An Online Knowledge Base to Improve Small Satellite Reliability

NEPP Electronics Technology Workshop 2020

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Sedaro Technologies

SSRI Knowledge Base

A website to provide high-quality resources on topics that drive SmallSat mission confidence

Key Organizations

Small Satellite Reliability Initiative (SSRI)

The SSRI seeks to share resources, best practices, and lessons-learned that improve mission confidence for small satellites while, to the extent practical, considering the constraints and maintaining the efficiencies associated with these missions.

## Small Spacecraft Systems Virtual Institute (S3VI)

The mission of the Small Spacecraft Systems Virtual Institute (S3VI) is to advance the field of small spacecraft systems and allied sciences by promoting innovation, exploring new concepts, identifying emerging technology opportunities, and establishing effective conduits for collaboration and the dissemination of research results relevant to small spacecraft systems and subsystems.

Problem Identification

CubeSat Mission Status 2000-Present
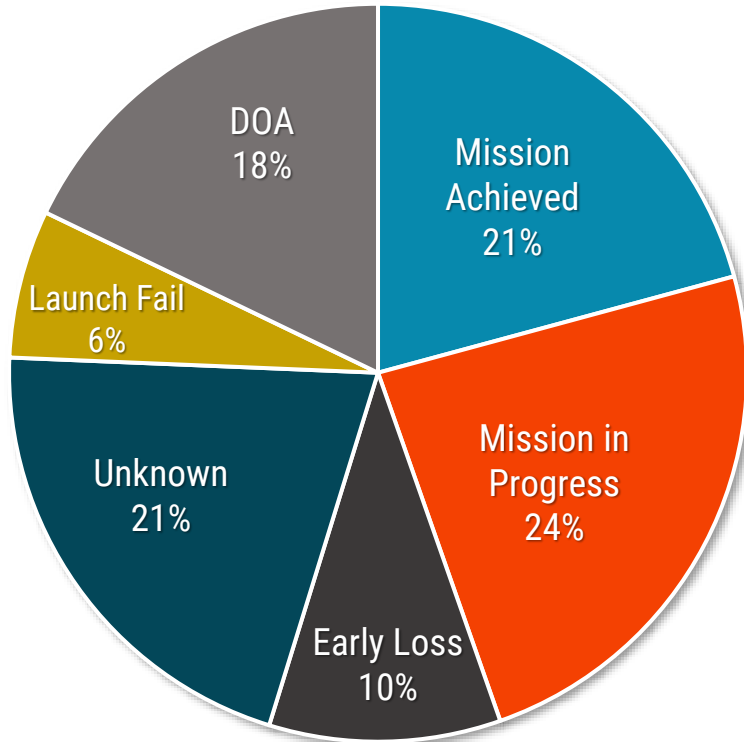

Data from M. Swartwout

- Too many small satellites fail

- Teams lack standard process and institutional knowledge

- No quality, public forum for sharing best practices and quality resources

SmallSat development teams and stakeholders (scientists, investors, funding agencies, etc.) need an efficient way to improve mission confidence. A lack of knowledge sharing is a significant contributor to high failure rates.

High-Level Goals and Approach

- Avoid prescriptive solutions
- Target a wide audience

- Fast, lean, development
- Adaptable, extendable

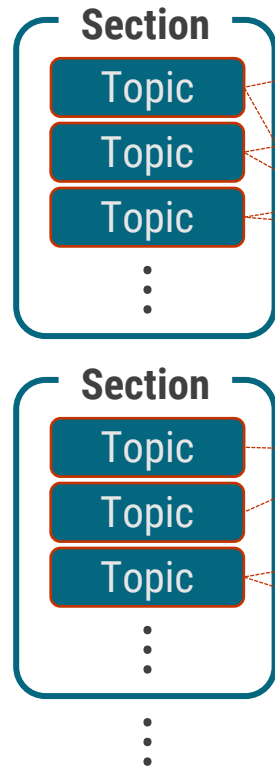Minimum Viable Product (MVP)

blog.bonzertech.com
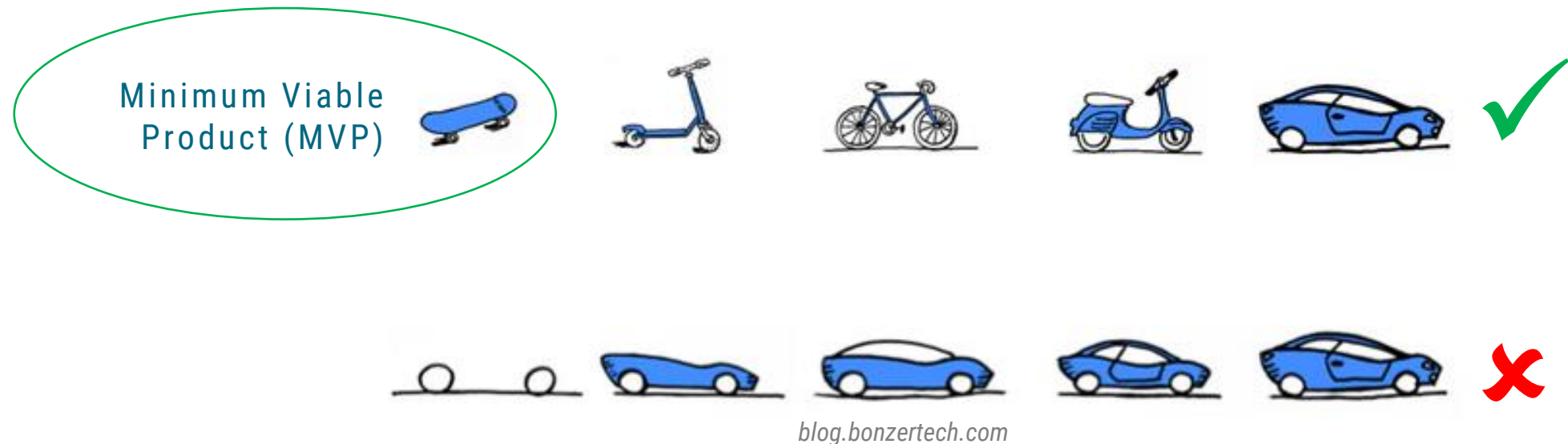
The SSRI aims to create a "minimum viable product" that quickly and efficiently starts improving SmallSat mission confidence and yields feedback/results to inform further work. This product should allow teams to better leverage commercial SmallSat capabilities by avoiding prescriptive solutions and targeting a wide range of risk postures.

Architecture

Mission Confidence Framework

- *Order and structure for the content*

- *Organizing and contextualizing resources to maximize their value to the target audience(s)*

- *Where users can participate and add value to each topic page*
  - *Ratings for each resource*
  - *Comments and Q&A*

Section
- Topic
- Topic
- Topic
⋮

Section
- Topic
- Topic
- Topic
⋮

⋮

Resource Library

- Resource
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⋮

- *The content*

- *Articles, websites, software tools, books, standards, SSRI white papers*

- *Description in the context of SmallSat mission confidence*

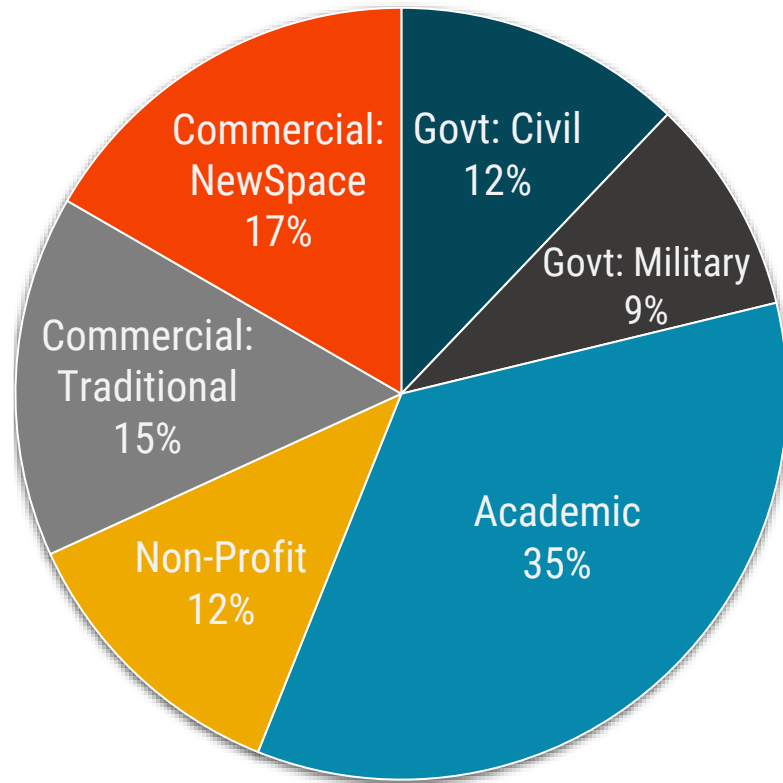- *Downloads or links whenever possible, otherwise just a reference*
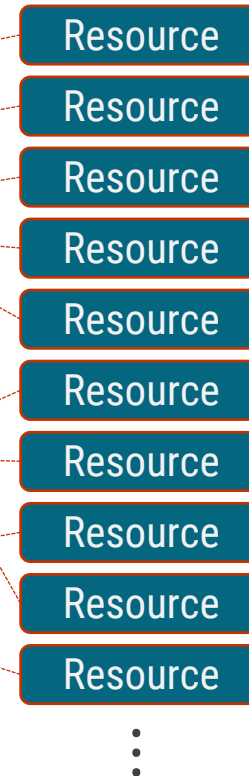
The Knowledge Base will leverage existing resources and add value to them by providing SmallSat-specific guidance on their use. Resources will be organized into topic pages within the *Mission Confidence Framework* - an easy to navigate graphical table of contents.

User Base Survey Findings

Respondent Demographics

Pie chart: Respondent Demographics
- Govt: Civil 12%
- Govt: Military 9%
- Academic 35%
- Non-Profit 12%
- Commercial: Traditional 15%
- Commercial: NewSpace 17%

- 70% prefer user comment interface on each topic page instead of centralized forum

- 40% recommended resources to include

- 40% offered to contribute resources from their organization

- 53% prefer a "Mission Phase and Task" structure for the Mission Confidence Framework

- Strong support (>80%) for resource search and rating features

User base feedback has driven the final selection of the Mission Confidence Framework structure, website features, and user interfaces. Future users have already contributed content to the site by recommending public resources and offering internal resources from their organizations.

Visual Design Approach

Priorities

Simplicity

- Less distraction and clutter
- Allows for quick and efficient development of MVP
- Easier to update, grow, and evolve

Utility

- Provide users with information
- Be efficient with users' time and energy

Aesthetic

Informal

Clean

Avoid:

- Harshly technical
- Aggressive/tactical

Website Prototype Walkthrough

SSRI KNOWLEDGE BASE
RESOURCES FOR SMALLSAT SUCCESS

Explore   About   Resource Search
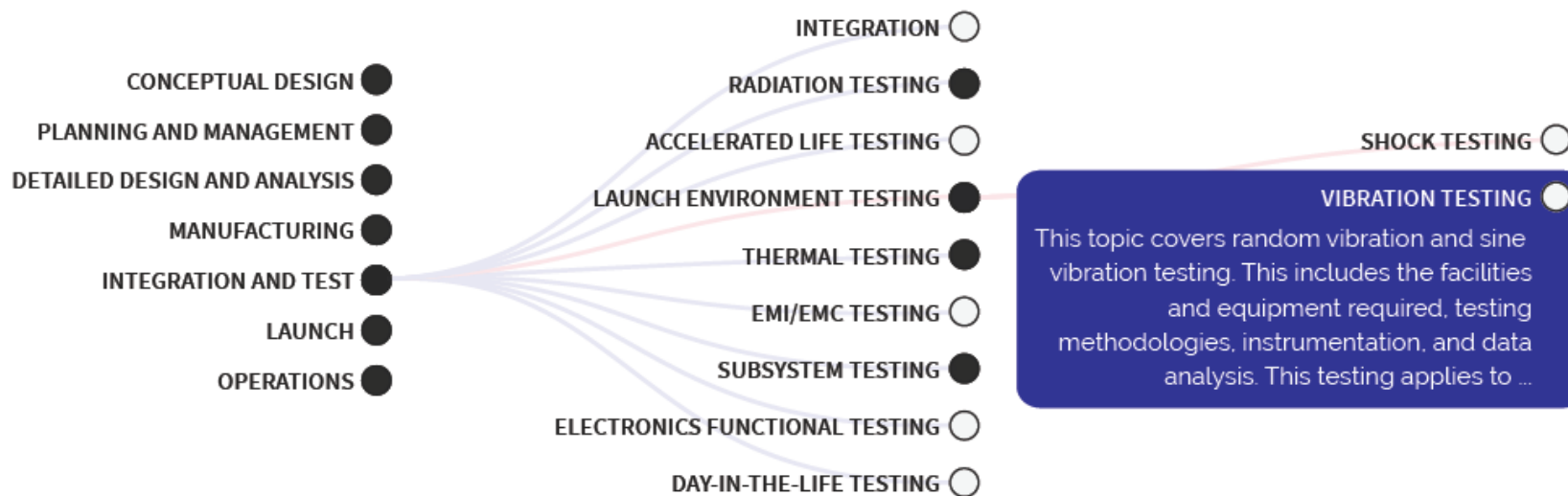
This tool provides high-quality resources on topics that drive SmallSat mission confidence. Explore the Mission Confidence Framework to find your desired topic page. The topic page will include best practices and lessons learned from experienced SmallSat developers and will provide you with links to high-quality, curated resources (books, articles, software tools, websites, articles and white papers). You can also search the resource library directly using the search bar above.

MISSION CONFIDENCE FRAMEWORK

● Hover over a **section** node to preview its children and click to select

○ Hover over a **topic** node to preview the topic and click to open

CONCEPTUAL DESIGN ●

PLANNING AND MANAGEMENT ●

DETAILED DESIGN AND ANALYSIS ●

MANUFACTURING ●

INTEGRATION AND TEST ●

LAUNCH ●

OPERATIONS ●

INTEGRATION ○

RADIATION TESTING ●

ACCELERATED LIFE TESTING ○

LAUNCH ENVIRONMENT TESTING ●

THERMAL TESTING ●

EMI/EMC TESTING ○

SUBSYSTEM TESTING ●

ELECTRONICS FUNCTIONAL TESTING ○

DAY-IN-THE-LIFE TESTING ○

SHOCK TESTING ○

VIBRATION TESTING ○

This topic covers random vibration and sine vibration testing. This includes the facilities and equipment required, testing methodologies, instrumentation, and data analysis. This testing applies to ...

MCF > Integration and Test > Launch Environment Testing >

Vibration Testing

Scope and Description

This topic covers random vibration and sine vibration testing. This includes the facilities and equipment required, testing methodologies, instrumentation, and data analysis. This testing applies to components, subsystems, and full spacecraft. This standard provides requirements and guidelines for environmental verification programs for GSFC payloads, subsystems and components and describes methods for implementing those requirements. It contains a baseline for demonstrating by test or analysis the satisfactory performance of hardware in the expected mission environments, and that minimum workmanship standards have been met.

Best Practices and Lessons Learned

- Ensure that your vibration test fixture is designed to provide a flight-like interface for the test article. A test fixture that over-constrains your test article will not provide accurate results. For full spacecraft testing, use an actual separation mechanism or separation mechanism simulator.

- This standard provides requirements and guidelines for environmental verification programs for GSFC payloads, subsystems and components and describes methods for implementing those requirements. It contains a baseline for

- This site offers software & tutorials for acoustics, shock & vibration analysis. Training and consulting are also available. The software and tutorials require a username and password which are given by subscription. The subscription

- Complete 3D software tools that let you create, simulate, publish, and manage your data.SOLIDWORKS solutions are easy to deploy, easy to use, and simple to administer. Instead of spending time maintaining your CAD system, you can

Resources

☑ Article ☑ Book ☑ Software Tool ☑ White Paper ☑ Standard ☑ Website   **Filter**

Solidworks Simulation ⧉
★★★★⯪ **Rate**
Software Tool
Daussalt Systemes
Complete 3D software tools that let you create, simulate, publish, and manage your data.SOLIDWORKS solutions are easy to deploy, easy to use, and simple to administer. Instead of spending time maintaining your CAD system, you can capitalize on new opportunities, reduce costs and get to market faster.

General Environmental Verification Standard 🗎
★★★★☆ **Rate**
Standard
NASA GSFC
This standard provides requirements and guidelines for environmental verification programs for GSFC payloads, subsystems and components and describes methods for implementing those requirements. It contains a baseline for demonstrating by test or analysis the satisfactory performance of hardware in the expected mission environments, and that minimum workmanship standards have been met. It elaborates on those requirements, gives guideline test levels, provides guidance in the choice of test options, and describes acceptable test and analytical methods for implementing the requirements.

VibrationData.com ⧉
★★★⯪☆ **Rate**
Website
Tom Irvine
This site offers software & tutorials for acoustics, shock & vibration analysis. Training and consulting are also available. The software and tutorials require a username and password which are given by subscription. The subscription instructions are given below. The subscription entitles the user to download all of the items on this page. The subscription is valid for twelve months.

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Vibration Testing of Small Satellites ⧉
★★★⯪☆ **Rate**
White Paper
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Complete 3D software tools that let you create, simulate, publish, and manage your data. SOLIDWORKS solutions are easy to deploy, easy to use, and simple to administer. Instead of spending time maintaining your CAD system, you can capitalize on new opportunities, reduce costs and get to market faster.

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Get Involved

Please submit feedback, questions, recommended resources, or your own lessons learned and best practices on this topic:

Provide your email for follow up: _____ (Optional)

Submit

☑ Article   ☑ Book   ☑ Software Tool   ☑ White Paper   ☑ Standard   ☑ Website   **Filter**

Resource Search Results

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Book
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Space Mission Engineering:The New SMAD is an entirely new approach to creating both a text and a practical engineering reference for space mission design. Just as space technology has advanced, the way we learn and work has changed dramatically in recent years. SME combines the best features of a traditional unified text and reference covering the entire field, an electronic version that does many of the calculations for you, and the web that allows regular updates and references to the vast literature base available online. Among the many features of this new edition.

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★★★★⯪ Rate

Rate this Resource

This text will provide guidance to users on how to select a star rating for a resource in the Knowledge Base. This will encourage consistent and quality ratings.

★ ★ ★ ⯪ ☆

Submit

Knowledge Base Content Discussion

Content Generation

Sedaro development team is writing all final website content

- Consistency in following high-level content style/format guidelines
- Minimizing burden on volunteers

We need input from subject matter experts (SME's)!

- Selecting the best, highest impact resources for each topic
- Populating *Best Practices and Lessons Learned* section on each topic page
- Development team will conduct brief (<30 minute) phone calls with volunteer SME's to get input and feedback on drafted topic pages

Relevant Topics for the ETW Audience

- SEE Testing

- TID Testing

- Accelerated Life Testing

- Burn-In

- Thermal Cycling

- Electronics Functional Testing

- Vibration Testing

- Shock Testing

- Thermal Analysis

- Structural Analysis

- **Part Selection**

- Circuit Analysis (FMECA, FMEA, WCA)

- Reliability Analysis

- Radiation Analysis

We are populating a sign-up spreadsheet to match SME volunteers to topics

Please email robbie.robertson@sedarotech.com if you are willing to contribute to the SSRI Knowledge Base as a topic page SME (or can recommend someone else)

Part Selection

From M. J. Campola Et al. presentation from ETW 2018:

- "SmallSat schedule, budget, size, mass, and other resource constraints dictate that the traditional NASA EEE parts paradigm is inappropriate (and in many cases IMPOSSIBLE) for SmallSats"

- "An alternative EEE parts selection approach based on risk trades at the system and component level should be explored"

Part Selection

Articles	Books	Software Tools	White Papers	Standards	Websites
		PMPedia	EEE Parts Guidelines for SmallSat Missions	EEE-INST-002 ASTM E595 MIL-STD-883 MIL-STD-750 MIL-STD-202 MIL-STD-1580	PMPedia S3VI Small Satellite Information Search NEPP RADHOME JPL RADATA (not working?) ESA ESCIES

Need introductory guides (e.g. what is derating?)
Need foundational book(s) on this topic
Articles/white papers providing high-level guidance on SmallSat part selection

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Thank You!

SSRI Knowledge Base Planned Release:

July 2020

Have questions, comments, or resource suggestions?

Want to get involved?

Please Email Robbie Robertson at

robbie.robertson@sedarotech.com