



Learning from past missions for today's case studies

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Problem Statement/Abstract

The extensive selection of SmallSat subsystem parts and service providers present unique challenges for mission design and implementation. It is difficult to quantify the viability and robustness of desired products and services, truly understand what solutions exist, account for unique failures from previous SmallSat missions, and capture and disseminate relevant lessons learned, experienced anomalies, and programmatic issues in both the laboratory and on-orbit setting. These types of information can be extremely sensitive, are specific to each unique mission, and not made publicly available.

Common Challenges and Best Practices



COMMON ISSUE

Inadequate Requirements Definition

Lack of coordination between stakeholders, as well of misunderstandings regarding the purpose of requirements can lead to contradictory, overly constraining or unverifiable requirements that result in poor system design or implementation.

BEST PRACTICES

- Ensure requirements are written correctly, are technically correct, satisfy stakeholders, are feasible, verifiable, and not redundant or over-specified.
- Ensure requirements enable the description of all inputs, outputs, and required relationships between inputs and outputs, including constraints, and system interactions with operators, maintainers, and other systems.



COMMON ISSUE

Communication Breakdown

Breakdown in communication across stakeholders, partners, commercial providers, and spacecraft team often results in different interpretation of system goals and interface definitions, where misunderstandings can necessitate last minute (costly) fixes.

BEST PRACTICES

- Communication and iteration with the relevant stakeholders, partners, commercial providers, and team are essential to ensure a mutual understanding of interface definitions and requirements.
- Iterative and open communication are a critically important part of project validation to confirm that the right products and results are being developed.



COMMON ISSUE

Risk Management

Issues often arise when assessing and managing a project's Safety, Technical, Cost, and/or Schedule risks. These issues include: 1) mismatch between stakeholder expectations and the true resources required to address the risks to achieve those expectations; 2) the miscomprehension of the risk that a decision maker is accepting when making commitments to stakeholders; and 3) the miscommunication in considering the respective risks associated with competing alternatives.

BEST PRACTICES

- Understand the constraints
- Establishment of the level of risk tolerance from the stakeholder, and buy-in on the cost implications (e.g. for redundant systems)
- Apply a level of effort to the task of risk management that provides assurance that objectives are met.
- Manage risks using iterative Continuous Risk Management and Risk-Informed Decision Making processes



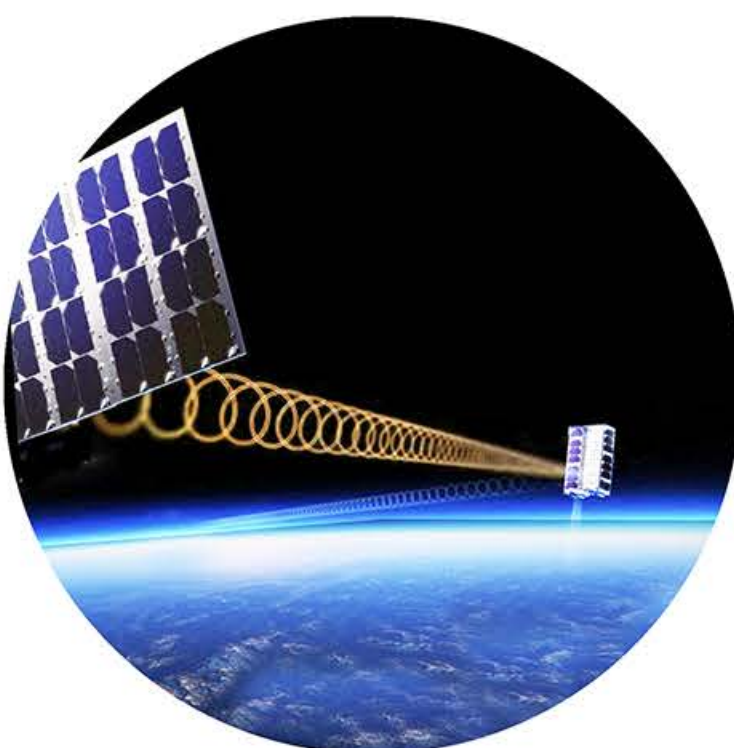
COMMON ISSUE

Hardware/Software Selection

Rapid spacecraft technology development often result in a lag or lack of information on actual hardware/software heritage, performance, reliability, and/or cost and lead times. These feed into build vs make trade studies and may result in a hardware/software selection that does not meet requirements.

BEST PRACTICES

- Cross-check claims about heritage and ensure hardware meets stated performance.
- Get involved in the small satellite community (conferences, research papers, lessons learned webinars) and seek recommendations from similar designs, trades, applications, and experiences.



COMMON ISSUE

Testing

Spacecraft technology developments often suffer from inadequate testing in non-flight configurations, performing environmental testing to the wrong levels (or in some cases too much), and/or missing/improper testing for verification and validation of requirements.

BEST PRACTICES

- Test as you fly by ensuring tests are made as flight-like as possible with minimal/no ground support equipment installed and configurations where spacecraft modes and environments are similar to what would be expected on orbit.
- Ensure testing verifies and validates requirements while staying within risk, cost, and schedule constraints.
- Ensure adequate resources and facilities are available to support required testing.



COMMON ISSUE

RF Licensing

RF licenses are complex, require long lead times, and delayed licenses can result in spacecraft being demanifested from their launches.

BEST PRACTICES

- Ensure the proper license is applied for: NTIA for government entities, FCC for commercial/ educational entities, IARU for amateur frequencies, and associated companion licenses
- Ensure the correct information is in the license applications
- Apply early, and ensure there is adequate schedule margin for application/approval
- Hire license experts if possible

Resources

- 1 **NASA CubeSat Launch Initiative (CSLI)** 
- 2 **Small Spacecraft Technology State of the Art Report** 
- 3 **Small Spacecraft Reliability Initiative (SSRI) Knowledge Base Tool** 
- 4 **SmallSat Parts On Orbit Now (SPOON)** 
- 5 **Small Spacecraft Community of Practice Webinar Series** 
- 6 **Systems Engineering and Assurance Modeling (SEAM)** 
- 7 **CubeSat 101**
Basic Concepts and Processes for First-Time CubeSat Developers 

Summary and Conclusions:

The adoption and use of existing tools and databases, as well as contributions toward the sharing of information available in literature, can help distribute useful information for future SmallSat missions to help avoid common pitfalls in mission design and implementation. The content presented here offers best practices and identifies helpful resources to assist with the multiple aspects of mission planning as well as subsystem parts and services selection.