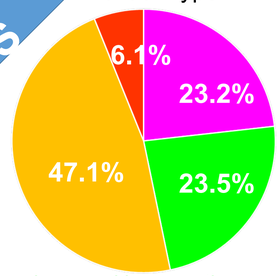
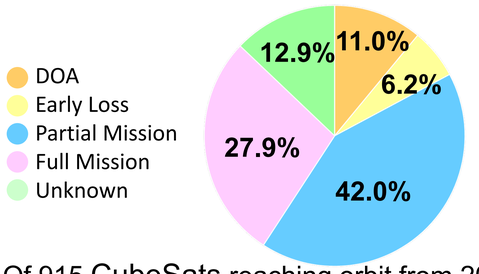
SHARE YOUR THOUGHTS

Builder Type



Hobbyists: no real experience; ad hoc practices
Crafters: experienced builder of small spacecraft; streamlined practices, experientially developed
Constellations: geographically-distributed service
Industrialists: experienced builder of big spacecraft; standard space system practices, with some truncation

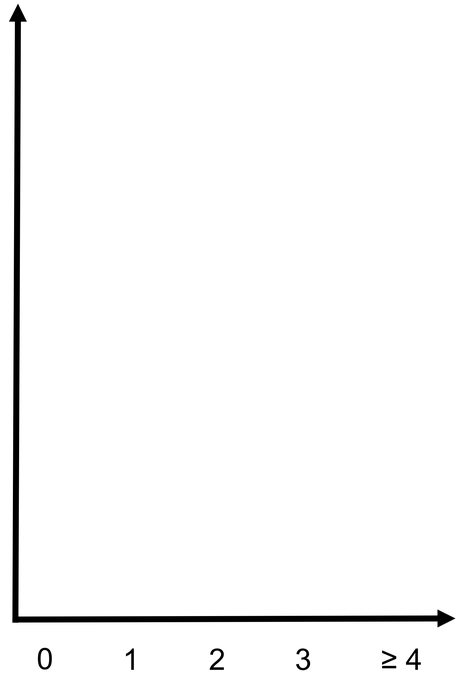
Mission Success Achieved



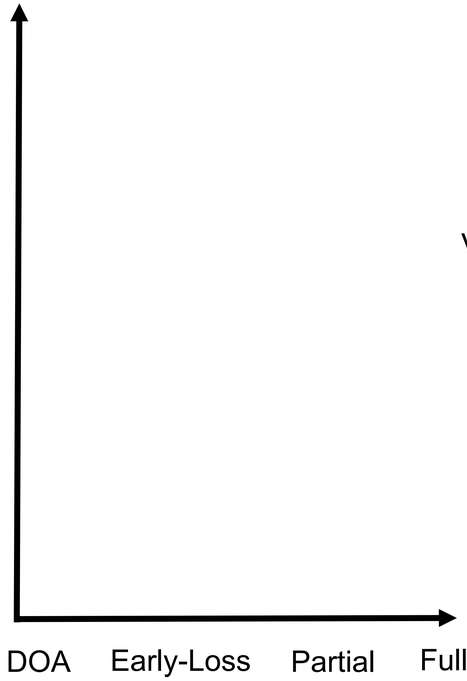
Of 915 CubeSats reaching orbit from 2000-2018

Swartwout, M., "CubeSat Mission Success: Are We Getting Better?," Proceedings of the CubeSat Developers' Workshop, CalPoly, 23 April 2019

How many satellites have you built?



What level of success did you have?



What are the MOST important practices/elements for a mission?

- Documentation
- Team Size
- Team Cohesiveness
- Requirements
- Verification Activities (e.g. test)
- Validation Activities
- Design Analysis
- Prototyping
- Reviews
- Reliability Analysis
- Funding Availability
- Schedule Flexibility
- Other?

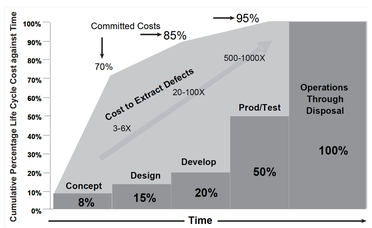
DO SMALL SATELLITES NEED NEW SYSTEM ENGINEERING AND MISSION ASSURANCE PARADIGMS?

Where do you spend the most time in a mission?

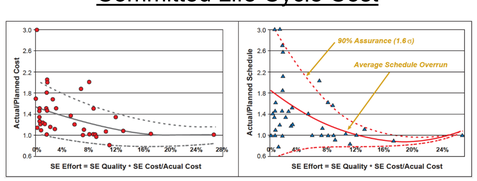
- Concept
- Design
- Build/Prototype
- AI&T
- Operations

Where has most impact to mission success?

- Concept
- Design
- Build/Prototype
- AI&T
- Operations



Committed Life Cycle Cost



Cost and schedule overrun

- Most cost is committed early in a project and the consequence of correcting problems increases greatly as a program proceeds.
- Early SE effort helps reduce cost and schedule variability and overall overruns experienced

Haskins, Cecilia, editor. Systems Engineering Handbook. A Guide for System Life Cycle Processes and Activities. 3rd ed., International Council on Systems Engineering, 2006.

Constraint-Based Mission Assurance for Small Satellites

Lee Jasper; Space Dynamics Laboratory
Lauren Hunt, Charlie Jacka, Kate Yoshino; Air Force Research Laboratory

1. **IF small satellites really <u>should</u> be faster & cheaper, THEN the scope of the mission and its development activities should focus on highest impact practices**
2. **Standards must be widely applicable and produce consistent results. The best we can achieve <u>right now</u> for constraint-based small satellites is to strive for normative satellite behaviors and/or consistent project processes.**

Implementation Methodology

HOW WELL DO WE KNOW HOW OUR SYSTEM WORKS? (e.g. analysis, testing)

TECHNICAL MARGIN (e.g. excess capability by design)

	LOW	HIGH
LOW	General approach: Project constraints strongly limit/drive available resources; expected return on investment may include factors outside mission success Possible Examples: • Student education primary goal	General approach: Heavy emphasis on project elements such as testing to verify how the system will work; constrained resources will impact response to verification results Possible Examples: • Some requirements-based missions • Design and test rigor (Verification, Validation) • Potential focus area: power system
HIGH	General approach: Purposeful design attributes / programmatic approaches reduce need for more extensive testing; needs basis for trust that things will go as planned Possible Examples: • Potential focus area: structural design • Design margin (e.g. large link margins reduce need for characterization / refinement of system), clear project definition (e.g. RVM), process definition (e.g. standard test plan), team/vendor expertise/relationship	General approach: Closest category to current standards, with purposeful flexibility built-in; more room to negotiate constraints when a problem is identified CLASS A – D MISSIONS (standards exist)

V&V Campaign

Demonstrated Level of Capability	Implication
Do No Harm	DOA is ok (education and/or fully constrained and not requirement driven)
Survival	Not DOA (power + low-rate comm). May have no higher level functionality
Minimum Functionality	Min. Mission Success. Mission Recoverable in event of fault: Ex: LEOPS/start up Ex: Maintain Formation
Nominal (payload performance driven by constraints)	Full Mission Success. Full Functionality
Nominal (payload performance driven by requirements)	Full Mission Success. Full Functionality

Space Dynamics LABORATORY
Utah State University Research Foundation

SMALL SATELLITE PORTFOLIO
AIR FORCE RESEARCH LABORATORY