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Agile Small Satellite Mission Assurance

Acquirer and Developer Best Practices and Lessons Learned for Agile, Rapid Development, Risk Tolerant, Lower-Cost Small Satellite Projects

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“It's good to learn from your mistakes. It's better to learn from other people's mistakes.”

– Warren Buffett

“Low Cost Small Satellite Project” = NASA Class D, For Example

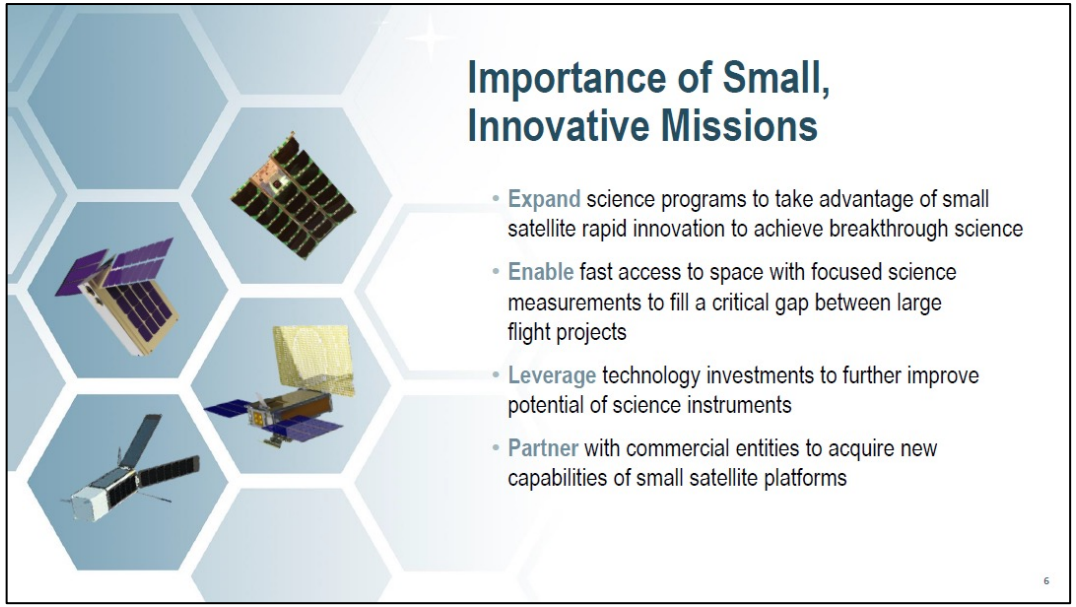
- Class D: “High risk tolerance that is driven more by programmatic constraints. This would normally represent a lower priority mission with a medium to low complexity”[1]
- Class D: “Cost and schedule are on equal or greater considerations compared to mission success risks. Technical risk is medium by design (may be dominated by yellow risks). Many credible mission failure mechanisms may exist.”[2]

Mission and Instrument Risk Classification Considerations		
Priority (Relevance to Agency Strategic Plan, National Significance, Significance to the Agency and Strategic Partners)	Very High: High: Medium: Low:	Class A Class B Class C Class D
Primary Mission Lifetime	Long, > 5 Years: Medium, 5 Years > – > 3 Years: Short, 3 Years > – > 1Years: Brief, < 1 Year:	Class A Class B Class C Class D
Complexity and Challenges (Interfaces, International Partnerships, Uniqueness of Instruments, Mission Profile, Technologies, Ability to Reservice, Sensitivity to Process Variations)	Very High: High: Medium: Medium to Low:	Class A Class B Class C Class D
Life-Cycle Cost	High : Medium to High Medium : Medium to Low	Class A Class B Class C Class D

1. NASA Procedural Requirements 8705.4A, Risk Classification for NASA Payloads
2. Goddard Procedural Requirements 8705.4, Risk Classification Guidelines and Risk-Based SMA Practices for GSFC Payloads and Systems

NASA Class D Background

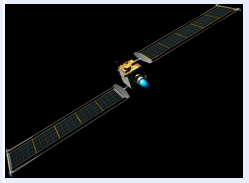
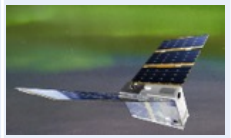
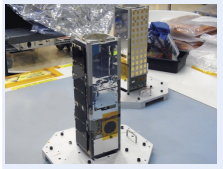
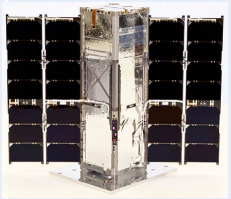
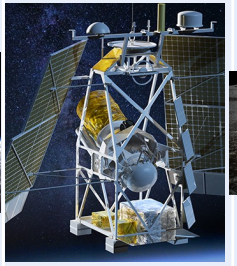
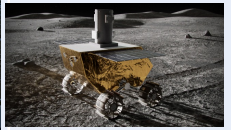
- "It's vital to continue leveraging Class-D missions to maximize science opportunities to augment our vast and robust science portfolio" – T. Zurbuchen[1]
- "These [Class D] missions are thus a critical part of the SMD mission portfolio, but only if their management processes are aligned with their overall goals…SMD has been pursuing a streamlined process for implementing Class-D missions that recognizes their unique and important role in SMD's mission portfolio, which can only occur if management processes traditionally applied to other mission classes don't inadvertently suffocate the innovative potential of these missions. We note that previous attempts for such management changes were not specific enough to drive this thought process."[2]



Zurbuchen and Robinson, "Science Mission Directorate Town Hall" January 2018

[1] NASA Press Release. "NASA Policy Provides New Approach To Space Science And Technology Missions" 8-December 2017
[2] NASA Science Mission Directorate (SMD) Class D Tailoring / Streamlining Decision Memorandum

Example Class D (Or Similar) Projects At JHU/APL

	DART Double Asteroid Redirection Test (Was Initially Class D; Reclassified as Class C)	RAVAN Radiometer Assessment using Vertically Aligned Nanotubes (Grant, not a 7120.5 project)	ORS Tech Demo-1 & -2	SKA Spacebased Kill Assessment	CAT Cubesat Assessment and Test)	EZIE Electrojet Zeeman Imaging Explorer	GUSTO Galactic/ Extragalactic ULDB Spectroscopic Terahertz Observatory	Lunar Vertex (NASA 7120.8 Research and Technology Project)	PeXT Polylingual Experimental Terminal Flight Demonstration (NASA 7120.8)	Others
Sponsor	NASA	NASA	Not NASA	Not NASA	Not NASA	NASA	NASA	NASA	NASA	Not NASA
Description	500kg spacecraft	3U CubeSat	3U CubeSat X 2	Hosted payload	3U CubeSat X 2	6U CubeSat X 2	Balloon-borne gondola and payload	Rover + instrumentation on the Moon via commercial landers	Flight demo of radio roaming across multiple commercial relay services	Spacecraft, Payload, Subsystems
Status	Met objectives	Met objectives	Met / meeting objectives	Met / meeting objectives	Met / meeting objectives	In Dev.	In Dev.	In Dev.	In Dev.	
										

13 Acquirer Best Practices / Lessons Learned

	Best Practice
1	Determine if the project is really a low-cost, higher risk tolerant project
2	Clearly define mission success criteria
3	Justify your requirements
4	Incentivize mission success
5	Get acquisition Program Office on same page with the safety and mission assurance (and overall management) approach
6	Choose your supplier(s) wisely

13 Acquirer Best Practices / Lessons Learned

	Best Practice
7	Prudently tailor safety and mission assurance requirements consistent with constraints, risk tolerance and mission success criteria
8	Respect proven commercial practices and evaluate them with an open mind
9	Define insight (vs. oversight) approach over developer
10	Ensure parity between level of rigor applied to spacecraft vs. launch vehicle
11	Do not skimp on safety or risk management
12	If possible, have a reserve budget to address risks and contingencies
13	If cost and schedule are constraints (independent variables), then technical performance must be allowed to be a dependent variable

19 Developer Best Practices / Lessons Learned

Themes: Mission Success Definition, Risk Tolerance Alignment, and Risk Management

	Best Practice
1	Clearly define mission success.
2	Ensure Sponsor's risk tolerance is aligned with Implementer's institutional risk tolerance, specifically including cost, schedule, and performance risk across the development and operational phases of the project.
3	Clearly define and communicate what risks are acceptable at program inception and their risk rating.
4	Understand why each safety and mission assurance requirement exists so you can assess the impact of waiving it or the acceptability of alternative approaches to meet the intent.
5	Prioritize the focus of the safety and mission assurance effort. Do not spend time or money on activities that do not reduce risk.
6	Risk management is more important than ever (budgets are constrained so mitigations need to be judiciously implemented).
7	Be prepared to spend effort calibrating the expectations of independent review boards (e.g. SRBs) as each Class D mission is unique and the rationale for tailoring may not be intuitive
8	Ensure MA approach is consistent and integrated with the overall project management and systems engineering approach

19 Developer Best Practices / Lessons Learned

Themes: Technical Review, Safety, Tailoring Process

	Best Practice
9	Don’t skimp on technical reviews or testing; sometimes it is helpful to develop project-unique review names with project-specific review criteria to disassociate them from “typical” technical reviews.
10	Safety is inviolate.
11	You might (will?) need to request flexibility from full compliance with some Sponsor standards.
12	It can take significant time to coordinate alternative approaches internally and externally.
13	Some (many?) standard internal processes may not scale down well or even apply at all.
14	Low-budget projects don’t have time or funds to redefine everything (anything?).
15	Class D projects generally do not have the resources to perform extensive, detailed tailoring. Detailed templates can really help. Specify the performance floor.
16	Sometimes you care less about the process and more about the end product; in those cases, focus efforts on testing and inspecting quality.

19 Developer Best Practices / Lessons Learned

Themes: Cultural Norms / Resistance, Staff expertise

	Best Practice
17	There is not a “one size fits all” Class D. It’s a big swath that encompasses small spacecraft, cubesats, payloads, hosted payloads, balloons, and other space applications. Tailoring requires thought and expertise.
18	Organizational culture and norms can stymie tailoring (parts quality, procurement) – buy-in can be a challenge that must be overcome immediately.
19	“Class D” projects can provide tremendous experience for early career staff due to their typical short development timelines, but need (properly calibrated) deep subject matter expert support given short development timelines, small development teams, limited funding, etc.

“Good judgement is usually the result of experience. And experience is frequently the result of bad judgement.”

– Robert Lovett, former Secretary of Defense

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