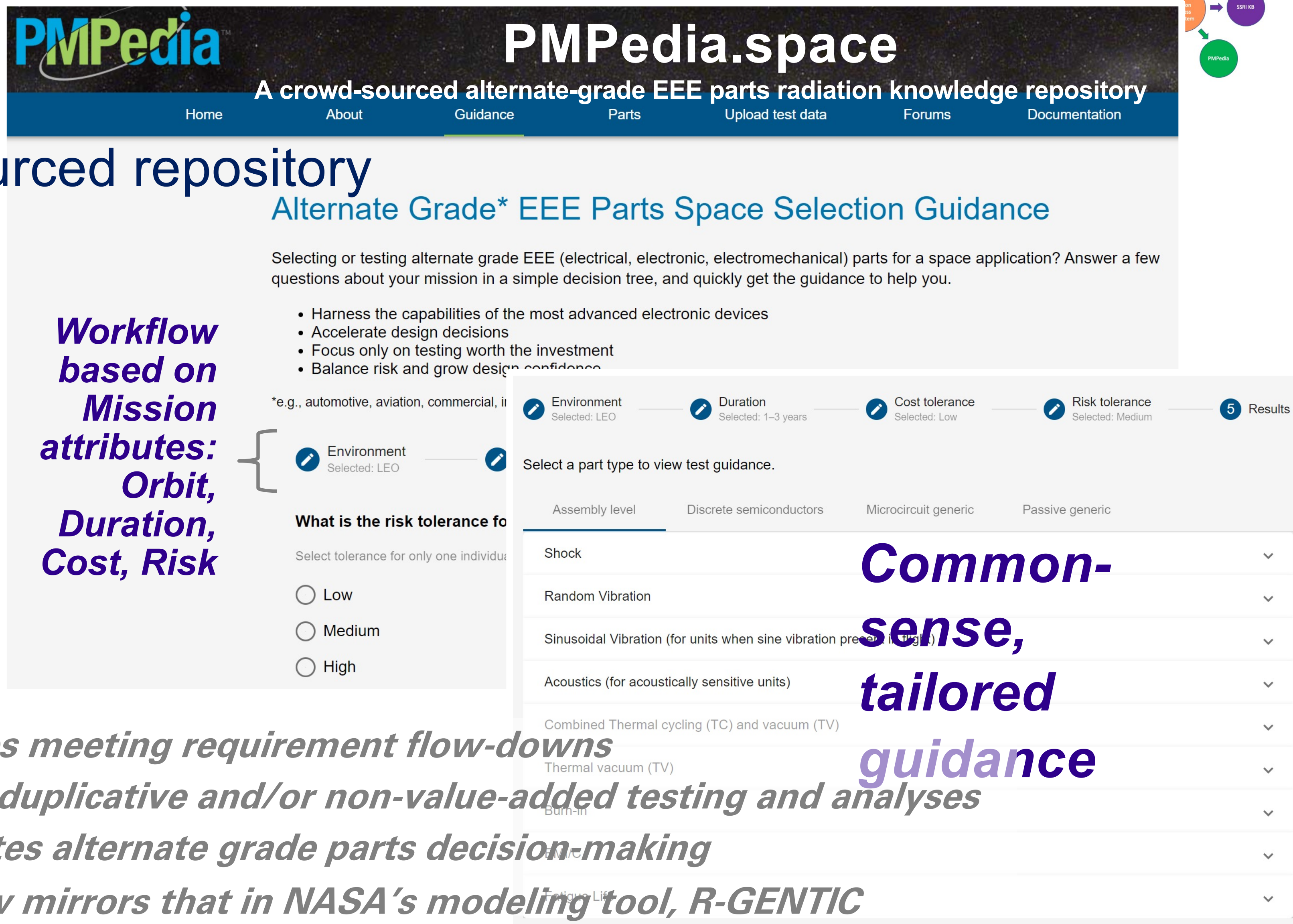
SEAM
SysML Model with Fault Propagation



Alternate Grade EEE Parts Selection & Test Guidance



Crowd Sourced repository



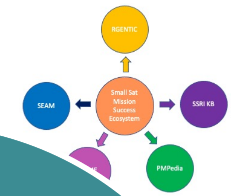
Workflow based on Mission attributes: Orbit, Duration, Cost, Risk

Content will evolve as user community experts offer updates and refinements

Common-sense, tailored guidance

- ***Facilitates meeting requirement flow-downs***
- ***Reduces duplicative and/or non-value-added testing and analyses***
- ***Accelerates alternate grade parts decision-making***
- ***Workflow mirrors that in NASA's modeling tool, R-GENTIC***

Alternate Grade EEE Parts Test Data Repository



Alternate Grade Part Construction, Test & Usage Data

Example part data

Analog Devices AD7983

Analog-to-Digital Converter, 16-Bit, 1.33 MSPS PulSAR in MSOP/QFN

Add to **compare**

Technology type:	CMOS
Approximate cost:	$$

Datasheet specs

- 16 bit
- Throughput: 1300 kS/sec
- Max Power Dissipation: 12 mW

Radiation tests

SEE test — LASP, 2015

TID test — LASP, 2014

SEE test — LASP, 2015

Test date:	2015
Data source:	LASP
Test facility:	TAMU
Test objective:	SEE
Results summary:	Tested up to 55 MeV-cm2/m

Test details

As-tested part number	AD7983BRMZ
Sample size ?	3
Radiation type	Heavy Ion
Flux	1.00E+04 particles/s
Fluence	1.00E+07 particles/cm^2/s
SEL LET ?	greater than 55 MeV-cm^2/mg
LETth ?	55 MeV-cm^2/mg

TID test — LASP, 2014

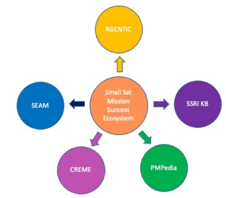
Test date:	2014
Data source:	LASP
Test facility:	ATC UMass Lowell
Test objective:	TID
Results summary:	Tested up to 50 kRad(Si). No degradation at 30 kRad(Si). Slight increase in noise a... ing at 50 kRad(Si).

Test details

As-tested part number	AD7983BRMZ
Sample size ?	3
Radiation type	Gamma
Dose rate	13000 mrad/s
TID ?	50 kRad(Si)
Max allowable TID ?	30 kRad(Si)
Other test conditions	4 units, decapped, monitor current draw on 3.3V and 5V ADC power lines

- Growing list of part types. (We need more, please!)
- Data types: radiation test data (TID, SEE, SEU), physical analyses
- Suggestions for for upcoming radiation tests are welcome

Alternate Grade EEE Parts User Discussion Forum



Search for “Part Reliability”

In reply to: What scope of power-on/turn-on data do you review?

PMPedia Admin
2020-06-19 at 12:19 pm #1444

Suggestions, Observations and Lessons Learned

In some sense, extremely short missions seem simpler than other types, just by virtue of their duration. Alternate-grade EEE parts' mean time to failure may far exceed the mission duration itself. On the other hand, these missions can be very challenging because the stakes are so high in the event of an anomaly. Therefore, prudent approaches to mitigating a mission-ending event might be to employ overly conservative redundancy schemes; selectively upgrade to higher- reliability devices for mission-critical functions; perform independent testing on a statistically significant sample of parts identical those in the mission or leverage heritage flight data, if it exists. However, these options incur costs which, in aggregate, must be weighed against the cost savings of procuring the alternate- grade part.

In reply to: Are the parts used in an application that is mission-critical?

PMPedia Admin
2020-06-19 at 12:10 pm #1434

Suggestions, Observations and Lessons Learned

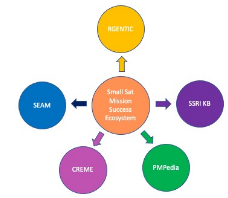
In a single-point failure or mission-critical part application, a few options are available to prevent premature end of the mission. The designers could significantly derate the part, consider selective use of a higher-quality part, add selective redundancy or invest in independent testing of identical samples.

Also as part of your architecture design and risk trade studies, it is important to evaluate the option of a single string of highly reliable units vs use of lower reliability, redundant units.

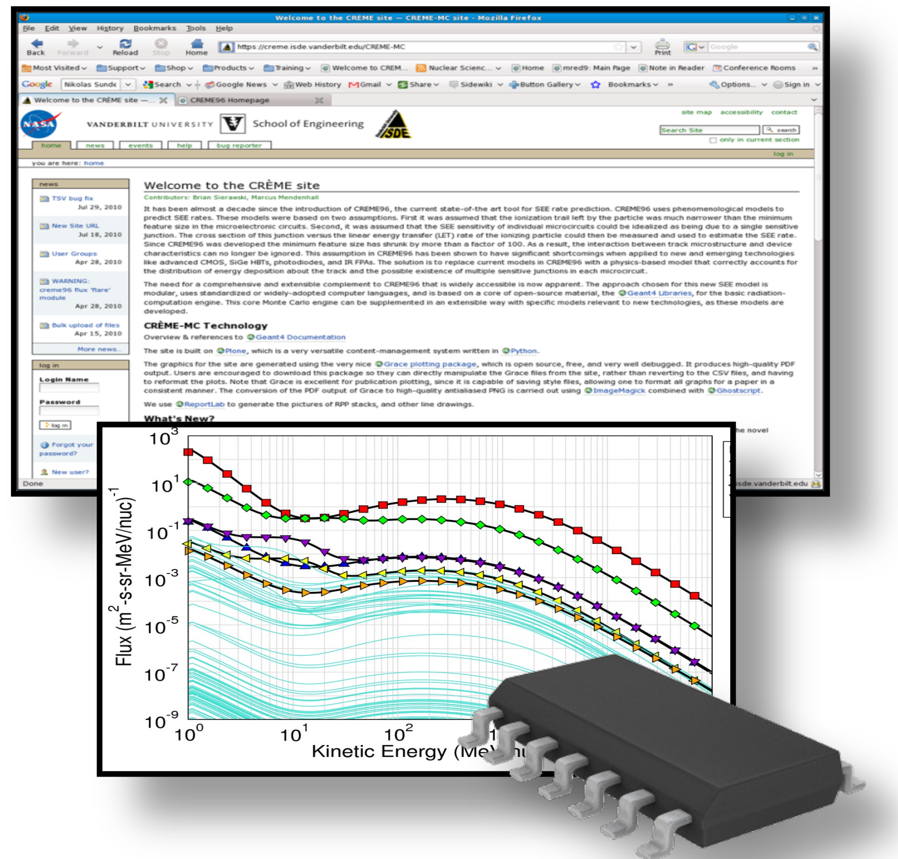
- Moderated forum
  - Q & A
  - Parts application advice
  - Common practices
  - Experience sharing
- User feedback on improvements to PMPedia™ content and usability

PMPedia is a collaboration between The Aerospace Corporation and Univ of CO-Boulder’s Laboratory for Atmospheric and Space Physics

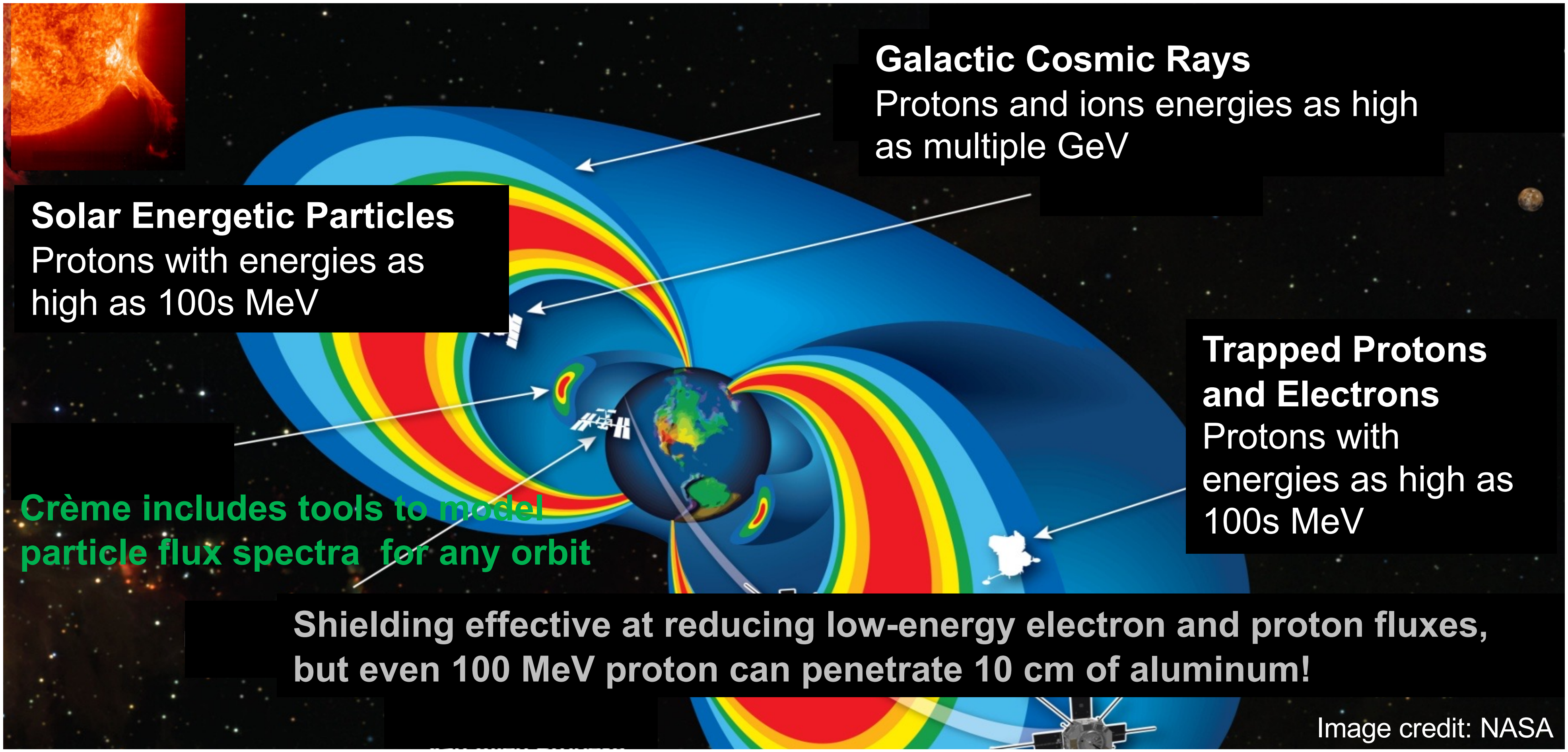
CRÈME Website



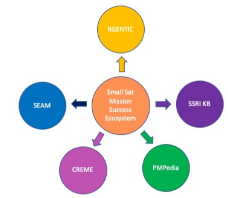
- **Single event effects** are unwanted or erroneous responses in a semiconductor device, triggered by the passage of a high energy particle
- Vanderbilt ISDE hosts the CRÈME tool suite for predicting **on-orbit error rates** and proton total ionizing dose in microelectronics
- Publicly available at https://creme.isde.vanderbilt.edu

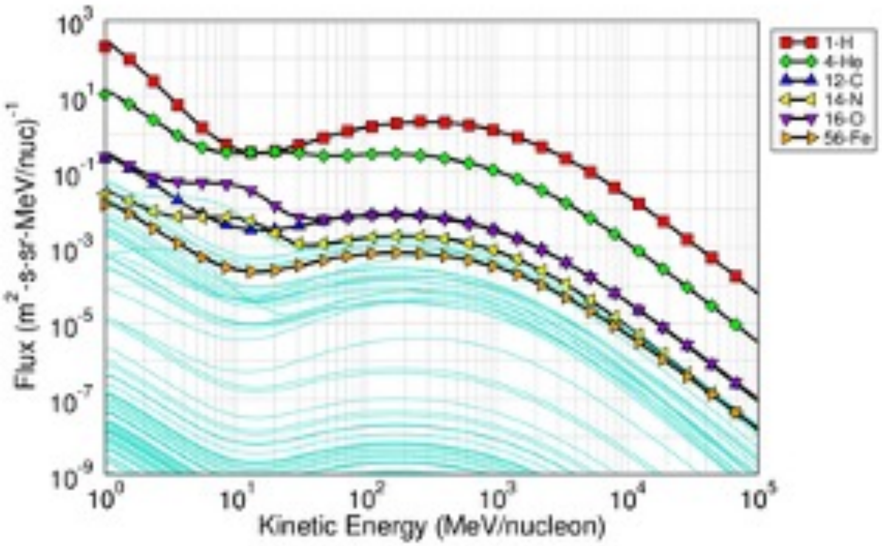


CRÈME Radiation Environments



CRÈME Radiation Environments

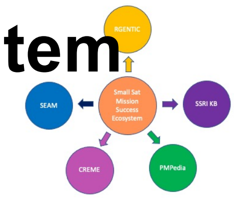




Particle flux vs. energy for different ion types from CRÈME

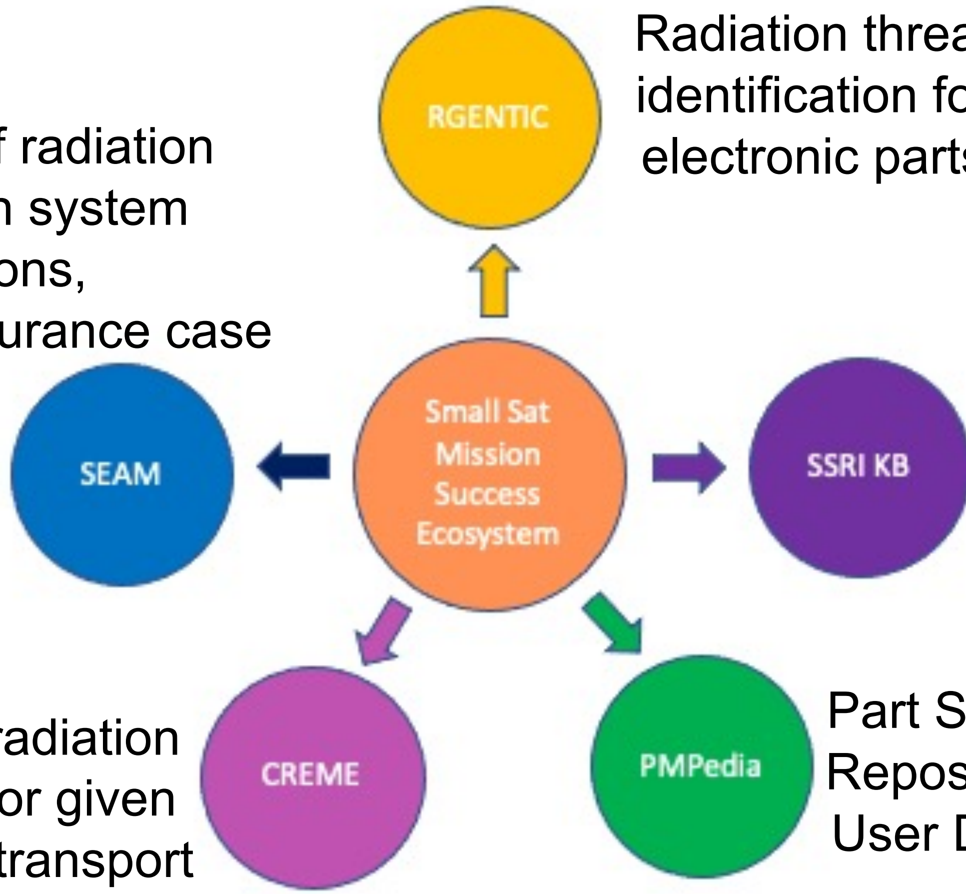
- Near-earth rad environment modulated by magnetosphere
- Many ions are deflected
- Protons and electrons particles trapped in radiation belts
- Transport software shows how energetic particles interact with spacecraft materials
  - Low energy particles stopped
  - High energy particles slowed
- Information for single-event error rate prediction

Summary: Small Sat Mission Success Online Ecosystem



Radiation threat identification for electronic parts

Modeling of radiation impacts on system functions,
Hardness assurance case



"Wikipedia for Satellites"
Knowledge base
Best practices

Characterize radiation environment for given orbit, material transport

Part Selection guidance
Repository rad test data
User Discussion Forum