



# A Tailored Systems Engineering Process for the Development of CubeSat Class Satellites

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## I. Abstract

It may not be feasible to apply complex Systems Engineering (SE) methodology to most CubeSat developments, but they can be improved by utilizing a rigorous but tailored process. The present work aims to develop and implement an optimized SE process for student-run CubeSat projects.

## II. Background

CubeSats are frequently utilized in education and research and can provide inexpensive access to space. At the U.S. Naval Academy (USNA), the Small Satellite Program has been developing student-built project satellites since 2001 and CubeSats since 2012. Due to the short schedules and small budgets associated with these projects, they typically do not employ traditional SE processes. A recent NASA study indicated that small satellites generally and CubeSats in particular have a higher failure rate than larger satellites. A lack of SE principals may be an impediment to the success of student-built CubeSats.

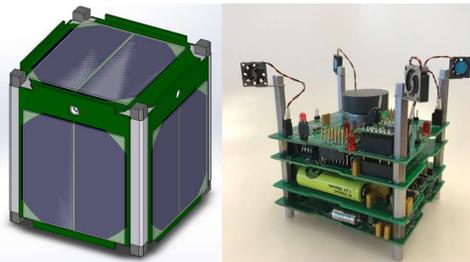
## III. Curriculum

A subset of senior capstone students in Aerospace Engineering at USNA form small teams to design, build, test, and launch a CubeSat. Currently, these projects are conducted with very cursory or no SE processes. The students follow instructions provided to them including a timeline of deliverables and reviews. The year-long capstone is the first time the students see an open-ended design problem. The challenge is that there are so many requirements students often don't have time to give necessary attention to each aspect of design.

## IV. Methodology

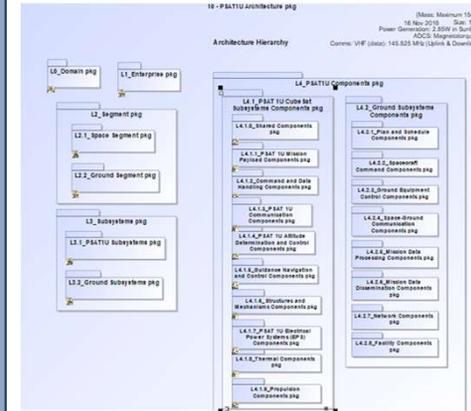
To understand the current state from the perspective of both students and subject matter experts, surveys were distributed at various milestones throughout the capstone development cycle of the 2019-20 academic year in order to ascertain the areas of most need in improving SE processes. These data were collected for the full academic year and will be analyzed to determine the most pressing deficiencies. In addition, data from successful CubeSat and Small Satellite missions was collected and will be combined with the local survey data to determine processes worth focusing on. Regression analysis and sensitivity analysis will be conducted to determine which activities are within scope and which can be ignored.

## V. PSAT1U CubeSat

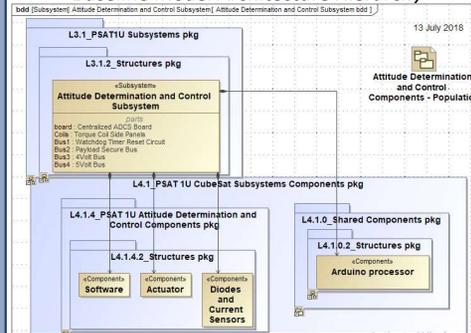


As the need for a simple build template for CubeSats was identified at USNA, the Parkinson Sat 1U (PSAT1U) system was developed. It serves as a modular architecture with easily accessible parts that enables a complete satellite bus development in three weeks. This allows students to focus on designing and implementing their preferred on-board payload and mission systems without spending undue time carrying trade studies on well understood subsystems and components.

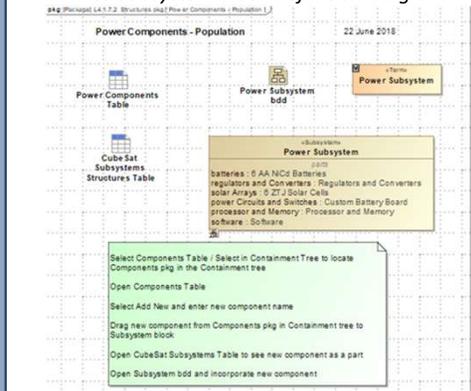
## VI. Baseline Model



Baseline Model Architecture Hierarchy



ADCS Subsystem Block Definition Diagram



EPS Package Diagram

## VII. Model-Based SE

In order to enhance the capability of the PSAT1U design for teaching and flying mission payloads, the technique of Model Based Systems Engineering (MBSE) is utilized. This baseline model, developed using the CubeSat System Reference Model (CSRSM) will serve as a reference architecture for future student-built systems. The baseline model is unique in that it defines all of the important subsystems, components, and interfaces of the PSAT1U, but leaves the payload and mission specific modules undefined. This allows a user to understand the design space clearly and tailor the system to their mission application.

## VIII. Conclusion

A methodology has been devised to develop and implement an optimized SE process for CubeSats. Survey data was collected over the 2019-20 academic year to determine the most needed SE processes to address. Additionally, the importance of utilizing MBSE has been identified. Future work will include the continued collection of survey data from subject matter experts and students, reduction and analysis of these data, improvement of the MBSE reference model, and ultimately the development of a written guide to be disseminated to future students. Once developed, the tailored SE guide will be implemented and project success measured against results from previous years when the guide was not available.

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