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Small Satellite Reliability Initiative (SSRI) Knowledge Base Tool: Use Case Review and Future Functionality and Content Direction

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ABSTRACT

The Small Satellite Reliability Initiative (SSRI) Knowledge Base is a comprehensive and searchable online tool that consolidates and organizes resources, best practices, and lessons learned from previous small satellite missions sponsored by NASA, other government agencies, and academia. This free, publicly available tool is available to the entire SmallSat Community.

The SSRI Knowledge Base provides vetted, high-quality sources of information on elements that are key to successful small satellite missions. These resources include SSRI working group generated documents and presentations in addition to existing guides, publications, standards, software tools, websites, and books. The Knowledge Base is fully searchable, offers downloadable content when possible, and otherwise links to or references content directly from within the tool.

This presentation and paper will discuss the motivation for the SSRI Knowledge Base, review educational use cases, and outline plans for further development. The SSRI is a collaborative activity with broad participation from civil, U.S. Department of Defense, and both national and international commercial space systems providers and stakeholders. NASA's Small Spacecraft Systems Virtual Institute (S3VI) funds the SSRI Knowledge Base. The S3VI is jointly sponsored by NASA's Space Technology Mission Directorate and Science Mission Directorate.

MOTIVATION AND APPROACH

The SSRI Knowledge Base was created to address the following causes of unacceptably high failure rates in SmallSats:

1) SmallSat teams and stakeholders often lack standard processes and institutional knowledge to guide the design and development of successful space missions.

2) There is no quality, public forum where the disparate set of individuals and organizations developing SmallSats can access and share best practices, lessons learned, and high-quality resources.

The traditional approach to solving these problems involves document-based communication; however, developing new standards is a slow and expensive process that usually only captures appropriate processes for a particular organization. In addition, SmallSat technology is always changing, and it is difficult to keep up with the pace of innovation using traditional, document-based communication. These factors led to the creation of the SSRI Knowledge Base as a crowdsourced, web-based platform for knowledge sharing.

The goal of the SSRI Knowledge Base is to become the go-to starting point for information on the full breadth of SmallSat topics - providing high-level guidance and connecting users to in-depth, third-party resources.

KNOWLEDGE BASE STRUCTURE

As shown in Figure 1, the SSRI Knowledge Base includes two primary components: the Resource Library and Mission Confidence Framework (MCF). The Resource Library is a database of resources which provides connections to third-party content. These resources are categorized as articles, books, software tools, white papers, standards, and websites – but a few of these are defined broadly to capture almost any useful tool or source of information. In each resource entry, in addition to providing access to the resource, we add a description of it in the context of small satellite development and attach a 1-5 star rating to be set based on user input. To enable effective filtering of resource items based on what a user is looking for, resources are categorized as one of six "resource types": article, book, software tool, white paper, website or standard.

Users can search the Resource Library, but the primary way that users locate and access resources is through the second element of the SSRI Knowledge Base: the Mission Confidence Framework. We use this term to refer to the structured set of topic pages which reference resources in the Resource Library and provide order, structure, and context for SSRI Knowledge Base information. In addition to a filter-able listing of relevant resources ranked by user rating, topic pages in the MCF include SSRI and user-recommended best practices and lessons learned and user interfaces for submitting feedback and recommending new content.

CAPABILITIES AND FEATURES

Explore Page

The "Explore" page is the homepage for the SSRI Knowledge Base website, and this is where users explore the MCF interface to locate the topic page for which they are looking. The MCF interface - shown in Figure 2 - is an interactive tree diagram that allows users to quickly navigate the entire set of topic pages in a compact view. Hovering over "leaf nodes" in the tree diagram displays a preview of the topic page description associated with that node. Clicking on one of these topic page nodes brings the user to the topic page.

Extensive discussion within the SSRI Knowledge Base and a survey of the SmallSat community were used to decide on a "mission phase and task" structure for the MCF. Each topic page is associated with a task, and these topic pages are sorted into mission phase sections and (as needed) subsections to group tasks together. This tree-diagram interface will automatically update as topic pages are added to the SSRI Knowledge Base.

Topic Pages

Each topic page in the SSRI Knowledge Base has a format and structure consistent with the example shown in Figure 3. This structure includes four sections: (1) Scope and Description, (2) Best Practices and Lessons Learned, and (3) Resources

The "Scope and Description" section at the top of each topic page describes and defines the scope of the task covered on that page. In addition to sharing valuable high-level information on the topic, this content serves to prevent overlap between topics and make the scope of included information clear to users.

The next section on each topic page is "Best Practices and Lessons Learned", which provides users with a list of concise pieces of guidance from experienced subject matter experts on the topic. These are not required to be consistent in tone or style but should provide valuable information to inform users' approach to their completion of the task. If a user has not already rated a best practice or lesson learned, they can provide a rating.

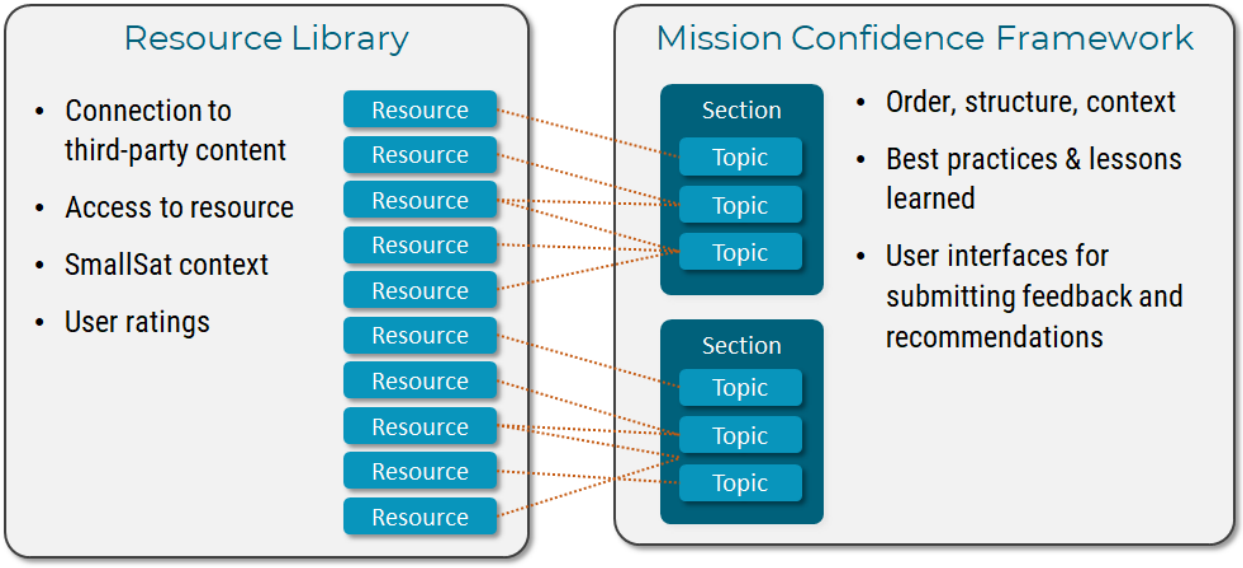

Figure 1: Small Satellite Reliability Initiative Knowledge Base Structure.
Credit: NASA/Sedaro Corporation

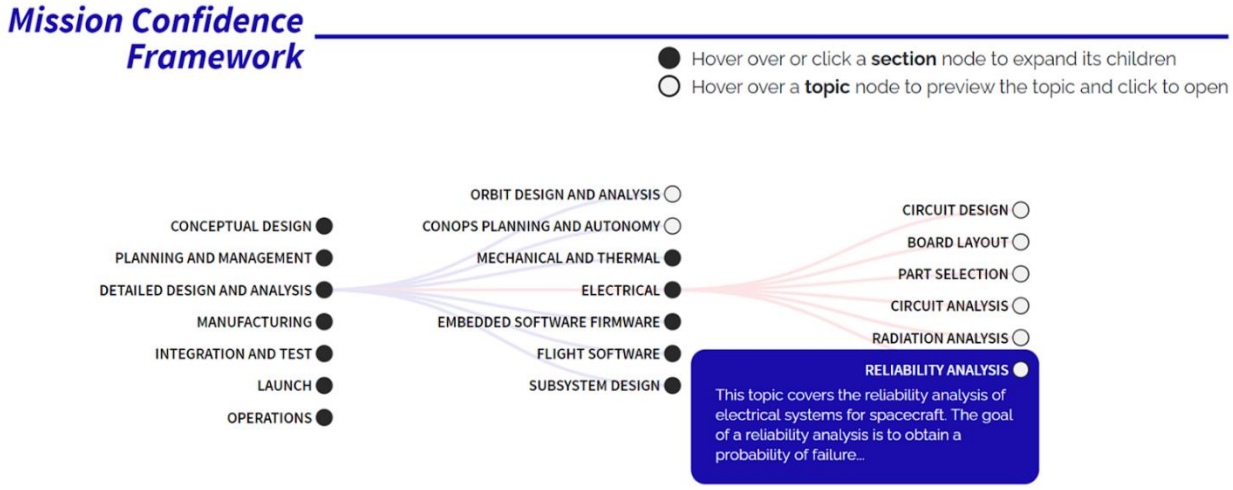

Figure 2: Mission Confidence Framework Interface
Credit: NASA/Sedaro Corporation

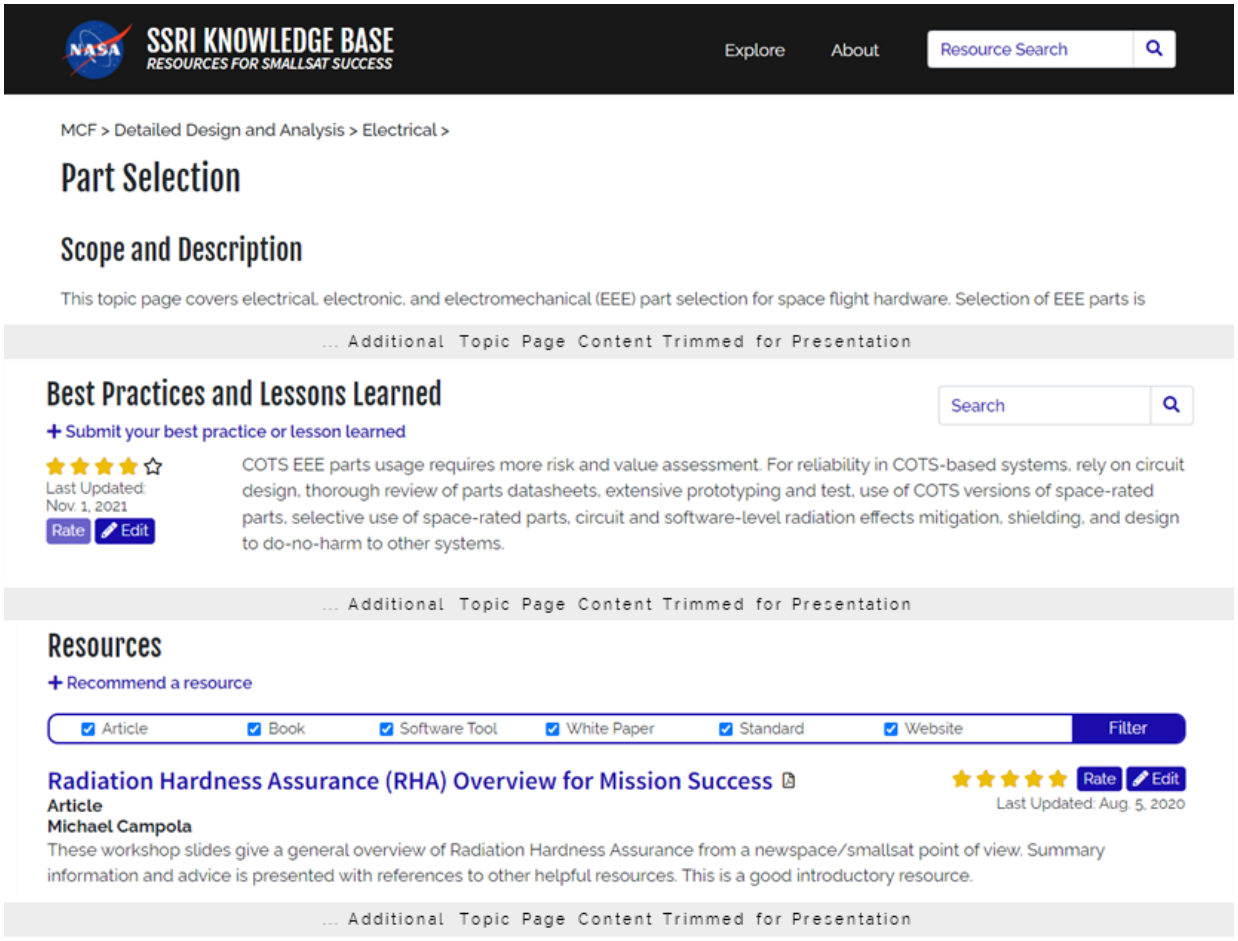

Figure 3: Example Small Satellite Reliability Initiative Knowledge Base Topic Page
Credit: NASA/Sedaro Corporation

The third section, titled "Resources", provides a listing of entries in the Resource Library that is relevant to the task covered by the topic page. Users can access these third-party resources by clicking on their title. The resource list can be filtered by type (e.g., article, book, software tool) and is automatically sorted by average user rating. If a user has not already rated a resource, they can rate it based on their experience using it on their SmallSat project(s).

Users are encouraged to utilize the crowdsourcing interfaces to rate content, recommend new content, the removal of existing content, or edits to existing content.

Baseline Content and Moderation Process

Baseline content has been incorporated for all 58 topic pages currently in the SSRI Knowledge Base. This baseline content has been created and reviewed by subject matter experts from NASA, other government agencies, industry, and academia. The Knowledge Base development team is using feedback from members of the SSRI, NASA stakeholders, and users to improve the website and inform the ongoing development of additional topic pages.

Acknowledging the constant increase and varied sources of small satellite knowledge, along with the value and depth of knowledge that exists beyond any single development team, the SSRI Knowledge Base is designed to be an open, collaborative platform. User participation is essential to the refinement and growth of the Knowledge Base. Therefore, all users are encouraged to rate resources and to submit feedback, questions, lessons learned, and best practices over the course of their mission lifecycle. Once baseline content is complete, the focus for the Knowledge Base team will be moderating the content in response to input from the user community.

User ratings on resources are immediately reflected in the content. Cookies, reCAPTCHA, and analytics are

used to identify and mitigate the influence of biased repeat ratings by a single user or by bots. Minor corrections to content and bug-fixes are managed by the website administration team directly. If a user recommends new content (i.e., a resource, best practice, or lesson learned) or substantive changes to existing content, then the administration team will forward the recommendation to the SSRI group for review. This moderation by the SSRI in conjunction with input from the user base will ensure the quality of SSRI Knowledge Base content.

Application Program Interface

The SSRI Knowledge Base application programming interface (API) enables a variety of use cases for information in the Knowledge Base. Anyone developing a website in the small spacecraft community can leverage the information in the Knowledge Base to incorporate references to resources or Best Practices and Lessons Learned (BPLL) in their workflows. API documentation is available at https://s3vi.ndc.nasa.gov/ssri-kb/api/.

EDUCATIONAL USE CASES

The SSRI Knowledge Base can be adapted to multiple educational use cases to streamline SmallSat development and increase chances of mission success. These educational use cases consist of but are not limited to: integration into current university SmallSat related courses, use for academia to transfer lessons learned and knowledge content from class to class, and to educate principle investigators (PIs) for SmallSat programs. Through the recent challenges of virtual work and amid the increasing prevalence of remote collaboration, the ability to transfer knowledge has been difficult. The Knowledge Base can addresss this need by passing along lessons learned and valuable resources from class to class. Providing training and education to PIs is vital to ensuring that the next generation of project leads have the resources necessary to lead SmallSat missions.

FUTURE ENHANCEMENTS

As a web-based tool, the SSRI Knowledge Base can be continuously improved and expanded. Enhancements to the Knowledge Base are driven by feedback from the user community via submissions to the General Feedback interface on the website's About page. Feedback is also solicited virtually or in-person at conferences and other industry events. In addition, SSRI members and NASA stakeholders regularly discuss opportunities to improve the Knowledge Base and encourage its integration into programs and with other online tools.

Near-term priorities include improved linking to PDF documents and interfacing with other online tools via the new Knowledge Base API. Most resources in the Knowledge Base are PDF documents. Many of these documents are very large and have been split into multiple Resources – distinct entries in the SSRI Knowledge Base. With improved PDF linking, when a user selects a PDF resource that has been split, the PDF viewer that opens in a new browser tab will automatically navigate to the first page of the section associated with the selected resource. This will improve user experience and allow users to more efficiently find the information they are looking for.

There is a diverse array of online tools – both from NASA and other organizations – which are free to SmallSat developers and provide complimentary capabilities. It is a high priority for the SSRI to identify Knowledge Base API integrations with these tools that can deliver value to further our mission of educating SmallSat developers. For example, educational tools can directly integrate our content with their own and digital engineering tools can utilize our information to provide dynamic, contextual guidance in their workflows.

The SSRI is constantly exploring options to expand the publicly available SmallSat content and features provided in the SSRI Knowledge Base to maintain relevance to Smallsat users and developers. We are soliciting feedback and recommended content from the entire SmallSat community to be incorporated into the tool to make it an all-encompassing resource. If you have any recommended sources and/or capabilities for the tool you can utilize the "Recommend a Resource" and "General Feedback" features located within the site to add your suggestions.

SUMMARY

In this presentation and paper, the motivation for the SSRI Knowledge Base was discussed, we described the existing tool, reviewed educational use cases, and outlined plans for further enhancements. The SSRI Knowledge Base was first initiated and developed from a collaboration between the SSRI and NASA's S3VI and is a free publicly available tool for the SmallSat community. The goal of this tool is to become the initial starting point to research information on a wide variety of small satellite topics and resources. The Knowledge Base is constantly being updated with new topic pages, resources, best practices, and enhancements to meet the needs of the small satellite community.