

Science Mission Directorate Implementation of Spacecraft Risk Classifications

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Expressed Community Concern

Cost growth of our missions under a flat budget is leading to a decrease in frequency of flight opportunities, particularly for small missions.

Community-expressed belief that principal reason for this is:

- New processes implemented to reduce risk.
- Uniform processes enforced across NASA.
- Projects subjected to multiple independent reviews.

These overstress capabilities of experiment teams and can drive up both risk and cost.

Question: *What is NASA's policy on mission risk classification and how is it being implemented by the Science Mission Directorate?*





SMD Missions Initiated in Two Ways

The Strategic Planning Cycle

- Strategic missions (Dedicated-purpose missions, “flagship” missions) are planned.
 - Working groups develop discipline-specific “roadmaps”
 - Roadmaps are then combined into a Strategic Plan, defining specific mission goals.
 - Science goals and mission priorities are vetted by NASA’s advisory bodies.
 - Spacecraft procured via RFP from Center.

Community-Proposed Mission Announcements of Opportunity

- Announcements of Opportunity are issued periodically to request proposals for cost capped PI-class missions.
 - The **Explorer** mission line consists of three mission sizes, and serves the Astrophysics and Heliophysics disciplines.
 - The **Earth Science System Pathfinders (ESSP)** serves the Earth Science discipline.
 - The **Discovery** mission line serves the Planetary Science discipline and the "Search for new Planetary Systems" theme in Astrophysics.
 - **New Frontiers** serves Planetary Science.
 - **Mars Scouts** serve the Mars Exploration Program.





Principles for Implementation

- Strategic missions tend to be more expansive and costly.
- Community proposed missions tend to be less costly and more frequent.
- Accepted risk is usually inversely proportional to development cost.
- Both types of missions are subject to risk classification.
- Each type follows standard processes which are designed to account for these variations.

Two principal requirements documents are relevant in this discussion:

- NPR 8705.4 - Risk Classification for NASA Payloads
- NPR 7120.5 - NASA Space Flight Program and Project Management Requirements





NASA Requirement for Risk Classification

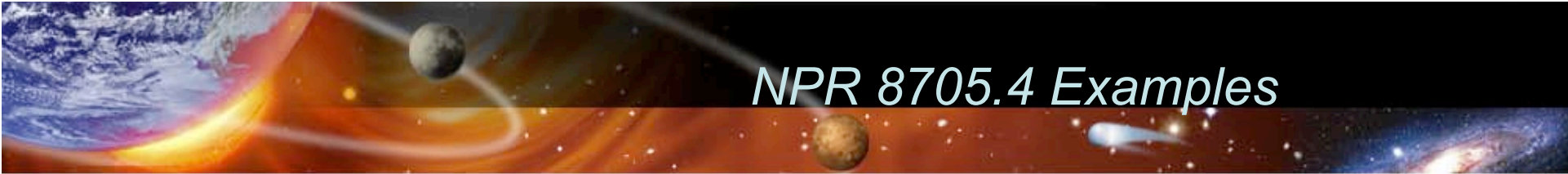
- NPR 8705.4, **Risk Classification for NASA Payloads**, requires the Directorate to establish an acceptable risk classification level for each NASA-sponsored payload.
- Classification can be applied to complete spacecraft, or to individual instruments.
- Four risk classification levels (A thru D) are defined in the NPR. The specific level is a function of several parameters. (The NPR lists 9 of them.) See next page.



NPR 8705.4 Appendix A

Characterization	Class A	Class B	Class C	Class D
Priority (Criticality to Agency Strategic Plan) and Acceptable Risk Level	High priority, very low (minimized) risk	High priority, low risk	Medium priority, medium risk	Low priority, high risk
National significance	Very high	High	Medium	Low to medium
Complexity	Very high to high	High to medium	Medium to low	Medium to low
Mission Lifetime (Primary Baseline Mission)	Long, >5years	Medium, 2-5 years	Short, <2 years	Short < 2 years
Cost	High	High to medium	Medium to low	Low
Launch Constraints	Critical	Medium	Few	Few to none
In-Flight Maintenance	N/A	Not feasible or difficult	Maybe feasible	May be feasible and planned
Alternative Research Opportunities or Re-flight Opportunities	No alternative or re-flight opportunities	Few or no alternative or re-flight opportunities	Some or few alternative or re-flight opportunities	Significant alternative or re-flight opportunities
Achievement of Mission Success Criteria	All practical measures are taken to achieve minimum risk to mission success. The highest assurance standards are used.	Stringent assurance standards with only minor compromises in application to maintain a low risk to mission success.	Medium risk of not achieving mission success may be acceptable. Reduced assurance standards are permitted.	Medium or significant risk of not achieving mission success is permitted. Minimal assurance standards are permitted.





NPR 8705.4 Examples

	<u>Class A</u>	<u>Class B</u>	<u>Class C</u>	<u>Class D</u>
Examples	HST, Cassini, Europa Orbiter	MER, MRO, Discovery payloads, ISS Facility Class Payloads, Attached ISS payloads	ESSP, Explorer Payloads (MIDEX, SMEX), ISS complex subrack payloads	SPARTAN, GAS Can, technology demonstrators, simple ISS, express middeck and subrack payloads





Implications to spacecraft development

(1 of 3)

- The NPR lists 16 development items as having potential implications.

Single point failures

Engineering Model, Prototype, and Flight Hardware
Qualification, Acceptance and Prototype Test

EEE Parts

Reviews

Safety (Adherence to NPD 8700.1)

Materials

Mishap Investigation Board Requirements

Reliability

Fault Tree Analysis

Probabilistic Risk Assessments

Maintainability

Quality Assurance

Software

Risk Management

Telemetry Coverage



Implications to spacecraft development

(2 of 3)

Examples:

Development Topic	<u>Class A</u>	<u>Class B</u>	<u>Class C</u>	<u>Class D</u>
Single Point Failures (SPFs)	Critical SPFs (for Level 1 requirements) are not permitted unless authorized by formal waiver. Waiver approval of critical SPFs requires justification based on risk analysis and implementation of measures to mitigate risk.	Critical SPFs (for Level 1 requirements) may be permitted but are minimized and mitigated by use of high reliability parts and additional testing. Essential spacecraft functions and key instruments are typically fully redundant. Other hardware has partial redundancy and/or provisions for graceful degradation.	Critical SPFs (for Level 1 requirements) may be permitted but are mitigated by use of high reliability parts, additional testing, or by other means. Single string and selectively redundant design approaches may be used.	Same as Class C.
Materials	Verify heritage of previously used materials and qualify all new or changed materials and applications or configurations. Use source controls on procured materials and acceptance test each lot/batch.	Use previously tested/flown materials or qualify new materials and applications or configurations. Acceptance test each lot of procured materials.	Use previously tested/flown materials or characterize new materials. Acceptance test sample lots of procured materials.	Requirements are based on applicable safety standards. Materials should be assessed for application and life limits.



Implications to spacecraft development

(3 of 3)

Development Topic	Class A	Class B	Class C	Class D
Reviews	Full formal review program. Either IPAO external independent reviews or independent reviews managed at the Center level with Enterprise Office participation. Include formal inspections of software requirements, design, verification documents, and code.	Full formal review program. Either IPAO external independent reviews or independent reviews managed at the Center level with Enterprise Office participation. Include formal inspections of software requirements, design, verification documents, and peer reviews of code.	Full formal review program. Independent reviews managed at Center level with Enterprise Office participation. Include formal inspections of software requirements, peer reviews of design and code.	Center level reviews with participation of all applicable directorates. May be delegated to Projects. Peer reviews of software requirements and code.

Note: NPR has not been updated to reflect nomenclature change from "Enterprise" to "Directorate" nor to incorporate the new Agency Governance Model for flight program/project management.



Project Categorization per NPR 7120.5D

NPR 7120.5D - NASA Space Flight Program and Project Management Requirements*

- Paragraph 2.1.6. Based on inputs from the Mission Directorate Associate Administrator (MDAA), the NASA Associate Administrator (AA) determines whether a project is Category 1, 2, or 3 using Table 2-1 as a guide.

Risk Classification	Life Cycle Cost		
	LCC<\$250M	\$250M<LCC<\$1000M	LCC>\$1000M
A	Category 2	Category 1	Category 1
B	Category 3	Category 2	Category 1
C or D	Category 3	Category 3	Category 2

Table 2-1 Project Categorization Guidelines

**Note: The "D" version is currently DRAFT; final approval is in progress.*





7120 Overriding Rules

- Other Characteristics that nearly always dictate Category 1:
 - Presence of nuclear fuels on-board
 - Necessity for human spaceflight rating
 - High public visibility
 - Significant international partnerships
 - Critical contributor to national goals
 - Congressionally mandated



NPR7120.5D Review Requirements

Governing Program Management Council determines project reviewers

	Agency PMC	Mission Directorate PMC
Programs	☑	✓
Category 1 Projects	☑	✓
Category 2 Projects		☑
Category 3 Projects		☑



Indicates governing PMC



Indicates PMC evaluation

For Gate (*Phase transition*) Reviews:

Category 1's require independent review by the IPAO, reporting to the APMC.

Category 2's can use IPAO (default) or other review body at choice of MD.

Category 3's use Directorate or Center-based independent review team.

Note: Center provides separate Standing Review Board for life cycle project reviews, (e.g PDR, CDR, TRR, etc)

