



Criteria for Flight Project Critical Milestone Reviews

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Change History Log

Revision	Effective Date	Description of Changes
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1.0 PURPOSE

This document provides standard criteria for the flight project critical milestone reviews that comprise the Integrated Independent Reviews prescribed by GPR 8700.4. For each mission system review during the project lifecycle (Figure 1), the document describes the purpose, timing, objectives, and success criteria.

This document is intended for use by both the project team and the Integrated Independent Review Team (IIRT). For the Project Manager, its first use should be as a guide in preparing the baseline version of the project's Integrated Independent Review Plan. Both the Project Manager and the Chair(s) of the IIRT should utilize the document as they finalize the specific objectives, agenda, and success criteria in preparation for each review.

It is expected that for each mission system review, the specific objectives and success criteria will closely adhere to the guidance herein, while accommodating discrete project-specific considerations. For reviews of items below the mission system (e.g.: spacecraft or science instruments) the guidance herein should be adapted appropriately.

2.0 MISSION CONCEPT REVIEW (MCR)

At the MCR, the project demonstrates to the Integrated Independent Review Team (IIRT) that the proposed mission is feasible and that the proposed mission's objectives and the concept (or concepts) for meeting those objectives are viable. In addition, the project articulates a preliminary plan for project life-cycle activities which illustrates reasonable execution of the mission within estimated programmatic resources in a way that accommodates foreseen constraints.

2.1 Purpose

The purpose of the MCR is to affirm the need for and feasibility of the mission, to confirm that preliminary planning for project execution is sound, and to demonstrate project readiness to proceed with mission definition. To that end, the project demonstrates an understanding of mission objectives and overarching system requirements. It conveys one or more conceptual approaches to fulfilling those requirements, including an approach for mission operations and data processing. It illustrates a thorough, albeit preliminary, plan for successful execution of the entire project lifecycle that is tractable and realistic in its resource estimates.

2.2 Timing

The MCR is normally held when mission feasibility studies are complete, at the end of pre-formulation activities. In advance of the review, the project should highlight and discuss with the review chairperson(s) any areas (e.g.: problematic mission requirements, critical technology dependencies, critical trade studies, or anticipated resource constraints) that may warrant consideration in the composition of the review team. Depending upon the intended acquisition approach for the mission, Goddard management may decide that an MCR will not be conducted or that it will be replaced by a management review. Such determination shall be made in conjunction with the planning and approval of the project's Integrated Independent Review Plan.

2.3 Objectives

The objectives of the MCR are to confirm that: (a) science objectives are clearly understood and comprehensively defined, (b) preliminary mission requirements are traceable to science objectives, (c) the operations concept clearly supports achievement of science objectives, (d) the conceptual system design meets mission requirements and the various system elements are compatible, (e) technology dependencies are understood and alternative strategies for achievement of requirements are understood, and (f) preliminary mission planning demonstrates technical and programmatic feasibility of mission execution within estimated programmatic resources in a way that accommodates foreseen constraints.

The MCR should contain a complete description of the conceptual mission design. It should present the design by means of block diagrams depicting system interfaces with external supporting systems as well as depicting interfaces between independent system elements.

Preliminary modeling and analysis results should be presented in order to illustrate feasibility of achieving science objectives.

Programmatic planning and resource estimates shall be discussed in sufficient detail to permit assessment of relevant review objectives.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Mission Requirements
- b. Mission Operations
- c. Conceptual Design
- d. Safety and Risk Management
- e. Implementation Planning
- f. Programmatic
- g. Project and Independent Review Activity

2.4 Criteria for Successful Completion

2.4.1 Mission Requirements:

- a. Mission objectives are defined completely and are realistically achievable within the context of the mission.
- b. Mission and system level requirements are clearly defined, unambiguous, and traceable to science objectives.
- c. Mission level assumptions and constraints are defined and quantified.
- d. Preliminary interface requirements with external systems are defined.
- e. An approach for flow down and control of requirements within the system is defined.
- f. A plan for usage of units of measurement is defined in accord with agency requirements.
- g. Preliminary requirements are identified for each independent system element (e.g.: spacecraft, science instruments, launch vehicle, ground operation system, ground support equipment) and are traceable to and compatible with preliminary system requirements.
- h. Reasonable interface requirements have been identified between independent system elements.
- i. Results of mission level requirements trades completed to date are documented and include rationale for selected alternatives. On-going or needed future trade studies are identified with potential impacts understood and able to be accommodated. Selection criteria are defined for evaluating the results of such studies.

2.4.2 Mission Operations:

- a. A mission operations concept has been defined that fulfills science objectives.
- b. Launch and early orbit considerations have been conceptually identified.
- c. Data flow scenarios exist that illustrate a data acquisition, processing, and analysis sequence that will satisfy science objectives.

2.4.3 Conceptual Design:

- a. A conceptual system configuration is defined with sufficient understanding to indicate that a design approach exists that is tractable and responsive to requirements.
- b. Preliminary modeling and analysis results (e.g.: performance, reliability, etc.) are available and have been considered in the conceptual system configuration.
- c. Iteration of the design since initial concept, whether trade study induced or otherwise, is articulated with rationale for all changes.
- d. Ongoing or future design related trade studies are identified and potential impact of results is understood. Selection rationale for evaluating trade results is defined.
- e. Technology dependencies are defined and understood. Timely availability is reasonable. Alternative approaches for critical dependencies have been determined.
- f. Utilization of major heritage elements has been identified. Adaptation for the current application appears tractable.
- g. Adequate design margins for critical resources (mass, power, data rate, etc.) are estimated.
- h. A baseline plan for compliance with the Goddard Rules (GSFC-STD-1000) has been defined. Preliminary discussion regarding potential non-compliances has been completed. Any required waivers / deviations have been initiated.

2.4.4 Safety and Risk Management:

- a. A baseline risk management approach is defined.
- b. Major mission risks are defined with impact and probability of occurrence identified. Acceptable mitigation plans and trigger events are defined.
- c. Design philosophy relative to single point failures is clearly documented and approved.
- d. Requirements for safety are defined.
- e. Initial hazard identification and control methods have been determined.

2.4.5 Implementation Planning:

- a. Program flow has been preliminarily defined to allow estimates for required hardware quantities.
- b. A conceptual system level verification approach has been defined.
- c. Preliminary approaches to controlling technical activities (e.g.: systems engineering, design, software development, verification) have been identified.
- d. Preliminary Mission Assurance requirements have been identified for EEE parts and reliability analyses.
- e. Appropriate environmental impact assessments and control activities have been initiated.

2.4.6 Programmatic:

- a. Roles, responsibilities, and interfaces between all participating institutions are preliminarily defined.

- b. A project organization chart clearly delineates functional responsibilities and relationships for all key members of the project team.
- c. Organization and staffing plans identify preliminary staffing estimates throughout the project lifecycle.
- d. Appropriate processes and metrics have been identified for tracking and controlling cost, schedule, and technical activities throughout the life-cycle.
- e. Preliminary schedules identify realistic events and span times (including slack) and are compatible with a launch date that meets mission needs.
- f. Cost to complete shows appropriate spending profiles and financial reserves, and is compatible with allocations.

2.4.7 Project and Independent Review Activity:

- a. A sufficiently comprehensive Integrated Independent Review Plan has been defined and approved in accordance with GPR requirements.
- b. An appropriate set of engineering peer reviews has been planned in compliance with GPR requirements.
- c. Recommendations from any completed project or external review activity that is applicable to the subject matter of the MCR have been adequately implemented.

2.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the MCR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta MCR may be required for the project to successfully complete this milestone.

Successful completion of the MCR constitutes readiness for consideration of approval to proceed with mission formulation.

3.0 MISSION DEFINITION REVIEW (MDR)

At the MDR, the project conveys to the Integrated Independent Review Team (IIRT) that the baseline mission requirements are clearly understood, that the requirements for each independent system element have been determined, and that the currently envisioned system design will fully satisfy those requirements in order to justify that it is ready to proceed to complete system definition and to flow down requirements to lower levels of the system. In addition, the project shall sufficiently articulate its planning for remaining project activities in order to justify that there are reasonable expectations that the project will accommodate any imposed constraints and meet its success criteria within the allocated resources.

3.1 Purpose

The purpose of the MDR is to demonstrate project readiness to complete system definition and to fully flow down requirements to lower levels of the system. To that end, the project demonstrates that the baseline mission requirements are clearly understood, that the distribution of those requirements to each independent system element is complete and traceable to the mission level, and that the currently envisioned system design will fully satisfy those requirements. It shows that the systems design is producible. It identifies a complete scenario for mission operations as well as data processing and analysis that will satisfy mission objectives.

3.2 Timing

The MDR is normally held very early in the definition phase upon completion of a feasible mission definition and while system concept changes can be accommodated with minimal impact. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any significant risk areas (e.g.: problematic mission requirements, critical technology dependencies, outstanding trade studies, or significant resource constraints) that may warrant consideration in the timing of the review or the composition of the review team. For efficiency, the Project Manager and the IIRT Chair may consider combining the MDR with the SDR if the lifecycle is such that both reviews would otherwise occur in relatively short succession. In that event, guidelines for the SDR should also be consulted and a review should be planned that simultaneously fulfills both sets of objectives.

3.3 Objectives

The objectives of the MDR are to confirm that: (a) science objectives are fully understood and, if feasible, prioritized so as to define acceptable descope options, (b) the conceptual system design is tailored to efficiently and effectively meet science objectives, (c) system level requirements are traceable to science objectives and are clearly and logically allocated amongst the independent system elements, (d) the operations concept clearly supports achievement of science objectives, (e) technology dependencies are fully defined with risks and viable mitigation plans identified, and (f) successful execution of the project can be reasonably expected within imposed constraints and available cost and schedule resources.

The MDR should contain a complete and comprehensive description of the mission and system design. It should present the design by means of block diagrams, depicting system interfaces with external supporting systems as well as depicting internal interfaces between independent system elements. Completed modeling and analysis results should be presented in order to illustrate that science objectives will be achieved.

Programmatic considerations shall be discussed in sufficient detail to permit assessment of relevant review objectives.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Mission Requirements
- b. Mission Operations
- c. Design Description
- d. Risk Management
- e. Safety
- f. Implementation Planning
- g. Programmatic
- h. Project and Independent Review Activity

3.4 Criteria for Successful Completion

3.4.1 Mission Requirements:

- a. Science objectives are clear, complete, and describe objectives in terms of meaningful measurable parameters.
- b. Science objectives are prioritized and descope opportunities are defined that meet minimum objectives.
- c. System level requirements are clearly and fully traceable to science objectives.
- d. System level assumptions and constraints are defined and quantified.
- e. Interface requirements with external systems are clearly defined and fully understood.
- f. Approach for flowdown and control of requirements within the system is fully defined and understood.
- g. Approach to usage, control, and verification of units of measurement is defined and documented.
- h. Attainable requirements are flowed down to each independent system element (e.g.: spacecraft, science instruments, launch vehicle, ground operation system, ground support equipment) or below and are traceable to and compatible with system requirements.
- i. Attainable interface requirements have been identified between each independent system element.
- j. Results of requirements trades are documented and include rationale for selected alternatives. Open trade studies are identified and potential impacts are understood.

3.4.2 Mission Operations:

- a. A mission operations scenario has been defined that fulfills science objectives.
- b. Launch and early orbit scenarios have been conceptually defined.
- c. Data flow scenarios exist that depict the data acquisition, processing, and analysis activity.

3.4.3 Design Description:

- a. Conceptual system configuration is defined with sufficient depth to indicate a feasible design approach has been selected and requirements will be met.
- b. Appropriate modeling and analysis results (e.g.: performance, reliability, etc.) are available and have been considered in the system design.
- c. Iteration of design since initial concept, whether trade study induced or otherwise, is articulated with rationale for all changes.
- d. Ongoing or future trade studies are identified and potential impact of results on design is understood. Selection rationale for trade results is defined.
- e. Technology dependencies are defined and understood. Timely availability is reasonable. Workarounds and associated trigger points are defined.
- f. Potential problems are understood and attendant risks have been adequately mitigated.
- g. Utilization of major heritage elements have been determined, rationale for such clearly defined, and considerations constraining use of such identified.
- h. Adequate design margins for critical resources (mass, power, data rate, etc.) are estimated.
- i. Preliminary functional flow diagrams exist. Mission critical failures have been identified. Redundancies and/or workarounds have been defined or acceptability approved.
- j. Current status of compliance with the Goddard Rules (GSFC-STD-1000) reflects adequate progress of activities to date and satisfactory plans for future activities. Any required waivers / deviations have been approved.

3.4.4 Risk Management:

- a. Baseline risk management approach is defined.
- b. Major mission risks are defined with impact and probability of occurrence. Acceptable mitigation plans and trigger events are defined.
- c. Design philosophy relative to single point failures is clearly documented and approved.

3.4.5 Safety:

- a. Requirements for safety are defined.
- b. Initial hazard identification and control methods have been determined.

3.4.6 Implementation Planning:

- a. Program flow has been sufficiently well defined to determine required quantities of hardware and software items.

- b. A preliminary system level verification approach has been defined.
- c. Approach to controlling technical activities (systems engineering, software development, verification, configuration control, etc.) have been defined.
- d. Preliminary Mission Assurance requirements have been defined (EEE parts and materials usage, reliability analyses, quality control, problem reporting, etc.).
- e. Appropriate environmental impact assessments and control activities have been initiated.

3.4.7 Programmatic:

- a. Roles, responsibilities, and interfaces between all participating institutions are clearly defined. Project organization chart clearly delineates functional responsibilities and relationships.
- b. Organization and staffing plans delineate clear responsibilities and adequate assignment of current and future staff.
- c. Appropriate processes and metrics are in place to track and control cost, schedule, and technical activities throughout the remaining life-cycle.
- d. Appropriately detailed schedules show realistic event times as well as appropriate funded slack and are compatible with approved launch dates.
- e. Cost to complete shows adequate spending profiles and financial reserves, and is compatible with allocations.

3.4.8 Project and Independent Review Activity:

- a. Timely response to RFAs from previous IIRT reviews, if any, has occurred.
- b. Resultant actions have been implemented effectively. Schedule for completion of any outstanding RFAs is defined.
- c. An appropriate set of engineering peer reviews has been planned and documented in compliance with GPR requirements.
- d. Recommendations from other project or external review activity that is applicable to the subject matter of the MDR have been adequately implemented.

3.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the MDR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MDR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta MDR may be required for the project to successfully pass this milestone.

Successful completion of the MDR constitutes readiness to proceed to complete system definition and to flow down requirements to lower levels of the system.

4.0 SYSTEM DEFINITION REVIEW (SDR)

At the SDR, the project conveys to the Integrated Independent Review Team (IIRT) that, for the current mission system design, requirements have been formally and fully allocated to all independent flight and ground system elements and, in turn, to their respective subsystems and that all system requirements will be satisfied. In so doing, the project justifies readiness to proceed with preliminary design. In addition, the project shall sufficiently articulate its planning for remaining project activities in order to justify that there are reasonable expectations that the project will accommodate any imposed constraints and meet its success criteria within the allocated resources.

4.1 Purpose

The purpose of the SDR is to demonstrate project readiness to begin preliminary design. To that end, the project demonstrates that the baseline mission requirements are clearly understood, that system definition is complete, that the allocation of requirements to each independent system element and their respective subsystems is complete and verifiable, and that those lower level requirements are traceable to the mission level.

4.2 Timing

The SDR is generally held at the end of system definition upon completion of a feasible design that will satisfy all system requirements. A meaningful SDR relies upon the current validity of those things covered during the MDR. To the degree that such is not wholly the case, then the SDR content must be revised so as to establish validity that MDR objectives are also satisfied. When such is necessary, separate guidelines applicable to the MDR shall be consulted for advice on restructuring the content of the SDR to accomplish these multiple sets of objectives. When, because of a shortened project lifecycle, the MDR and the SDR are combined, all objectives of each must be simultaneously fulfilled. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any significant areas that may warrant consideration in the timing of the review or composition of the review team.

4.3 Objectives

When all MDR objectives have been satisfied (see discussion in above paragraph when such is not the case), the objectives of the SDR are to confirm that: (a) definition of a producible system is complete and fully satisfies all mission objectives, (b) system requirements have been logically and fully allocated to each independent system element and in turn to their respective subsystem level or below, (c) all allocated requirements are verifiable and traceable to their corresponding system level requirement, (d) preliminary verification approaches and acceptance criteria are defined, and (e) the requisite level of detail and resources are available to support the acquisition and development plan within existing constraints.

After establishing that current mission planning continues to be compatible with the requirements of the MDR, the SDR should contain a complete and comprehensive description of

the system design in order to establish the baseline for which the requirements are defined. It should present the design by means of block diagrams, depicting system interfaces with external supporting systems, internal interfaces between independent system elements, and interfaces within each independent system element to the subsystem level and below. Completed modeling and analysis results that demonstrate the ability of the design to fulfill system requirements should be presented.

The requirements allocation and control process should be presented followed by a formal delineation of all allocated requirements in a way that illustrates their completeness, traceability, and verifiability. An understanding of attendant risk, safety, and assurance considerations shall accompany a discussion of implementation. Programmatic considerations shall be discussed in sufficient detail to permit assessment of relevant review objectives.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Design Description
- b. Requirements Related Processes
- c. Requirements Definition
- d. Requirements Verification
- e. Risk Management
- f. Safety
- g. Assurance
- h. Implementation Planning
- i. Programmatics
- j. Project and Independent Review Activity

4.4 Criteria for Successful Completion

4.4.1 Design Description:

- a. System design changes since MDR are documented and rationale for continued compliance with MDR criteria is provided. Results of requirements trades are documented and include rationale for selected alternatives. On-going or future trade studies are identified and potential impact of results on design is understood. Selection rationale for trade results is defined.
- b. Block diagrams illustrate functional flow and clearly define interfaces with external systems, interfaces between each independent system element (spacecraft, science instruments, launch vehicle, ground system, etc.), and interfaces within each independent element down to the subsystem level or below.
- c. Results of appropriate system analyses (e.g.: performance, error budgets, reliability) illustrate adequacy of system design to accomplish mission objectives within constraints and with acceptable risk.
- d. Mission critical failures have been identified. Redundancies and/or workarounds have been defined or single-string design approach has been approved.

- e. Technology development related items continue on track and mitigation plans remain viable.
- f. Utilization of heritage elements has been determined. Preliminary assessment of activity needed to verify usage on the current mission has been completed.
- g. Margins for all critical resources (mass, power, data rate, etc.) meet applicable criteria.
- h. Current status of compliance with the Goddard Rules (GSFC-STD-1000) reflects adequate progress of activities to date and satisfactory plans for future activities. Any required waivers / deviations have been approved.
- i. Usage and control of units of measurement is fully defined and approved.
- j. Approach to verification of compatibility across all interfaces is defined.

4.4.2 Requirements Related Processes:

- a. Processes for the allocation and control of requirements are documented and approved.
- b. The approach for tracking and controlling allocation and reserves of key resources (such as mass, power, memory, etc.) is documented and approved.
- c. The approach to controlling and integrating all technical activities is defined and documented.
- d. Plans for design, production, and verification activities are defined and documented.

4.4.3 Requirements Definition:

- a. Interface requirements with external systems are defined.
- b. Interface requirements between independent system elements are defined.
- c. Interface requirements between subsystems and components of each independent system element are defined.
- d. Functional requirements for subsystems and components of each independent system element are defined so as to fully achieve system requirements. Such requirements are verifiable and are traceable to their respective system and mission requirements.
- e. Allocation of key resources (mass, power, etc.) to elements of flight subsystems is reasonable.
- f. Mission operations, data acquisition, data processing, and data analysis requirements are fully defined.

4.4.4 Requirements Verification:

- a. Preliminary approaches for the verification of all requirements have been defined.
- b. Preliminary acceptance criteria have been defined at the deliverable end-item level.

4.4.5 Risk Management:

- a. A risk management process that meets GPR requirements is defined and utilized.
- b. All significant risks, problems, and open items are identified and tracked (including programmatic, development and flight performance related items). Risk mitigation plans are appropriate. Credible triggers for exercising alternatives are defined.

- c. Reliability considerations have been factored into design decisions.
- d. Single point failures are compatible with approved project philosophy.
- e. Lessons learned have been appropriately researched and adapted.

4.4.6 Safety:

- a. A preliminary safety plan identifies all requirements as well as any planned tailoring approaches or intended non-compliances.
- b. Preliminary hazards, controls, and verification methods are identified and documented.
- c. Any open safety issues are identified with plans for resolution.
- d. Preliminary plans and schedules for all required safety submittals are defined.

4.4.7 Assurance Activities:

Mission Assurance requirements have been defined (EEE parts and materials usage, reliability analyses, quality control, problem reporting etc.) and preliminary plans are completed.

4.4.8 Implementation Planning:

- a. Program flow has been defined and required quantities of hardware and software items are defined..
- b. A preliminary system level verification plan has been defined.
- c. Plans for controlling technical activities (systems engineering, software development, verification, configuration control, etc.) have been approved.
- d. Environmental impact assessments and control activities are on track.

4.4.9 Programmatic:

- a. Roles, responsibilities, and interfaces between all participating institutions are clearly defined.
- b. Project organization chart clearly delineates functional responsibilities and relationships.
- c. Organization and staffing plans delineate clear responsibilities and adequate assignment of current and future staff.
- d. Appropriate processes and metrics are in place to track and control cost, schedule, and technical activities throughout the remaining life-cycle.
- e. Appropriately detailed schedules show realistic event times as well as appropriate funded slack and are compatible with approved launch dates.
- f. Cost to complete shows adequate spending profiles and financial reserves, and is compatible with allocations.

4.4.10 Project and Independent Review Activity:

- a. Timely response to RFAs from previous IIRT reviews has occurred. Resultant actions have been implemented effectively. Schedule for completion of any outstanding RFAs is defined.

- b. An appropriate set of engineering peer reviews has been conducted and documented in compliance with GPR requirements. Resultant actions have been effectively dispositioned and executed. Appropriate additional reviews are planned.
- c. Recommendations from other project or external review activity that is applicable to the subject matter of the SDR have been adequately implemented.

4.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the SDR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta SDR may be required for the project to successfully pass this milestone.

Successful completion of the SDR constitutes readiness to proceed with preliminary design.

5.0 PRELIMINARY DESIGN REVIEW (PDR)

At the PDR, the project discloses the complete system design to the Integrated Independent Review Team (IIRT) and justifies that it has completed a credible and acceptable mission formulation, is prepared to proceed with the detailed design, and is on track to complete the flight and ground system development and mission operations in order to meet mission performance requirements within the identified cost and schedule constraints.

5.1 Purpose

The purpose of the PDR is to demonstrate project readiness to proceed with the detailed design and to complete the flight and ground system development and mission operations in order to meet mission performance requirements within the identified cost and schedule constraints. To that end, the project demonstrates that the preliminary design meets all system requirements with acceptable risk. It shows that the correct design option has been selected, resource allocations have been made, interfaces have been identified, and verification methods have been identified. Supportive design analyses confirm compliance with requirements.

5.2 Timing

The PDR is the first major review of the overall system design and is normally held prior to the preparation of detailed design drawings and the initiation of any full-scale flight hardware/software development. A PDR is held when the design is advanced sufficiently to begin some breadboard testing and /or the fabrication of design models. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any significant development areas (significant due to the amount, the criticality, the technical difficulty/complexity, etc.) that may warrant attention regarding timing of the review or composition of the review team.

5.3 Objectives

The objectives of the PDR are to: (a) ensure that all system requirements have been allocated, the requirements are complete, and the flow-down is adequate to verify system performance; (b) show that the proposed design is expected to meet the functional and performance requirements; (c) show sufficient maturity in the proposed design approach to proceed to final design; (d) show that the design is verifiable and that the risks have been identified and characterized, and where appropriate, mitigation plans have been defined; (e) show that the management processes used by the mission team are sufficient to develop and operate the mission; (f) show that the cost estimates and schedules indicate that the mission will be ready to launch and operate on time and within budget and that the control processes are adequate to ensure remaining within allocated resources.

The PDR should contain a complete and comprehensive presentation of the entire design. It should present the design and interfaces by means of block diagrams, power flow diagrams, signal flow diagrams, interface circuits, software logic flow and timing diagrams. Appropriate

modeling results should be presented. Traceability for all items specified for previous IIRT reviews, updated to the present stage of the development process, shall be presented.

Programmatic considerations shall be discussed in sufficient detail to permit assessment of relevant review objectives.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Design Description (including Requirements, Evolution and Heritage)
- b. Total System Performance (budgets/projections/margins for combined optical, thermal, mechanical, control, etc.)
- c. Design Analyses
- d. Development Test Activities
- e. Risk Management
- f. Safety
- g. Assurance Activities
- h. Implementation Plans
- i. Qualification/Environmental Test Plans and Test Flow
- j. Interface Control Documents
- k. Logistics
- l. Launch Vehicle Interfaces
- m. Ground Operations, Mission Operations, and End-of-Life
- n. Programmatic
- o. Project and Independent Review Activity

5.4 Criteria for Successful Completion

5.4.1 Design Description (including Requirements, Evolution and Heritage):

- a. A complete and comprehensive definition of the entire design exists to the component level.
- b. Current status of compliance with the Goddard Rules (GSFC-STD-1000) reflects adequate progress of activities to date and satisfactory plans for future activities. Any required waivers / deviations have been approved.
- c. Results of trade studies and rationale for selected alternatives are defined.
- d. Remaining trade studies are identified and potential impacts are understood.
- e. Requirements flowdown and traceability to the appropriate subsystem of each system element, and, to the extent practical, to the component, has been completed. A preliminary verification matrix has been defined that includes the selected verification method for each requirement , including the compatibility of units of measurement, where applicable.
- f. Requirements and design changes since MDR and SDR and their rationale are documented.

- g. Appropriate descopes have been identified.
 - o Plans and trigger points have been identified.
 - o Impact to science objectives and deliverables has been defined.
 - o Potential impacts to mass, power, software and other resources have been quantified.
 - o Budget and schedule impacts have been estimated.
- h. Long lead items and their acquisition plans have been identified. Any fabrication needed prior to CDR has been identified.
- i. Proof of heritage applicability (similarity) has been assessed. Required analyses and/or tests of heritage designs to address all design modifications, changes in the expected environment and operational differences has been identified.
- j. EEE Parts Considerations:
 - o Parts Stress Analysis (PSA) requirements have been defined.
 - o Radiation tolerance requirements have been defined.
 - o Selection, de-rating, screening and qualification test criteria are defined.
 - o Preliminary parts lists are complete.
 - o Long lead acquisitions are planned. Risk mitigations are defined.
- k. Software Considerations:
 - o Preliminary requirements are identified, including language, structure, logic flow, CPU throughput and memory loading, re-use, safety, and security.
 - o Nominal operating scenarios are identified, along with fault detection, isolation, and recovery strategies.
 - o Design and development plans are defined including lines of code estimates, number of builds, tools, and procedures.
 - o Verification strategies are defined including test environments.
 - o Preliminary system performance estimates exist.
 - o IV&V plans are identified.

5.4.2 Total System Performance (budgets/projections/margins for combined optical, thermal, mechanical, control, etc.):

- a. Budgets and margins for system performance (pointing, throughput, etc.) are defined.
- b. Preliminary system performance estimates are complete.
- c. Estimates of critical resource margins (i.e., mass, power, delta V, CPU throughput and memory, etc.) have been delineated based on design maturity.
 - o Sufficient margin exists based on applicable standards. Risk mitigation strategies are defined for margins below guidelines.
- d. Preliminary analyses are completed for:
 - a. Mechanical loads, stress, fracture control, and torque margins,
 - c. Thermal environment, including predicted performance and margins,
 - d. Radiation protection requirements and design margins,
 - b. Expected lifetime and margins for limited life items.

5.4.3 Design Analyses:

- a. Preliminary analyses critical to proof of design are complete.

- b. Analyses required to enable detailed design should be complete.
- c. Rationale and risk assessment exists for outstanding analyses that may, at completion, impact the design baseline, i.e. mass, power, volume, interfaces.
- d. Status and schedule of final analyses are defined.

5.4.4 Development Test Activities:

- a. Breadboard and engineering model development activities have been defined.
- b. Test objectives and criteria have been identified.
- c. Completed breadboard and engineering model test results have been iterated into the design.
- d. Required life tests have been identified and are planned for completion by CDR.

5.4.5 Risk Management:

- a. A risk management process that meets GPR requirements is defined and utilized.
- b. All significant risks, problems, and open items are identified and tracked (including programmatic, development and flight performance related items). Risk mitigation plans are appropriate and credible.
- c. Lessons learned have been appropriately researched and adapted.
- d. Initial reliability analyses are completed and results have been factored into the design. Analyses include:
 - o Fault Tree Analysis (FTA),
 - o Probabilistic Risk Assessment (PRA), as appropriate,
 - o Failure Mode and Effects Analysis (FMEA),
 - o Single Point Failure (SPF) assessment and retention rationale
 - o Reliability driver (weak design links) assessment, and
 - o Worst Case Analysis (WCA).

5.4.6 Safety:

- a. An approved safety plan identifies all requirements as well as any planned tailoring approaches or intended non-compliances.
- b. Preliminary hazards, controls, and verification methods are identified and documented.
- c. Any open safety issues are identified with plans for resolution.
- d. Plans and schedules for all required safety submittals are defined and documented.

5.4.7 Assurance Activities:

- a. Quality Assurance plans are complete including the problem reporting system.
- b. Preliminary production planning and process controls (including strategy for control/verification of units of measurement) have been identified. Applicable workmanship standards have been defined.
- c. Special materials considerations have been identified.

5.4.8 Implementation Plans:

- a. Equipment and facilities for the development and test of hardware and software have been identified.
- b. Preliminary planning for Systems Integration and Test activities, including science validation and calibration, as well as operations compatibility testing, has been defined. Facilities are available and, if needed, utilization agreements are in work.
- c. Risks associated with I&T have been characterized and preliminary mitigations have been defined.
- d. Contamination requirements and preliminary control plans are defined.

5.4.9 Interface Control Documents:

- a. Preliminary ICDs, with external systems as well as between system elements, are complete.
- b. "TBD"s are clearly identified. Plans and schedules exist for their definition.

5.4.10 Qualification/Environmental Test Plans and Test Flow:

- a. Approach to Qualification/Proto-flight/Acceptance testing has been defined.
- b. Environmental verification flow is traceable from component to system level.
- c. Interleaving of environmental and functional test flow has been defined.
- d. Preliminary identification of all mechanical and electrical GSE has been completed.
- e. Special test requirements have been defined.
- f. Test facilities have been defined. Facilities are available and, if needed, utilization agreements are in work.

5.4.11 Logistics:

- a. Transportation methods are identified including environmental control and monitoring considerations.
- b. Preliminary identification of all GSE has been completed.
- c. Transportation container requirements have been identified.

5.4.12 Launch Vehicle Interfaces:

- a. Preliminary ICD is complete. "TBD"s are clearly identified. Plans and schedules exist for their definition.
- b. Payload-driven first flight/mission unique items have been identified and mission implications are understood.
- c. Potential launch vehicle related risk items are identified.
- d. Preliminary vehicle Orbital Debris Assessment has been completed.
- e. Preliminary integrated payload/launch vehicle activity flow has been defined.
- f. Preliminary schedule of all vehicle/payload inter-related activities has been defined.
- g. Preliminary coupled loads analysis has been initiated.

5.4.13 Ground Operations, Mission Operations, End-of-Life:

- a. Science and mission operations concepts are defined.
- b. Launch site and mission operations unique ground systems have been defined.
- c. Preliminary plans are defined for launch site activities, launch & early orbit operations.
- d. Preliminary planning for involvement and training of launch site and of mission operations teams are defined.
- e. Preliminary Orbital Debris Assessment is complete. Potential trades have been determined. End-of-life requirements and design accommodations are understood.

5.4.14 Programmatic:

- a. Organization and staffing plans delineate clear responsibilities and adequate assignment of current and future staff.
- b. Appropriate processes and metrics are in place to track and control cost, schedule, and technical activities throughout the remaining life-cycle.
- c. Appropriately detailed schedules show realistic event times as well as appropriate funded slack and are compatible with approved launch dates.
- d. Cost to complete shows adequate spending profiles and financial reserves, and is compatible with allocations.

5.4.15 Project and Independent Review Activity:

- a. Timely response to RFAs from previous IIRT reviews has occurred. Resultant actions have been implemented effectively. Schedule for completion of any outstanding RFAs is defined.
- b. An appropriate set of engineering peer reviews has been conducted and documented in compliance with GPR requirements. Resultant actions have been effectively dispositioned and executed. Appropriate additional reviews are planned.
- c. Recommendations from other project or external review activity that is applicable to the subject matter of the PDR have been adequately implemented.

5.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the PDR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta PDR may be required for the project to successfully pass this milestone.

Successful completion of the PDR constitutes readiness for detailed design to proceed.

6.0 CRITICAL DESIGN REVIEW (CDR)

At the CDR, the project discloses the complete system design to the Integrated Independent Review Team (IIRT) and justifies that the maturity of the design and development effort is appropriate to support proceeding with full scale fabrication activities, and is on track to complete the flight and ground system development and mission operations in order to meet mission performance requirements within the identified cost and schedule constraints.

6.1 Purpose

The purpose of the CDR is to demonstrate that the maturity of the design and development effort is appropriate to support proceeding with full scale fabrication activities and that the project is on track to complete the flight and ground system development and mission operations in order to meet mission performance requirements within the identified cost and schedule constraints. To that end, the project demonstrates that the final detailed design, as represented by completed drawings and analyses, supported by results of breadboard and engineering model evaluation, will meet the final performance and interface specifications and the required design objectives.

6.2 Timing

The CDR is held near the completion of the final design stage, including the completion of engineering model evaluations, as applicable, and of breadboard development and test. Although substantial completion of drawings is expected, the review should be held prior to any design freeze and before any significant fabrication activity begins. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any significant development areas (significant due to the amount, the criticality, the technical difficulty/complexity, etc.) which may not be sufficiently mature and may warrant consideration regarding either timing of the review or composition of the review team. Start of some fabrication, typically long lead items, off-the-shelf hardware or common buy items, before CDR is common and generally acceptable, however the project should consult with the review chairman to obtain concurrence with respect to any significant flight hardware fabrication that will take place before CDR.

6.3 Objectives

The objectives of the CDR are to demonstrate that: (a) all elements of the design are compliant with functional and performance requirements, (b) the verification approach is viable and will confirm compliance with all requirements, (c) risks have been appropriately identified and mitigated or are on track for timely mitigation, (d) the design is sufficiently mature to proceed with full scale fabrication, (e) the management processes used by the project team are sufficient to develop and operate the mission, and (f) the schedules and cost estimates indicate that the mission will be ready to launch and operate on time and within budget and that the control processes are adequate to ensure remaining within allocated resources.

The CDR should represent a complete and comprehensive presentation of the entire final design. It should present the final design and interfaces by means of completed drawings, block diagrams, power flow diagrams, signal flow diagrams, interface circuits, software logic flow and timing diagrams, modeling results, and breadboard and engineering model test results. Traceability for all items specified for previous IIRT reviews, updated to the present stage of the development process, shall be presented.

Programmatic considerations shall be discussed in sufficient detail to permit assessment of relevant review objectives.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Design Description (including Requirements, Evolution and Heritage)
- b. Total System Performance (budgets/projections/margins for combined optical, thermal, mechanical, control, etc.)
- c. Design Analyses
- d. Development Test Activities
- e. Risk Management
- f. Safety
- g. Assurance Activities
- h. Implementation Plans
- i. Qualification/Environmental Test Plans and Test Flow
- j. Interface Control Documents
- k. Logistics
- l. Launch Vehicle Interfaces
- m. Ground Operations, Mission Operations, and End-of-Life
- n. Programmatic
- o. Project and Independent Review Activity

6.4 Criteria for Successful Completion

6.4.1 Design Description (including Requirements, Evolution and Heritage):

- a. A complete and comprehensive definition of the entire design exists to the piece-part level.
- b. Current status of compliance with the Goddard Rules (GSFC-STD-1000) reflects adequate progress of activities to date and satisfactory plans for future activities. Any required waivers / deviations have been approved.
- c. Trade studies and rationale for selected alternatives are complete. Impacts of trade decision have been fully integrated into systems requirements, design, verification, operations, etc.
- d. Requirements flowdown and traceability has been completed. A verification matrix exists that will incorporate reference to documented results for each requirement, including the compatibility of units of measurement where applicable.

- e. Requirements and design changes since PDR and attendant rationale are documented.
 - f. Potential de-scopes have been identified.
 - o Plans and trigger points have been identified.
 - o Impact to science objectives and deliverables has been defined.
 - o Impacts to mass, power, software and other resources have been quantified.
 - o Budget and schedule impacts have been determined.
 - g. Verification of heritage applicability (similarity) has been completed. Results of analyses and tests of heritage designs to address all design modifications, changes in the expected environment and operational differences have been documented. Deficiencies have been corrected.
 - h. A high percentage of drawings (> 80 %) are completed:
 - o Number and title of all drawings has been identified,
 - o Status and schedule of drawing completion (e.g.: draft/preliminary/under review/final) have been defined.
 - o Rationale for outstanding drawings is defined and impact understood.
 - i. EEE Parts Considerations:
 - o Radiation tolerance requirements have been defined.
 - o Selection, de-rating criteria, screening and qualification test criteria are defined.
 - o Parts lists are complete. Waivers to requirements are approved.
 - o Parts stress analysis is complete. Non-conformances have been acceptably resolved.
 - o Acquisitions and risk mitigations are on-track.
 - j. Software Considerations:
 - o Requirements changes since PDR are identified, including those to language, structure, logic flow, CPU throughput and memory loading, re-use, safety, and security.
 - o Current operating scenarios are identified, along with fault detection, isolation, and recovery strategies.
 - o Current software performance estimates exist. Results meet requirements.
 - o Software Requirements Specification is approved. Document includes verification matrix mapping requirements to subsystems or CSCIs.
 - o Software Management Plan is approved and includes lines of code estimate, number of builds, tools, and procedures to be utilized, and the verification strategy including planned test environments.
 - o IV&V plans are approved. Activities are on-track. Results to date have been considered.
- 6.4.2 Total System Performance (budgets/projections/margins for combined optical, thermal, mechanical, control, etc.):
- a. Budgets and margins for system level performance (pointing, throughput, etc.) are fully defined.
 - b. System performance estimates are complete. Margins are adequate or viable corrective actions are in work.

- c. Current estimates of critical resource margins (i.e., mass, power, delta V, CPU throughput and memory, etc.) are regularly updated based on design maturity.
- d. Sufficient margin exists based on applicable standards. Viable corrective actions are defined for margins below guidelines.
 - Analyses are completed for:
 - o Mechanical loads, stress, fracture control, and torque margins,
 - o Thermal environment, including predicted performance and margins,
 - o Radiation protection requirements and design margins,
 - o Expected lifetime and margins for limited life items.

6.4.3 Design Analyses:

- a. All analyses critical to proof of design are complete.
- b. Additional outstanding analyses have acceptable completion dates and potential impacts are understood and can be reasonably accommodated.
- c. Schedules for required updates of analyses are defined.

6.4.4 Development Test Activities:

- a. Breadboard and engineering model development activities have been completed. Results are understood and have been iterated into the final design.
- b. Viable rationale exists for any outstanding testing which may at completion impact the design baseline, i.e. mass, power, volume, interfaces.
- c. All required life testing is complete. Where necessary, the design has been modified to accommodate results.
- d. Potential impact of other outstanding activity is understood and can be reasonably accommodated.

6.4.5 Risk Management:

- a. A risk management process that meets GPR requirements is defined and utilized.
- b. All significant risks, problems, and open items are defined and tracked (including programmatic, development and flight performance related items). Risk mitigation plans are credible and will retire risks in a timely fashion.
- c. Lessons learned have been appropriately researched and adapted.
- d. Reliability analyses have been updated with appropriate results factored into the design. Analyses include:
 - o Fault Tree Analysis (FTA),
 - o Probabilistic Risk Assessment (PRA), as appropriate,
 - o Failure Mode and Effects Analysis (FMEA),
 - o Single Point Failure (SPF) assessment and retention rationale
 - o Reliability driver (weak design links) assessment, and
 - o Worst Case Analysis (WCA).

6.4.6 Safety:

- a. An approved up-to-date safety plan identifies all requirements as well as any planned tailoring approaches or intended non-compliances.
- b. Analysis of system hazards, identification of control methods, and definition of verification methods is complete. Documentation has been approved.
- c. Verification of hazard controls is on-track.
- d. Preliminary safety data package has been submitted to launch range. Timely updates are scheduled.
- e. Hazardous integration and test procedures and appropriate controls have been identified.

6.4.7 Assurance Activities:

- a. Quality Assurance plans are complete including the problem reporting system.
- b. Preliminary production planning and process controls (including strategy for control/verification of units of measurement) have been identified. Applicable workmanship standards have been defined.
- c. Special materials usages have been approved.

6.4.8 Implementation Plans:

- a. Equipment and facilities for the development and test of hardware and software have been identified. Design for mission unique items has been completed.
- b. Planning for Systems Integration and Test activities, including science validation and calibration, as well as operations compatibility testing, is defined. Facilities are available. Needed utilization agreements are complete.
- c. Risks associated with I&T have been characterized and mitigations are on track for timely closure.
- d. Contamination requirements and control plans are defined. Required implementation activities are complete.

6.4.9 Interface Control Documents:

Up-to dates ICDs, with external systems as well as between system elements, are approved. No TBDs exist.

6.4.10 Qualification/Environmental Test Plans and Test Flow:

- a. Qualification/Proto-flight/Acceptance test plans are complete.
- b. Environmental verification flow is traceable from component to system level.
- c. Appropriate interleaving of environmental and functional test has been planned.
- d. Design of all mechanical and electrical GSE has been completed.
- e. Special test requirements have been fully defined. Compliance activities are on track.
- f. Test facilities have been defined. Facilities are available and, if needed, utilization agreements are complete.

6.4.11 Logistics:

- a. Transportation considerations have been fully defined including environmental control and monitoring requirements.
- b. Preliminary design of all GSE has been completed.
- c. Preliminary transportation container design has been completed.

6.4.12 Launch Vehicle Interfaces:

- a. ICD is complete.
- b. First flight/mission unique items have been identified and mission implications are understood.
- c. Launch vehicle related risk items are identified. Appropriate mitigations are on-track for timely completion.
- d. Vehicle Orbital Debris Assessment has been approved.
- e. Integrated payload/launch vehicle activity flow has been defined.
- f. Schedule of all vehicle/payload inter-related activities has been defined.
- g. Coupled loads analysis has been completed.

6.4.13 Ground Operations, Mission Operations, End-of-Life:

- a. Science and mission operations concepts are fully defined.
- b. Design of launch site and mission operations unique ground systems is complete.
- c. Plans are defined for launch site activities, launch & early orbit operations.
- d. Planning for involvement and training of launch site and of mission operations teams are defined.
- e. Orbital Debris Assessment is approved. End-of-life requirements and plans are defined.

6.4.14 Programmatic:

- a. Organization and staffing plans delineate clear responsibilities and adequate assignment of current and future staff.
- b. Appropriate processes and metrics are in place to track and control cost, schedule, and technical activities throughout the remaining life-cycle.
- c. Appropriately detailed schedules show realistic event times as well as appropriate funded slack and are compatible with approved launch dates.
- d. Cost to complete shows adequate spending profiles and financial reserves, and is compatible with allocations.

6.4.15 Project and Independent Review Activity:

- a. Timely response to RFAs from previous IIRT reviews has occurred. Resultant actions have been implemented effectively. Schedule for completion of any outstanding RFAs is defined.

- b. An appropriate set of engineering peer reviews has been conducted and documented in compliance with GPR requirements. Resultant actions have been effectively dispositioned and executed. Appropriate additional reviews are planned.
- c. Recommendations from other project or external review activity that is applicable to the subject matter of the CDR have been adequately implemented.

6.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the CDR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta CDR may be required for the project to successfully pass this milestone.

Successful completion of the CDR constitutes readiness to proceed with full-scale fabrication.

7.0 MISSION OPERATIONS REVIEW (MOR)

At the MOR, the project presents the Integrated Independent Review Team (IIRT) with the comprehensive status of its mission operations planning in order to demonstrate that the requirements for all phases and modes of mission operations, data processing, and analysis are thoroughly understood and will be adequately staffed and executed. Additionally, the project documents that the planned implementation of the ground system satisfies all operational requirements and that preliminary preparation for the execution of a comprehensive verification and validation program are complete.

7.1 Purpose

The purpose of the MOR is to demonstrate that the project has identified the full scope of the ground system's involvement in the mission and has incorporated all aspects of flight and ground operations into the plans and schedules necessary to support all required activities at the flight system integration site and the launch site, as well as launch and early orbit, routine mission, and end-of-life operations.

7.2 Timing

The MOR is the first of two IIRT reviews designed to focus on mission operations. It is typically held upon completion of detailed design and in all cases should be held prior to initiation of major integration activities of flight subsystem elements. When scheduling the review, the project should highlight and discuss with the review chairman any extenuating circumstances or problem areas that may deserve consideration regarding timing of the review or composition of the review team.

7.3 Objectives

The objectives of the MOR are to demonstrate that: (a) mission requirements are fully understood and supported by the mission operations concept, the ground system architecture, and the organizational and staffing approach; (b) the linkage of mission requirements to the ground system support requirements and subsequent flow-down to performing personnel and elements within the ground system is complete, traceable, and verifiable; (c) planning is compatible with applicable policies and procedures associated with asset protection considerations such as, but not limited to, IT and physical security; (d) considerations regarding mission operations personnel are complete with respect to organization, roles and responsibilities, staffing and training; (e) implementation activity associated with the design and development of mission unique elements as well as the adaptation of institutional elements will meet mission requirements in a timely fashion; (f) plans for comprehensive verification and validation of ground system elements are complete and include independent execution of mission readiness testing and interactive testing with the flight system; (g) the scope and approach for maintaining appropriate mission system elements (such as flight and ground software) throughout their operational lifetime are well understood.

The MOR should focus predominately upon the planning in areas driven by operational considerations. To that end, it is not an in-depth review of the design. Project peer review activity and other mission level IIRT reviews address those considerations. Consequently, information on development tasks should focus on current status and plans for interacting with verification and operations related activities in a coordinated fashion.

Specifically, the areas listed below, as a minimum, shall be addressed in sufficient detail to permit assessment of compliance with the success criteria delineated in the following section:

- a. Mission Requirements / Operations Concept
- b. Documentation
- c. Risk Management
- d. Safety / Security
- e. Assurance Activities
- f. Operations Planning
- g. Flight Team Development
- h. Implementation
- i. Test Planning
- j. Project and Independent Review Activity

7.4 Criteria for Successful Completion

7.4.1 Mission Requirements / Operations Concept:

- a. Ground system requirements are fully linked to mission requirements and are functionally allocated in a manner that permits traceability and the creation of verification matrixes.
- b. Mission support requirements are fully documented and a process for identifying and tracking changes to the requirements baseline is in place.
- c. Major constraints associated with flight (including the spacecraft, instrument, and launch vehicle elements) and ground systems have been fully accommodated within the operations concept and reflected in the ground system support requirements. A plan for capturing lower-level constraints and restrictions in a timely fashion is defined.

7.4.2 Documentation:

- a. Mission Operations Concept Document is complete (no TBDs) and baselined.
- b. Detailed Mission Requirements Document is current with no TBDs and baselined
- c. Approach for documenting flight operations information, including contingencies, trending plans, and S/C and instrument operational constraints is fully defined with the following applicable documents in preliminary form:
 - o Flight Operations Plan
 - o Flight Procedures Document
 - o Launch and Ascent Handbook
 - o Mission Rules
 - o Operations Agreements

- Flight Operations Test Plan
 - Flight Operations Team Certification Plan
 - On-Orbit Handbook
 - Spacecraft User's Manual
- d. Element-level Requirements Specifications, Design Specifications and ICDs are complete with no TBDs.
 - e. Mission Readiness Test Plan has been completed and Test Requirements Database has been prepared.

7.4.3 Risk Management:

- a. All ground system related risks are fully defined, documented and regularly updated with credible triggers and mitigation strategies defined. Any active mitigations strategies are on track.
- b. The risk management system is fully compliant with and appropriately linked to the project risk management system.
- c. Lessons learned have been appropriately researched and adapted.

7.4.4 Safety / Security:

- a. Hazards identification, control methods, and verification approaches have been defined and approved.
- b. Required documentation, such as the IT documentation set required in NPR 2810.1, is complete. Completion dates have been defined for necessary updates and for other documentation.
- c. Personnel and physical security considerations have been defined and are compatible with all applicable requirements.

7.4.5 Assurance Activities:

- a. Quality Assurance planning, including problem reporting, is in compliance with applicable policy, complete, and approved.
- b. Required IV&V activities are fully defined and on schedule.

7.4.6 Operations Planning:

- a. Mission operations plans are complete for all routine operational scenarios. Areas from which contingency operations requirements will arise are identified.
- b. Science data acquisition, processing and analysis approach is defined and plans for maintaining data throughput and integrity have been identified.
- c. Spacecraft operations at the system- and subsystem-levels are well understood for the routine, special and contingency operations modes.
- d. The approach to mission planning and scheduling is fully defined.
- e. Preliminary plans for launch and early orbit (including deployment activities, in-orbit checkout, and communication coverage), routine science data acquisition (including

health and safety monitoring as well as on-board data memory management), contingency, safe-mode, and end-of-life scenarios are complete.

- f. Adequate planning has been completed for the successful definition, development, verification, validation and configuration management of all operations procedures.
- g. The planned flight and ground software maintenance approach is defined.
- h. The development approach for receipt of interim databases and operating procedures from flight system element providers is defined.
- i. Passive and active approaches for insight into flight system- and subsystem-level activities during integration are defined.
- j. The approach for offline parameter trending is defined. The data archival, retrieval, and reporting approach are defined. Anomaly reporting is integrated into these plans.

7.4.7 Flight Team Development:

- a. Flight Operations Team (FOT) roles, responsibilities, staffing levels (including timing of and numbers during initial phase-in as well as for each mission phase), certification requirements, and training approach, are defined.
- b. Plans for preparing the FOT for operations through the use of classroom training, mission simulations, flight rehearsals, and network exercises are fully defined.
- c. Plans for involvement of FOT in key flight system activities such as Thermal-Vacuum testing and Comprehensive System Testing are defined.
- d. Plans are defined for integrating flight system- and subsystem-level experts in a manner that creates a unified mission operations team.

7.4.8 Implementation:

- a. The design and development of mission-unique ground system elements are compliant with requirements. Designation of launch critical facilities and functions has been made. Development progress is satisfactory.
- b. The modifications of institutional ground system elements are compliant with mission requirements. Any modifications are defined and implementation progress is satisfactory.
- c. Development schedules have been defined for all development activities and integrated with operational activities and the top-level project schedule.
- d. The facilities identified to host ground system elements and support simulations have been identified, are adequate, or if modifications are required then necessary plans have been completely defined and work schedules support the schedules. Management of critical resources will be adequate to support mission reliability requirements.
- e. Preliminary loading studies for institutional elements such as the Space Network, Ground Network and NASA Integrated Services Network (NISN) are complete.

7.4.9 Test Planning:

- a. Intra- and inter-element test approaches are defined and scheduled.
- b. A mission readiness test approach of the integrated ground system is defined in a separate written test plan and includes RF Compatibility and network compatibility verification.

Test requirements are traceable to system-level documentation and derived strictly from element-level documentation. Activities are on track.

- c. Validation activities with the flight system, adequate in both scope and number, are planned prior to shipment of the flight system to the launch site. Simulations and rehearsals, using the end-to-end flight and ground system and involving the entire mission operations team, are included in these activities. Such tests shall include stress induced operational situations based upon anticipated and unanticipated contingencies and anomalies.
- d. Sufficient test opportunities are planned at the launch site both prior to and after integration with the launch vehicle. Such testing will include validation of the space/ground interface. Adequate periods shall be allocated to accommodate regression testing to confirm resolution of anomalies.

7.4.10 Project and Independent Review Activity:

- a. Timely responses to RFAs from previous IIRT reviews have occurred. In the event that RFAs are still open then disclosure of the remaining work prerequisite to closure is to be provided along a description of the current risk exposure.
- b. An appropriate set of engineering peer reviews has been conducted and documented in compliance with GPR requirements. Resultant actions have been dispositioned and modifications made. Appropriate additional reviews are planned.
- c. Recommendations from other project or external review activity that is applicable to the subject matter of the MOR have been adequately implemented.

7.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the MOR. Subsequent to the review, therefore, the review chairman (in consultation with the review team) will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MOR has been successfully completed. Successful completion may be contingent on the responses to some or all of the Requests For Action (RFAs) generated at the review. In some cases the review chairman may determine that a delta-MOR is necessary.

Successful completion of the MOR constitutes readiness to continue with the execution of project plans associated with developing the required ground system elements, and the preparation of operations personnel necessary to operate them. The results of the plans presented at the MOR will be reviewed at the Flight Operations Review, the second of the two IIRT reviews that focus on mission operations.

8.0 PRE-ENVIRONMENTAL REVIEW (PER)

At the PER, the project discloses to the Integrated Independent Review Team (IIRT) the complete and comprehensive project status in order to justify readiness to proceed with environmental testing of the integrated flight system and to demonstrate that the project is on track to complete the flight and ground system development and mission operations in order to fully meet mission performance requirements within allocated cost and schedule resources.

8.1 Purpose

The purpose of the PER is to demonstrate readiness to proceed with environmental testing of the integrated flight system and to demonstrate that the project is on track to complete the flight and ground system development and mission operations in order to fully meet mission performance requirements within allocated cost and schedule resources. To that end, the project demonstrates that a requirements-compliant flight system design has been fabricated, appropriately tested at lower levels of assembly, integrated, and subjected to a successful comprehensive systems test. In addition, adequacy of planning for subsequent flight system activities, satisfactory progress on development of other system elements, and adequacy of available resources to complete remaining project activities shall be demonstrated.

8.2 Timing

The PER is held after completion of the initial successful comprehensive systems test of the fully-integrated flight system and prior to initiation of the system level environmental test sequence. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any extenuating circumstances or problem areas that may deserve consideration regarding timing of the review or composition of the review team.

8.3 Objectives

The objectives of the PER are to demonstrate that: (a) all supportive flight system design analyses have been successfully completed and demonstrate adequate margin, (b) all lower level flight system verification activities have been satisfactorily completed and all discrepancies are sufficiently understood to warrant proceeding, (c) initial flight system comprehensive performance testing has established a valid performance baseline that complies with requirements, (d) planning is adequate for all remaining flight system activities, (e) development of all other flight system elements (e.g.: launch vehicle, ground system, data processing and analysis system) is satisfactory, and (f) available cost and schedule resources support completion of all necessary remaining activities with adequate margin.

The PER should present a complete and comprehensive status of the final system with emphasis on changes to requirements and to the design since CDR. It should trace all fabrication and lower level verification activities with emphasis on discrepancies and their resolution. It should detail

the composition and results of the comprehensive system test. It should detail all remaining project activities and detail status of all other mission system elements.

Programmatic considerations shall be discussed in sufficient detail to permit assessment of relevant review objectives.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Requirements / Design Update
- b. Completed Verification Activities
- c. Risk Management
- d. Safety
- e. Assurance Activities
- f. System Test Activity
- g. Launch Site Activities
- h. Launch Vehicle Interfaces
- i. Mission Operations
- j. Programmatic
- k. Project and Independent Review Activity

8.4 Criteria for Successful Completion

8.4.1 Requirements / Design Update:

- a. Requirements and design changes to hardware or software since CDR and attendant rationale are documented. As required, ICDs have been updated and approved. Resultant changes to verification matrix have been incorporated and approved.
- b. Current status of compliance with the Goddard Rules (GSFC-STD-1000) reflects adequate progress of activities to date and satisfactory plans for future activities. Any required waivers / deviations have been approved.
- c. Changes since CDR to heritage applicability or resultant verification thereof have been documented and approved.
- d. Current calculations of all critical resource margins are adequate and based on actual measured values.

8.4.2 Completed Verification Results:

- a. Current calculations for systems performance are fully compliant with requirements.
- b. Completed analyses of current design demonstrate adequate margin for:
 - o mechanical loads, stress, and torque margin,
 - o thermal effects,
 - o radiation protection, and
 - o expected lifetime of limited life items.
- c. Results of ETU testing since CDR are documented. The design reflects the results.

- d. Life testing of limited life items is complete and the design appropriately reflects results.
- e. Results of all hardware and software verification activities below the fully integrated flight system level are successfully complete, including those associated with compatibility of units of measurement. The project verification matrix documents the results of such.
- f. All discrepancies (non-conformances, anomalies, failures, “cannot duplicate”s, etc.) are fully explained and justify proceeding to subsequent activities. All waivers are approved.
- g. A fully successful Comprehensive Performance Test of the fully integrated flight system has been completed. All discrepancies are fully explained and justify proceeding to subsequent activities.

8.4.3 Safety:

- a. Hazards and control methods have been defined and approved.
- b. Verification of controls is on-track.
- c. Required documentation is complete. Timely updates are scheduled.
- d. Appropriate interaction with test facilities, the launch range, and the launch vehicle is on track.
- e. End-of-life scenarios are fully approved.

8.4.4 Risk Management:

- a. All development related risks are fully retired and associated residual risk is approved.
- b. Risks associated with remaining activities are defined and credible mitigations will retire risks in a timely fashion.
- c. Lessons learned have been appropriately researched and adapted.
- d. A credible plan for utilization of limited life items and consumables (e.g.: cryogenic fluids, pyrotechnics, batteries, mechanisms) has been approved.

8.4.5 Assurance Activities:

- a. Appropriate reliability analyses have been updated.
- b. Quality Assurance planning for all subsequent activities are complete and approved.
- c. All discrepancies have been reviewed for acceptable closure. Any items requiring special attention or monitoring during subsequent activity have been identified and appropriate action planned.
- d. EEE parts and materials related qualification tests are successfully completed.
- e. Any waivers are approved.
- f. IV&V activities are successfully completed.

8.4.6 System Test Planning:

- a. Planning for Integrated Systems Test activities is complete and includes sufficient activity devoted to science validation and calibration, and operations compatibility testing.

- b. Adequate systems performance testing is planned during and between environmental exposures so as to ensure adequate functionality or uncover any deviations. Adequate testing of primary and redundant elements is planned.
- c. Sufficient operating time (including failure-free operating time) will be obtained. Critical parameters to be trended throughout the system test sequence are defined.
- d. A comprehensive environmental test sequence at appropriate exposure levels is planned that will complete all remaining required verification activities.
- e. Facility readiness reviews have been completed. Resultant actions are on track for timely completion. Handling equipment and test equipment are qualified and ready for use.
- f. Contamination control plans and required equipment are in place and compliant with requirements.

8.4.7 Launch Site Activities:

- a. Transportation plans are fully defined. Shipping containers, handling equipment, environmental control and monitoring equipment are complete and available. Qualification activities are on track.
- b. Launch site activity plan is approved and includes appropriate comprehensive system performance testing.
- c. Facilities are available for use. Support requirements, including contamination control, will be met.
- d. Ground handling and support equipment are qualified and available.

8.4.8 Launch Vehicle Interfaces:

- a. An approved up-to-date ICD is in place.
- b. First flight/mission unique items have been qualified for use.
- c. Launch vehicle related risk items are retired. Residual risks are approved.
- d. Vehicle Orbital Debris Assessment has been approved.
- e. Integrated payload/launch vehicle activity flow has been approved.
- f. Schedule of all vehicle/payload inter-related activities has been approved.
- g. An updated coupled loads analysis has been completed.

8.4.9 Mission Operations:

- a. Mission operations plans are complete for all routine and contingency scenarios.
- b. Mission operations systems are complete and available.
- c. Operations team staffing needs are fully defined. Staffing will be available to support simulations.
- d. Planning for involvement and training of launch site and of mission operations teams are defined.
- e. End-to-end operational simulations of flight and ground mission systems by actual operations team are planned and include launch and early orbit, routine science data acquisition, contingency, and end-of-life scenarios.

8.4.10 Programmatic:

- a. Organization and staffing plans delineate clear responsibilities and adequate assignment of current and future staff.
- b. Appropriate processes and metrics are in place to track and control cost, schedule, and technical activities throughout the remaining life-cycle.
- c. Appropriately detailed schedules show realistic event times as well as appropriate funded slack and are compatible with approved launch dates.
- d. Cost to complete shows adequate spending profiles and financial reserves, and is compatible with allocations.

8.4.11 Project and Independent Review Activity:

- a. Timely response to RFAs from previous IIRT reviews has occurred. Resultant actions have been implemented effectively. Schedule for completion of any outstanding RFAs is defined.
- b. An appropriate set of engineering peer reviews has been conducted and documented in compliance with GPR requirements. Resultant actions have been effectively dispositioned and executed. Appropriate additional reviews are planned.
- c. Recommendations from other project or external review activity that is applicable to the subject matter of the PER have been adequately implemented.

8.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the PER. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta PER may be required.

Successful completion of the PER constitutes readiness to proceed with environmental testing of the flight system.

9.0 FLIGHT OPERATIONS REVIEW (FOR)

At the FOR, the project presents the Integrated Independent Review Team (IIRT) with the results of its mission operations activities to demonstrate that compliance with all requirements have been verified and that the ability to execute all phases and modes of mission operations, data processing, and analysis have been demonstrated. Additionally, the project demonstrates that adequate planning and resources are in place for any remaining activities associated with interactive flight/and ground testing, network compatibility testing, and other remaining pre-launch testing. Finally, completion status of staffing, training and certification of the flight team are reviewed.

9.1 Purpose

The purpose of the FOR is to demonstrate that ground system mission elements are ready to proceed with final integrated flight and ground system testing as well as remaining support to pre-launch, launch, mission operations, data processing, and analysis activities. To that end, the project provides results of activities since the MOR as well as plans for all remaining work prior to launch.

9.2 Timing

The FOR is the second of two IIRT reviews held to examine mission operations status. It is held during the test flow of the fully integrated flight system, after completion of the initial successful comprehensive systems test but prior to the last major interactive test between the flight and ground system elements that is conducted before shipment of flight system elements to the launch site. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any extenuating circumstances or problem areas that may deserve consideration regarding timing of the review or composition of the review team.

9.3 Objectives

The objectives of the FOR are to demonstrate that: (a) all mission requirements, including any changes since the MOR, have been fully supported by the mission operations concept, the ground system architecture, and the organizational and staffing approach; (b) asset protection considerations, including IT and physical security, are complete and compatible with applicable policies and procedures; (c) organizational reporting, roles and responsibilities, staffing and training of mission operations personnel are complete; (d) the design of mission unique ground system elements as well as any required institutional elements has been verified as compatible with mission requirements and all discrepancies have been satisfactorily resolved; (e) comprehensive independent verification and validation of the ground system, including mission readiness testing and interactive testing with the flight system has been completed and all discrepancies have been satisfactorily resolved; (f) plans for remaining pre-launch activities as well as all operational scenarios and contingencies are complete with adequate simulation planned for all situations; (g) the scope and approaches for maintaining mission system elements

(such as flight and ground software) throughout their operational lifetime are fully defined, planned, and staffed.

The FOR should highlight any changes to requirements or design since the MOR. It should provide details of verification and checkout of ground system elements with emphasis on discrepancies and their resolution. It should detail all remaining activities and emphasize adequacy of operations planning and planned testing to demonstrate that all operations scenarios can be handled successfully.

In general, all areas addressed at the MOR shall be updated as to current status at the FOR. Specifically, the areas listed below shall be discussed in sufficient detail to permit assessment of compliance with the success criteria delineated in the following section:

- a. Mission Requirements / Operations Concept
- b. Documentation
- c. Risk Management
- d. Safety / Security
- e. Assurance Activities
- f. Operations Planning/Demonstration
- g. Flight Team Development
- h. Implementation
- i. Testing
- j. Project and Independent Review Activity

9.4 Criteria for Successful Completion

9.4.1 Mission Requirements / Operations Concept:

- a. Mission support requirements documentation is current, including any changes since MOR.
- b. Ground system requirements, including any changes since MOR, are fully traceable to mission requirements. Verification results have been documented in the verification matrixes.
- c. All constraints associated with flight (including the spacecraft, instrument, and launch vehicle elements) and ground systems, including any changes since MOR, have been fully accommodated

9.4.2 Documentation:

- a. Mission Operations Concept Document is current and approved.
- b. Detailed Mission Requirements Document is current and approved.
- c. Approach for documenting flight operations information, including contingencies, trending plans, and all operational constraints is fully functional with the following applicable documents current and approved:
 - o Flight Operations Plan

- Flight Procedures Document
 - Launch and Ascent Handbook
 - Mission Rules
 - Operations Agreements
 - Flight Operations Test Plan
 - Flight Operations Team Certification Plan
 - On-Orbit Handbook
 - Spacecraft User's Manual
- d. Element-level Requirements Specifications, Design Specifications and ICDs are current and approved.
- e. Mission Readiness Test Plan is current and approved. Test Requirements Database is current and operational.

9.4.3 Risk Management:

- a. All ground system related risk mitigations have been successfully executed. Residual risks are fully understood and have been accepted.
- b. Lessons learned have been fully researched. All applicable lessons have been adapted.

9.4.4 Safety / Security:

- a. Hazard control methods have been verified. Hazard reports are closed.
- b. Required updates to documentation, such as the IT documentation set required in NPR 2810.1, are complete and approved.
- c. Personnel and physical security considerations are complete and compatible with all applicable requirements.

9.4.5 Assurance Activities:

- a. Quality Assurance activity is defined and operational. Problem reporting databases reflect current status, including any discrepancies that occurred during verification and validation activities. Open problem reports are being actively investigated and tracked. Closed problem reports are fully understood. Any required waivers are approved.
- b. IV&V activities are complete.

9.4.6 Operations Planning/Demonstration:

- a. Mission operations plans are complete for all operational scenarios and contingency situations.
- b. Science data acquisition, processing and analysis approach is fully implemented.
- c. Approach for maintaining data throughput and integrity have been verified.
- d. The approach to mission planning and scheduling has been successfully verified.
- e. Scenarios for launch and early orbit (including deployment activities, in-orbit checkout, and communication coverage), routine science data acquisition (including health and safety monitoring as well as on-board data memory management), contingency, safe-mode, and end-of-life have been verified.

- f. All operations procedures are current, verified, and approved.
- g. The flight and ground software maintenance approach has been verified.
- h. Databases and operating procedures from flight system element providers are current and have been appropriately incorporated into ground system operations.
- i. The approach for offline parameter trending is operational. The data archival, retrieval, and reporting approach is operational. Anomaly reporting of detected trends is an integral part of the process.

9.4.7 Flight Team Development:

- a. Flight Operations Team (FOT) roles and responsibilities, as currently defined, are documented and approved. Staffing levels meet current needs. Staffing needs for all future mission phases are defined with plans in place to secure the necessary staff in time to complete training prior to being placed in line with operations.
- b. Certification and training on board staff is complete. Plans for certification and training of future staff are complete and approved.
- c. Training of the FOT for operations through the use of classroom training, mission simulations, flight rehearsals, and network exercises has been completed.
- d. Flight system- and subsystem-level experts have been effectively integrated into the FOT to form a unified team.

9.4.8 Implementation:

- a. The design of mission-unique ground system elements has been verified to be compliant with requirements. Launch critical facilities and functions have been verified ready to provide the required mission support.
- b. Required institutional ground system elements have been verified to be compliant with mission requirements.
- c. The facilities needed to host ground system elements and support simulations have been verified.
- d. Loading studies for institutional elements such as the Space Network, Ground Network and NASA Integrated Services Network (NISN) are complete. Results are compatible with mission needs.

9.4.9 Testing:

- a. Intra- and Inter-element tests have been successfully completed. All discrepancies are fully understood. Corrective actions have been fully implemented.
- b. Mission readiness testing of the integrated ground system has been successfully completed. All discrepancies are fully understood. Corrective actions have been fully implemented. RF Compatibility and network compatibility have been verified.
- c. Validation activities with the flight system, adequate in both scope and number, have been completed using the launch-support S/W versions. Adequate simulations and rehearsals, using the end-to-end flight and ground system, involving the entire mission operations team, and including stress induced operational situations based upon anticipated and unanticipated contingencies and anomalies, have been conducted.

- d. Sufficient test opportunities are planned at the launch site both prior to and after integration with the launch vehicle. Such testing will include validation of the space/ground interface. Adequate periods are allocated to accommodate regression testing which may be needed in order to confirm and document the acceptable resolution of anomalies.

9.4.10 Project and Independent Review Activity:

- a. Timely responses to RFAs from previous IIRT reviews have occurred. In the event that RFAs are still open then disclosure of the remaining work prerequisite to closure is to be provided along a description of the current risk exposure.
- b. An appropriate set of engineering peer reviews has been conducted and documented in compliance with GPR requirements. Resultant actions have been dispositioned and modifications made. Appropriate additional reviews are planned.
- c. Recommendations from other project or external review activity that is applicable to the subject matter of the FOR have been adequately implemented.

9.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the FOR. Subsequent to the review, therefore, the review chairman (in consultation with the review team) will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the FOR has been successfully completed. Successful completion may be contingent on the responses to some or all of the Requests For Action (RFAs) generated at the review. In some cases the review chairman may determine that a delta-FOR is necessary.

Successful completion of the FOR constitutes readiness to proceed with final integrated flight and ground system testing as well as with other remaining activity needed to support pre-launch, launch, mission operations, data processing, and analysis.

10.0 PRE-SHIP REVIEW (PSR)

At the PSR, the project discloses current status of all activities and establishes that all flight and ground system verification activities have been successfully completed and that the system is ready for final processing prior to launch and mission operations.

10.1 Purpose

The purpose of the PSR is to demonstrate that the flight system is ready for shipment to the launch site and for final processing prior to launch and mission operations.

To that end, the project demonstrates that all performance and environmental verification activities of the integrated flight system have been successfully completed, that all ground system verification and compatibility testing have been successfully completed, that all discrepancies of any type have been satisfactorily resolved, and that planning and preparation for all remaining activities has been completed.

10.2 Timing

The PSR is conducted prior to shipment of flight system elements to the launch site and after successful completion of all verification activities of flight and ground system elements. When scheduling the review, the project should highlight and discuss with the review chairperson(s) any significant problem areas that may pose difficulty during the review.

10.3 Objectives

The objectives of the PER are to demonstrate that: (a) all functional performance and environmental testing of the flight system has been successfully completed, including network and ground system compatibility testing as well as mission simulations, (b) all discrepancies are fully understood and satisfactorily resolved, including completion of corrective actions as well as planning and preparation of any required follow-on actions, (c) any changes since the PER have been evaluated for mission implications, have been successfully incorporated into appropriate system elements, have been verified, and are compatible with any interfacing system element, and (d) planning and preparation for shipping and subsequent ground processing, launch, and mission operations is complete.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Requirements / Design Update
- b. Completed Verification Activities
- c. Risk Management
- d. Safety
- e. Assurance Activities
- f. Launch Site Activities

- g. Mission Operations
- h. Project and Independent Review Activity

10.4 Criteria for Successful Completion

10.4.1 Requirements / Design Update:

- a. Requirements and design changes to hardware or software since PER and attendant rationale are documented. Mission implications and interface compatibility have been considered, and verification updates (analyses and tests) have been completed.
- b. Current status of compliance with the Goddard Rules (GSFC-STD-1000) reflects adequate progress of activities to date and satisfactory plans for future activities. Any required waivers / deviations have been approved.
- c. Current calculations of all critical resource margins remain adequate and based on actual measured values.
- d. Analyses of the current design are complete and demonstrate adequate margin.

10.4.2 Completed Verification Results:

- a. All integrated flight system performance and environmental verification activities have been successfully completed.
- b. Ground system verification activities have been successfully completed.
- c. Network compatibility demonstrations have been successfully completed.
- d. All verification results have been documented in the verification matrix, including those associated with compatibility of units of measurement.
- e. Mission simulations of all operational scenarios, including contingency situations, have been successfully completed.
- f. Current calculations for systems performance have been updated as appropriate with system test results and continue to demonstrate full compliance with system requirements.
- g. All discrepancies (non-conformances, anomalies, failures, "cannot duplicate"s, etc.) are fully understood. Corrective actions are completed, and plans and preparations for any required follow-on actions are completed. All waivers are approved.

10.4.3 Safety:

- a. Hazard verifications are complete.
- b. Required documentation is complete.
- c. End-of-life scenarios are fully approved.

10.4.4 Risk Management:

All risks have been fully retired. Residual risks, including those resulting from incomplete or uncertain closure of discrepancies, have been fully characterized and formally accepted by appropriate management.

10.4.5 Assurance Activities:

- a. Quality Assurance planning for all subsequent activities are complete and approved.
- b. All discrepancies have been reviewed for acceptable closure. Any items requiring special attention or monitoring during subsequent activity, including during mission operations, have been identified and appropriate action planned.
- c. IV&V activity is successfully completed, including updates resulting from recent changes.

10.4.6 Launch Site Activities:

- a. Transportation plans are fully defined. Shipping containers, handling equipment, environmental control and monitoring equipment are verified and available.
- b. Launch site facilities are available and have been verified to meet requirements, including those for contamination control.
- c. Launch site activity plan, including integrated activity with the launch vehicle, is approved and includes appropriate comprehensive system performance testing as well as end-to-end system compatibility testing.

10.4.7 Mission Operations:

- a. Mission operations plans are complete for all routine and contingency scenarios.
- b. Mission operations systems are complete and available.
- c. Operations team staffing is in place. Required personnel certifications have been approved.
- d. Adequate end-to-end operational simulations of flight and ground mission systems have been completed by actual operations team.

10.4.8 Project and Independent Review Activity:

- a. All RFAs from all previous IIRT reviews are closed. Resultant actions have been implemented effectively.
- b. An appropriate set of engineering peer reviews has been completed and documented in compliance with GPR requirements. Resultant actions have been effectively implemented.
- c. Recommendations from other project or external review activity have been adequately implemented.

10.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the PSR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on

the responses to some or all of the RFAs generated at the review. In some cases a delta-PSR may be required for the project to successfully pass this milestone.

Successful completion of the PSR constitutes readiness for shipment of the flight segment to the launch site.

11.0 DISPOSAL REVIEW (DR)

At the DR, the project presents to the IIRT the rationale and plans for decommissioning and safe disposal of mission assets in order to confirm its readiness to proceed with executing those plans.

11.1 Purpose

The purpose of the DR is to confirm readiness to proceed with the safe decommissioning and disposal of mission assets with particular attention to those assets in Earth orbit.

To that end, the project demonstrates that the reasons for decommissioning are valid, that plans for safe and effective disposal of assets, in particular flight assets, have been completed, and that disposal activities can and will be successfully executed in a timely fashion.

11.2 Timing

The DR is normally conducted near the end of routine mission operations upon accomplishment of planned mission objectives. It may be advanced if some unplanned event gives rise to a need to pre-maturely terminate the mission, or delayed if operational life is extended to permit additional investigations.

11.3 Objectives

The objectives of the DR are to demonstrate that: (a) the requirements associated with decommissioning and disposal are fully understood, (b) plans for decommissioning, disposal, and any transition are correct, current and appropriate for existing safety, environmental, and other constraints as well as current system capabilities, (c) resources are in place to support decommissioning and disposal activities, and (d) appropriate plans have been completed for disposition of project assets and archival of essential mission and project data.

Specifically, the areas listed below shall be addressed in sufficient detail to permit a judgment by the IIRT regarding accomplishment of review objectives. That judgment will be guided by attainment of the expectations delineated in the following section:

- a. Requirements and Constraints
- b. Current System Capability
- c. Implementation Planning
- d. Readiness Verification
- e. Project and Independent Review Activity

11.4 Criteria for Successful Completion

11.4.1 Requirements and Constraints:

- a. Rationale for decommissioning and disposal is appropriate and well documented.

- b. Safety, health, and environmental requirements are fully defined. Applicable updates to such since launch have been identified and implications understood. Required waivers, if any, have been approved.
- c. System performance requirements for both the flight and ground systems, as well as supporting communications networks, have been defined and reflect current needs and applicable constraints.
- d. Operations requirements to support decommissioning and disposal activities have been defined and reflect current needs and applicable constraints. Personnel certification requirements have been identified.

11.4.2 Current System Capability:

- a. Changes to hardware and software since launch have been considered with respect to potential impact on compliance with decommissioning and disposal requirements.
- b. Critical resources (e.g.: power, propellant, link margin, data storage, processing speed) are adequate to support required activities based on actual measured values.
- c. All discrepancies that have occurred since launch have been assessed for implications related to the ability to successfully execute decommissioning and disposal activities. Alterations to previously planned scenarios have been modified as needed.
- d. Analyses of the currently planned and potential alternate disposal configurations demonstrate adequate performance capability to meet requirements.

11.4.3 Implementation Planning:

- a. The decommissioning and disposal plan is complete, approved by appropriate management, and compliant with applicable agency safety, environmental, and health regulations.
- b. Safety, health and environmental hazards have been identified. Controls have been verified.
- c. Risks associated with the disposal have been identified and adequately mitigated. Residual risks have been accepted by the required management.
- d. Operations plans for all potential scenarios, including contingencies, are complete and approved. All required support systems are available.
- e. Quality assurance plans for all subsequent activities have been defined and approved. Plans identify problem reporting and resolution requirements, including situations requiring real-time action in response to anomalous occurrences.
- f. If hardware is to be recovered from orbit:
 - o Return site activity plans have been defined and approved.
 - o Required facilities are available and meet requirements, including those for contamination control, if needed.
 - o Transportation plans are defined and approved. Shipping containers and handling equipment as well as contamination and environmental control and monitoring devices are available.
- g. Plans for disposition of mission owned assets (hardware, software, facilities, etc.) have been defined and approved.

- h. Plans for archival and subsequent analysis of mission data have been defined and approved. Arrangements have been finalized for the execution of such.
- i. Plans for the capture and dissemination of appropriate lessons learned during the project life cycle have been defined and approved.
- j. Adequate resources (schedule, budget, and staffing) have been identified and are available to successfully complete all decommissioning, disposal, and disposition activities.

11.4.4 Readiness Verification:

- a. All flight and ground system performance verification activities have been completed. Anomalies have been satisfactorily resolved and implications of such on upcoming activities have been accommodated.
- b. Required personnel certifications have been completed.
- c. Simulations of all potential scenarios, including contingencies, have been successfully completed by the actual operations team.
- d. Demonstrations of communications network support have been successfully completed. Anomalies have been satisfactorily resolved and any needed changes incorporated.
- e. Any required IV&V activity necessitated by changes to software since launch has been completed. Recommendations from such have been satisfactorily accommodated.

11.4.5 Project and Independent Review Activity:

- a. A set of engineering peer reviews has been conducted for appropriate technical areas. Recommendations from such have been satisfactorily accommodated.
- b. Recommendations from other project or external reviews with bearing on upcoming activities have been satisfactorily accommodated.

11.5 Results of Review

It is recognized that projects may not fully satisfy all of the above criteria at the time of the DR. Subsequent to the review, therefore, the review chairperson(s), in consultation with the review team, will assess the degree to which the above criteria have been met, the criticality of the areas where there are shortfalls, how straightforward and likely to succeed are the project's recovery plans, and other relevant factors in making a judgment as to whether the MCR has accomplished its objectives and has been successfully completed. Successful completion may be contingent on the responses to some or all of the RFAs generated at the review. In some cases a delta DR may be required for the project to successfully pass this milestone.

Successful completion of the DR constitutes readiness to proceed with decommissioning and disposal activities.