Government SmallSat Reliability Group
Reliability Subcommittee

Mission / System Classification Guidelines

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Terminology: High Confidence

- You want a system and execution approach that generates *HIGH CONFIDENCE* when:
  - It's a single vehicle that *has got to work* (no opportunity to refly)
  - It's a multi-vehicle system that needs *every vehicle to work* (no vehicle redundancy, no opportunity for a second launch)
- You can achieve *HIGH CONFIDENCE* through various combinations of:
  - Part, component, and vehicle redundancy
  - EEE parts selection
  - Design practices and margins
  - Previous flight and system experience; heritage
  - Testing (HW and SW) and requirements verification
  - Spares policy
  - Design iterations (e.g. breadboards, EMs, Qual units, flight units)

Terminology: Low Confidence

- You could say you have a system and execution approach in which there may be *LOW CONFIDENCE* when:
  - It's a completely new item (system, component, application, environment….) (aka low TRL)
  - It hasn't been analyzed or tested
  - Operational environment is unknown (e.g. launch vibe, radiation) or unproven (e.g. first flight of launch vehicle)
- Proceeding with a *LOW CONFIDENCE* approach or component can be okay when:
  - It's a demo or prototype
  - It's "inexpensive" and another can be made
  - Reflight is readily available (fly-fail-fix-fly again)
  - Time scales are "fast"

Recommendations

- **Reliability Subcommittee should:**
  - **Capture characteristics of missions / systems for which *HIGH CONFIDENCE* is expected**
  - **Capture characteristics of missions systems for which *LOW* or *MEDIUM CONFIDENCE* is acceptable**
  - **Outline priorities for *increasing the confidence level* of a component, system, or approach**
- **Proposed output (Guideline Document):**
  - **Decision criteria for when to use Guidelines as opposed to NASA and other Standards (7120, INST-002…)**
    - **Some missions, especially NASA deep space, may use CubeSats / SmallSats but effectively still be “Class D” or above (?)**
  - **Focus on *RAPID SPACE***
    - **Fast, cheap, “failure is acceptable” missions**

Example

Mission Characteristics

Classification → Mission Type ↓	High Confidence Required when	Moderate Confidence Acceptable when	Low Confidence Acceptable when	Comments
Deep space	5-10 years operation expected	1-3 years	Up to months	
LEO	5+ years operation expected	~ 1 year	Months	
Mission Criticality	Operational mission; national security	Experimental; tech demo; tech maturation	Tech demo; teaching	
Reflight	First launch has to work (no reflight possible)	Rapid reflight available	OK to try again on another launch opportunity	
Repeat cost	Build / launch / operate another is too expensive		Fix / design / build a new one costs are low	
Operational Criticality	Single vehicle / every vehicle *has got to work*	"Down time" is acceptable	System as a whole is resilient to individual failures	

Reviews #1

Classification → Reviews↓	When High Confidence is needed	When Moderate Confidence is expected	When Low Confidence is acceptable	Comments
SRR, MCR, SDR, MDR (Combine into a single “Mission / System Design Review” – M/SDR)	Add mission radiation effects analysis to discussion.	Add mission radiation effects analysis to discussion.	Focus on driving requirements, mass and power margins	For all confidence levels: Are the requirements: - Complete - Address objectives and needs of sponsor What is missing/ What are driving requirements?
	“Large” SRB (1-2 sponsor reps, 1-2 system engineers, 1 each engineer with expertise in the areas of the driving requirements, mission objectives / science, I&T).	Medium SRB (1 sponsor rep, 1-2 system engineers, 1 each engineer with expertise in the areas of the driving requirements and of mission objectives / science)	Small informal SRB (1 sponsor rep, 1-2 system engineers, 1 engineer with expertise in the area of the driving requirements).	
	System Design: address what commercial items will be bought and what items will be custom design. Discuss heritage and approach for commercial items. Discuss heritage and approach for custom items and how they interface to commercial items. Discuss integration approach.		System Design: address what commercial items will be bought and what items will be custom design; focus on custom items and how they interface to commercial items.	
	Development team conducts internal peer review of requirements prior to M/SDR			

Development Units and Spares - #1

Classification → Item ↓	When High Confidence is needed	When Moderate Confidence is expected	When Low Confidence is acceptable	Comments
Engineering Models	Recommended for payload and spacecraft bus	Not typically included	Not typically included	EMs / EDUs are always a good idea if you can afford the cost and schedule
Flight spare components	Sparing at component level for payload and critical items	Sparing at component level for payload and critical items	Not typically included	
I&T of spares, EMs, EDUs	For large “flocks”, might build and test a full spare vehicle.	Often used for early interface testing, fit checks, and procedure development	Usually only if /when primary unit(s) have problems	Can also test all units and cherry pick best-performing item for flight
Qual unit	Recommended	Not typically included	Not typically included	
Vendor testing of procured components	Vendor has done qual level testing of design, acceptance testing of delivered items	Vendor has done qual level testing of design preferred	None	

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Design Management

Classification → Design Activity ↓	When High Confidence is needed	When Moderate Confidence is expected	When Low Confidence is acceptable	Comments
Mechanical drawings	Review and signature(s) for critical parts	Review at discretion of team	Sketches of custom parts if needed; peer review at discretion of team	
CAD Model	CAD model to box level, including cabling, stowed and deployed configurations	Representative CAD model useful for I&T and estimation of mass properties; stowed and deployed configurations	Representative CAD model useful for I&T and estimation of mass properties; stowed configuration at a minimum	Generally at board level and above
Configuration Control	Configuration control of custom mechanical parts drawings; FSW		Developer version control of sketches and FSW	

Abbreviations, Acronyms, Initialisms

- CAD = Computer-Aided Design
- CADRe = Cost Analysis Data Requirement
- CDR = Critical Design Review
- DDT&E = Design, Development, Test and Evaluation
- DOD = Department of Defense
- DoD = Depth of Discharge
- EDU = Engineering Development Unit
- EM = Engineering Model
- EMC = Electromagnetic Compatibility
- EMI = Electromagnetic Interference
- EOM = End of Mission
- ESPA =
- EVM = Earned Value Management
- FMEA = Failure Modes and Effects Analysis
- FRR = Flight Readiness Review
- FSW = Flight Software
- GEO = Geosynchronous, Geostationary
- GIDEP =
- GTO = GEO Transfer Orbit
- HDP = Hardware Development Plan
- IMS = Integrated Master Schedule
- I&T = Integration and Test
- KDP = Key Decision Point
- LCC = Life-cycle Cost estimate
- LEO = Low Earth Orbit

- MAP = Mission Assurance Plan
- MCR = Mission Concept Review
- MDR = Mission Definition Review
- MRB = Materials Review Board
- MRR = Mission Readiness Review
- NASA = National Aeronautics and Space Administration
- ORR = Operational Readiness Review
- PDR = Preliminary Design Review
- PER = Pre-Environmental (Test) Review
- PSR = Pre-Ship Review
- R&D = Research and Development
- RFA = Request for Action
- RID = Review Item Discrepancy
- RMP = Risk Management Plan
- SDP = Software Development Plan
- SDR = System Definition Review
- SEMP = Systems Engineering Management Plan
- SRB = System Review Board
- SRR = System Requirements Review
- TRR = Test Readiness Review
- TVAC = Thermal-Vacuum (test)
- WBS = Work Breakdown Structure

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