



Ames Procedural Requirements

APR 7120.3

Effective Date: July 24, 2018

Expiration Date: July 24, 2023

COMPLIANCE IS MANDATORY

Subject: Development and Operation of Center Critical Facilities and Infrastructure

Responsible Office: D/Office of the Chief Engineer

DOCUMENT CHANGE LOG

Status [Baseline /Revision /Cancelled]	Document Revision	Date of Change	Description
Baseline	0	7/24/2018	New document

TABLE OF CONTENTS

PREFACE

- P.1 Purpose
- P.2 Applicability
- P.3 Authority
- P.4 Applicable Documents and Forms
- P.5 Measurement/Verification
- P.6 Cancellation

CHAPTER 1. CENTER CRITICAL FACILITY AND INFRASTRUCTURE IDENTIFICATION

CHAPTER 2. ROLES AND RESPONSIBILITIES

- 2.1 Deputy Center Director
- 2.2 Ames Chief Engineer
- 2.3 Ames Safety and Mission Assurance Director
- 2.4 Center Critical Facility and Infrastructure Project Team
- 2.5 Center Critical Facility and Infrastructure Operator Organization Manager

CHAPTER 3. LIFE CYCLE MANAGEMENT

- 3.1 Formulation
- 3.2 Management and Control
- 3.3 Planning and Analysis
- 3.4 Operation

CHAPTER 4. LIFE CYCLE REVIEWS

- 4.1 Development Life Cycle Reviews
- 4.2 Operational Life Cycle Reviews

APPENDIX A. DEFINITIONS

APPENDIX B. ACRONYMS

APPENDIX C. VERIFICATION MATRIX OR REFERENCES

APPENDIX D. ADDITIONAL GRAPHICS

Preface

P.1 PURPOSE

- a. NASA Ames Research Center maintains several facilities that provide unique and critical capabilities for the agency. The purpose of this Ames Procedural Requirements (APR) document is to ensure that critical facilities developed and operated by NASA Ames Research Center – as well as supporting infrastructure elements – are safe, effective, and managed to a standard commensurate with the value and importance of the facility to the center and agency.
- b. NASA Procedural Requirements (NPR) 8820.2, Facility Project Requirements, applies to Construction of Facilities (CoF) projects costing \$1M or more, including center critical facility projects. This document supplements NPR 8820.2 for center critical facility projects through the application of relevant concepts from NPR 7123.1, NASA Systems Engineering Processes and Requirements. The resulting tailored requirements establish the necessary level of engineering process integrity and rigor appropriate for the development and maintenance of critical facilities.

P.2 APPLICABILITY

- a. This APR is applicable to ARC and associated facilities, e.g., contractor facilities, etc. This APR applies to facility development, modification, and upgrade projects, whether funded by the CoF program or other programs, where the facility is determined by the Deputy Center Director to be a center critical facility and the project cost is \$1M or greater. This APR also applies to operation of such critical facilities and critical infrastructure elements – such as electrical power supply – that support critical facilities. This APR does not apply to center non-critical facility projects or facility demolition projects. For existing facilities, the requirements of this document are applicable to the project's extant phase as of the effective date of the APR and to phases yet to be completed. This includes modifications and upgrades to the facilities, post-mishap recovery and re-commissioning.
- b. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms: "may" or "can" denote discretionary privilege or permission, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.
- c. In this directive, all document citations are assumed to be the latest version unless otherwise noted.

P.3 AUTHORITY

- a. APR 1280.1, Ames Management Systems (AMS) Quality Manual.

P.4 APPLICABLE DOCUMENTS AND FORMS

- a. APD 8735.3 Verification of Product/ Service Conformance to Requirements

- b. APD 8800.1 Real Property Management
- c. APR 1150.2 Ames Engineering Technical Authority
- d. APR 7120.11 Ames Health and Medical Technical Authority
- e. APR 8040.1 Configuration Management
- f. APR 8705.2 Safety and Mission Assurance Technical Authority
- g. APR 8735.1 Control of Nonconforming Products and Services
- h. NASA-STD-8719.7 Facility System Safety Guidebook
- i. NPD 8831.1 Maintenance and Operations of Institutional and Program Facilities and Related Equipment
- j. NPR 7123.1 NASA Systems Engineering Processes and Requirements
- k. NPR 8820.2 Facility Project Requirements
- l. QS.0011 Work Instruction: Safety Hazard Report Preparation, Tracking and Closure

P.5 MEASUREMENT/VERIFICATION

- a. Verification of compliance is measured through the internal audit process and management review and those results. Measuring effectiveness will at a minimum use customer satisfaction data.

P.6 CANCELLATION

- a. None.

Eugene Tu
Director

DISTRIBUTION STATEMENT:

There are no restrictions on distribution of this document within NASA and NASA Ames Research Center contractors.

This document is distributed through the Center Directives Management System (CDMS).

CHAPTER 1. CENTER CRITICAL FACILITY AND INFRASTRUCTURE IDENTIFICATION

Per NPD 8831.1, Maintenance and Operations of Institutional and Program Facilities and Related Equipment, NASA Ames Research Center maintains a list of critical facilities. These facilities are subject not only to standard NASA facility development and maintenance requirements but also the special requirements contained in this APR. Periodic review of the Center Critical Facility and Infrastructure List is necessary to ensure that the list is current, complete and correct.

Factors to be considered in the designation of center critical facilities and infrastructure include:

- a. Whether the facility capability is necessary to support development, test or operation of flight systems and/or missions such that loss of their function would have significant impact on programs, projects, or other development efforts,
- b. Whether the facility involves human test subjects,
- c. Whether the facility implements high energy capabilities whose failure would be sufficient to cause injury, death, or significant damage.

CHAPTER 2. ROLES AND RESPONSIBILITIES

As key assets, center critical facilities and infrastructure are managed at the center management level. The roles and responsibilities of key center organizations in performing these management functions are summarized below.

2.1 Deputy Center Director

The Deputy Center Director is the Designated Governing Authority (DGA) for all management processes associated with this APR.

Specific duties include:

- a. Maintain a list of center facilities and infrastructure elements considered to be “center critical”,
- b. Perform periodic review and update of the center critical facilities and infrastructure list content,
- c. Approve the assignment of project managers and independent review board chairs for center critical facility and infrastructure development and upgrade projects,
- d. Approve center critical facility and infrastructure project management plans,
- e. Monitor execution and progress through regular reporting forums.
- f. Determine project readiness to enter the next development at Key Decision Points (KDPs)

2.2 Ames Chief Engineer

The Ames Chief Engineer is the Designated Governing Authority (DGA) for all technical efforts associated with this APR.

Specific duties include:

- a. Recommend independent review board chair assignments for center critical facility projects,

- b. Provide recommendations to Deputy Center Director regarding development and operation of center critical facilities,
- c. Review reports and issues from center critical facility projects and operating organizations.

Additional details regarding these and related responsibilities are provided in APR 1150.2, Ames Engineering Technical Authority.

2.3 Ames Safety and Mission Assurance Director

The Safety and Mission Assurance Directorate provides an independent perspective in assessing the health and hazard concerns of all facilities, including center critical facilities. Center critical facility development and upgrade projects work with the Safety and Mission Assurance Directorate to conduct safety and hazard analyses listed in section 3.3 of this APR. Safety and Mission Assurance Directorate is responsible for execution of these analyses, augmented by external third-party organizations as necessary to achieve efficiency in the development and review of related document products. Funding to support these activities will be incorporated in FURB/PPBE planning.

Specific duties include:

- a. Ensure safety and hazard analyses are executed properly
- b. Review and disposition of personnel health and safety issues and concerns related to center critical facilities,
- c. Assess project compliance with all relevant Occupational Safety and Health Administration (OSHA), county, state, and federal regulations as applicable.

Additional details regarding these and related responsibilities are provided in APR 7120.11, Ames Health and Medical Technical Authority, and APR 8705.2, Safety and Mission Assurance Technical Authority.

2.4 Center Critical Facility and Infrastructure Project Team

Center Critical Facility and Infrastructure project teams implement new or upgrades facilities and infrastructure, as assigned, per NPR 8820.2, Facility Project Requirements, and this APR.

When more than one construction or upgrade project is active in a critical facility, the DCD may appoint a single Critical Project Management Team to consolidate the management functions and decision authority of the multiple projects. This action will require an update to a consolidated Project Management Plan and FURB concurrence.

2.5 Center Critical Facility and Infrastructure Operator Organization Manager

The facility operator organization manager is the manager of the organization that takes delivery of the completed facility and maintains responsibility for maintenance and operation of that facility. The operator organization maintains hazard reports and associated hazard controls for facilities that have transitioned to operations.

In some cases, operations responsibility for separate elements within a facility of infrastructure element may be distributed across multiple organizations. For example, a test facility may be operated by a technical organization, but electrical power system protection devices in the facility may be maintained

and operated by the Center Operations Directorate. In such cases, effective coordination and regular communication between the two operating organizations is essential.

Specific duties include:

- a. Manage ongoing operation of the facility or infrastructure element,
- b. Maintain hazard reports for the extant center critical facility or infrastructure element,
- c. Verify proper implementation and operation of hazard controls per a defined schedule,
- d. Coordinate generation and delivery to the development project of requirements for the center critical facility function, reliability, maintainability, availability, spares policy, operational constraints, etc.,
- e. Implement engineering change management procedures per NPR 7123.1, NASA Systems Engineering Processes and Requirements,
- f. Implement Configuration Management (CM) requirements under APR 8040.1, Configuration Management,
- g. Implements component quality assurance under APD 8735.3, Verification of Product/ Service Conformance to Requirements, as part of maintenance activities,
- h. Manage the facility in accordance with all applicable OSHA, county, state and federal requirements, and
- i. Report status and issues to the Office of the Chief Engineer and the Safety and Mission Assurance Directorate.

CHAPTER 3 LIFE CYCLE MANAGEMENT

3.1 Formulation

Development activities and processes for CoF development and upgrade projects are defined in NPR 8820.2, Facility Project Requirements, and APD 8800.1, Real Property Management. The paragraphs below state additional requirements to be applied in formulation of Ames center critical facility development and upgrade projects.

3.1.1 Project Proposal

Per APD 8800.1, Real Property Management, the Facility Utilization Review Board (FURB) reviews and approves all proposed Ames CoF project requests for agency consideration. Requesting organizations submit facility development and upgrade requests to the FURB.

The Facility Utilization Review Board (FURB) shall identify and recommend projects associated with Center Critical Facilities and infrastructure to the Deputy Center Director.

The FURB will review and approve, with Deputy Center Director concurrence:

- a. Preliminary Project Management Plan (PPMP) that provides a preliminary cost estimate for both CoF procurement and Center support costs;
- b. Project Impact Statement describing the impacts of project construction activities on both the capability and the customers of the capability.

This PPMP is approved by the FURB prior to submission for consideration of CoF funding.

The FURB also advises the Deputy Center Director regarding Procurement Approach and special support to center critical facility projects (e.g. funding for project team support and upgrade of hazard reports for current facilities).

3.1.2 Project Support Funding

The Center Operations Directorate coordinates the submittal of all proposals to the agency CoF program. The CoF program provides procurement funding for the design and construction of facilities. CoF funding supports vendor/contractor staff, but specifically cannot be used to fund FTE support for center critical facility development team support and similar activities defined by this APR.

The Deputy Center Director shall coordinate non-CoF funding requests for center critical facility and infrastructure development and upgrade support through the Planning, Programming, Budgeting, and Execution (PPBE) process.

3.1.3 Procurement Approach

As described in NPR 8820.2, Facility Project Requirement, two procurement approaches are available to support development of facilities – the design-build contract structure and the design-bid-build contract structure. Application of these approaches to center critical facility development and upgrade projects should be planned based on the characteristics and uniqueness of the facility. In the Design-Bid-Build approach, the design is provided by a contractor and then the approved design is put out for a construction bid with the winning contractor building the approved design. In the Design-Build approach, a single entity – the design-build team – works under a single contract with the Center to provide the design and then do the construction for the project. Different elements of the contract may be subcontracted out, but there is a single responsible organization. This approach is suitable for center critical facility projects that implement commonly available commercial solutions without significant modification. The Design-Build approach allows the project to leverage existing standards and codes (generally not specific to NASA) to address safety needs.

3.2 Management and Control

3.2.1 Center Critical Facility and Infrastructure Project Team Skills

A development / upgrade project team brings together key personnel and stakeholders under the leadership of an experienced facility project manager. The project team enables coordination between provider and operating organizations, ensuring that requirements and implementation result in operable facilities and systems. Center critical facility and infrastructure project teams report to the Deputy Center Director. Project team membership should include personnel with the following skillsets:

- a. Project management,
- b. Construction contract management,

- c. System Engineering,
- d. Facility safety,
- e. Facility operations,
- f. Facility customer interfaces, and
- g. Facility-specific technical disciplines.

The facility project manager coordinates with responsible line organization managers to propose assignments for all other project team positions. The Deputy Center Director approves the list of personnel assigned to these roles.

3.2.2 Independent Review Board (IRB)

Formal development project reviews are conducted by an Independent Review Board (IRB). The IRB assesses progress and risks at each milestone review and reports to the Executive Council. The Office of the Chief Engineer recommends the chairperson of the IRB to the Deputy Center Director for approval. The IRB may, at the discretion of the Deputy Center Director, also be called upon to review significant changes and concerns during facility development, upgrade, and operation.

3.2.3 Development Phase Reporting to Engineering Technical Authority

Consistent with APR 1150.2, Ames Engineering Technical Authority, each Center Critical Facility and Infrastructure development and upgrade project manager assigns a Project Systems Engineer who assesses technical requirements, non-conformances and issues. This systems engineer also interfaces with the Office of the Ames Chief Engineer.

Center critical facility and infrastructure development and upgrade projects shall report status to the Office of the Ames Chief Engineer monthly.

3.2.4 Operations Phase Reporting to Engineering Technical Authority

Once the facility or infrastructure element enters its operations phase, the operator organization assigns a systems engineer who monitors facility / infrastructure configuration, performance, and sustaining engineering activities. This systems engineer also interfaces with the Office of the Ames Chief Engineer. Center critical facility / infrastructure operator organizations shall report status to the Office of the Ames Chief Engineer monthly.

3.2.5 Development Phase Reporting to Safety and Mission Assurance Technical Authority

Consistent with APR 8705.2, Safety and Mission Assurance Technical Authority, each Center Critical Facility and Infrastructure development and upgrade project reports status and issues to the Safety and Mission Assurance Directorate.

Center critical facility and infrastructure development and upgrade projects shall report status to Safety and Mission Assurance Directorate monthly.

3.2.6 Operations Phase Reporting to Safety and Mission Assurance Technical Authority

Once the facility or infrastructure element enters its operations phase, the operator organization for each center critical facility / infrastructure element provides facility status insight to the Safety and Mission Assurance Director.

Center critical facility / infrastructure operator organizations shall report status to Safety and Mission Assurance Directorate monthly.

3.3 Planning and Analysis

In addition to standard processes associated with any facility development, upgrade and operation, the following processes are necessary in support of center critical facility activities.

3.3.1 Concept Definition

Successful implementation of center critical facility development projects must consider the needs and constraints of the organization that receives, maintains and operates the completed facility. The operations concept defines intended operational constraints, configurations, duration and frequency as well as supporting maintainability, sparing and logistics, and similar topics.

In support of a center critical facility development or upgrade project, the operator organization shall document an operations concept.

3.3.2 Requirements Definition

User requirements guide both the development and operation of the center critical facility. The facility operator organization is responsible for developing and delivering requirements that address both operator and customer needs.

As important center and agency assets, management of center critical facilities must be guided by established safety, reliability, availability, maintainability and cost requirements. Safety requirements are well documented and are broadly applicable across many diverse facility types (see NASA-STD-8719.7, Facility System Safety Guidebook). These requirements are applicable to center critical facilities but are not restated in this document. Other, requirements, however, may vary based on facility type and use.

The facility operator organization shall define facility development requirements that explicitly state:

- a. Facility and system functions,
- b. Reliability,
- c. Availability,
- d. Maintainability, and
- e. Operational cost constraints

Where known, requirements shall be stated to address safety-related functionality including:

- f. Automation of monitoring functions that can improve overall system reliability by reducing failures due to human error.
- g. Audible and visual cues that focus the operator's attention on important changes in the facility's safety status and can reduce operator response time.

- h. Automated safety functions that can increase the probability that hazards will be controlled even in the event of operator incapacitation. Automated safing may also provide higher reliability and faster response times than may be achieved by human operators.
- i. Recording of performance data that can be critical in the review and identification of long-term performance trends, including those that may provide early indications of impending failures. Such recorded data is also valuable in the reconstruction of events following a failure or mishap.

3.3.3 Hazard Analysis

Comprehensive hazard analyses, as defined by NASA-STD-8719.7, Facility System Safety Guidebook, are necessary to ensure that center critical facilities are safe and effective. Further guidance in performing hazard analysis is given in QS.0011, Work Instruction: Safety Hazard Report Preparation, Tracking and Closure.

All center critical facility development and upgrade projects shall document the following hazard analyses:

- a. Facility Risk Indicator (FRI)
- b. Preliminary Hazard List (PHL) / Preliminary Hazard Analysis (PHA)
- c. Facility Hazard Analysis (FHA)
- d. Hazard Analysis Tracking Index (HATI) / Hazard Verification Tracking Log (HVTL)
- e. Failure Modes and Effects Analysis (FMEA)
- f. Hazard and Operability Study (HAZOP)
- g. Operating and Support Hazard Analysis (O&SHA)

The Safety and Mission Assurance Directorate defines the level of detail required in each of the products.

3.3.4 Safety Planning

As described in NASA STD 8719.1, Facility System Safety Guidebook, a Facility Safety Management Plan (FSMP) implements tailored safety requirements, including organizational responsibilities, resources, milestones, methods of accomplishment, depth of effort, and integration with other program engineering and management activities and related systems. The objective is to document recommended safety efforts for the remainder of the life cycle of the facility.

The center critical facility and infrastructure development project shall develop a Facility Safety Management Plan (FSMP).

3.4 Operation

Operator organizations hold responsibility for the appropriate maintenance and operation of assigned center critical facilities and infrastructure. These operator organizations should perform periodic

(recommended annual) inspections and audits to ensure that records, procedures, training, and certification are appropriate and current. It is also recommended that user organizations perform frequent (recommended monthly) safety meetings to review safety issues related to upcoming operations, discuss safety implications of facility configuration changes, and highlight findings of recent safety walk-downs.

3.4.1 Distributed Operation Responsibilities

For facility operations and maintenance activities which are distributed across more than one organization, the facility operating organization shall convene a team comprised of technical representatives from each of the involved organizations.

3.4.2 Configuration and Change Management

Formal documented and configuration control promotes safety and preservation of capability in center critical facilities.

Center critical facility or infrastructure operating organizations shall, in operation and maintenance of center critical facilities, comply with:

- a. Engineering Change Management per NPR 7123.1, NASA Systems Engineering Processes and Requirements
- b. Configuration management requirements per APR 8040.1, Configuration Management

3.4.3 Quality Assurance

Appropriate inspection, test, and documentation of components prior to installation in center critical facilities is necessary to preserve facility quality.

Center critical facility and infrastructure operating organizations shall, in operation and maintenance of center critical facilities, perform and document component quality verification per APD 8735.3, Verification of Product/ Service Conformance to Requirements.

3.4.4 Documentation

Operating organizations hold responsibility for ensuring that facility documentation, including drawings, interface definitions, and hazard analyses, are complete and current during operations. The operating organization takes delivery of these documents from the development or upgrade project at the completion of facility development and test activities.

Center critical facility and infrastructure operating organizations shall assess the completeness and correctness of the following documents at least once every two calendar years:

- a. As-built drawings
- b. Interface definition documents
- c. Facility /hazard analysis

3.4.5 Inspection and Calibration

Periodic inspection and, as appropriate, calibration of center critical facility components is necessary to ensure that the facility operates safely and provide expected value to customers.

3.4.5.1 Periodic Inspection

Center critical facility and infrastructure operating organizations shall document and adhere to a regular schedule and procedure for such inspections and calibrations.

3.4.5.2 Inspection and Calibration Documentation

Center critical facility and infrastructure operating organizations shall maintain records indicating completion and outcome of inspection and calibration activities.

Center critical facility and infrastructure operating organizations shall periodically inspect center critical facility system hardware according to a documented schedule and procedure.

3.4.6 Hazard Control Management

Without direct inspection and test, misconfiguration and failures in hazard controls may remain undetected for years. Periodic, documented functional checks of hazard controls (whether implemented in hardware or software) are therefore necessary in all center critical facilities.

3.4.6.1 Periodic Hazard Control Verification

Center critical facility and infrastructure operating organizations shall perform and document hazard control verification per a periodic schedule.

3.4.6.2 Center Infrastructure Hazard Control Verification

Where center critical facility hazard controls also involve components of center infrastructure maintained by the Center Operations Directorate, the center critical facility operating organization shall coordinate with the Center Operations Directorate to ensure that hazard control verifications have been performed successfully.

3.4.7 Problem Tracking and Resolution

Operating organizations are responsible for identifying, tracking and resolving problems related to center critical facilities.

Center critical facility and infrastructure operating organizations shall track and resolve problems using the ARC PRACA system, per APR 8735.1, Control of Nonconforming Products and Services.

CHAPTER 4 LIFE CYCLE REVIEWS

Center critical facility development, upgrade and operation present unique needs and challenges when compared to those of standard facilities. Unique review milestones, as shown in Appendix C Figure 1, are therefore defined for both the development and operational phases of these facilities' life cycles.

4.1 Development Life Cycle Reviews

As an augmentation to the process normally executed for any facility development or upgrade project, the IRB will execute the following reviews either in addition to or in place of traditional milestones:

- a. Facility & System Requirements Review (FSRR)
- b. 30-Percent Design Review
- c. 90-Percent Design Review
- d. Integrated System Safety Review (ISSR)
- e. Operational Readiness Review (ORR)

The FSRR is executed prior to the start of significant design activities. The 30-percent design review encompasses both the requirements stated in NPR 8820.2, Facility Project Requirements, and the associated requirements stated in this APR. The 90-percent design review encompasses both the requirements stated in NPR 8820.2, Facility Project Requirements, and the associated requirements stated in this APR. The ISSR and ORR occur as part of Phase D and E activities, respectively. Following successful completion of these reviews, primary responsibility for the facility is transferred to the operator organization. For new facility development, primary responsibility for the facility transitions from the facility development project to the operator organization. If the development project is limited to the modification of an existing facility that continues to operate during modification, the operator organization retains primary responsibility for the facility throughout the upgrade project lifecycle.

As part of each Development Review the offices of the operating organization, Safety and Mission Assurance, Chief Engineer, and Center Operations Director will provide the Deputy Center Director with their assessments of project status. The Development Review results serve as a recommendation to the Deputy Center Director, who provides the project with authorization to proceed to the next development activity.

4.1.1 Facility and System Requirements Review

The FSRR evaluates whether the project functional and performance requirements are properly formulated and correlated with center and operating organization needs, goals and objectives. Project requirements are baselined by the conclusion of the FSRR. The FSRR also assesses the credibility of the project's estimated budget and schedule.

The center critical facility development project IRB shall conduct a Facility and System Requirements Review per the criteria listed in Table 4.1.1-1.

Table 4.1.1-1 Facility and System Requirements Review Criteria

Entrance Criteria	Success Criteria
1. The operator organization has provided an operations concept and user requirements set and current hazard analyses for existing facility and systems	1. The top-level requirements are agreed upon (by developer and operator organizations), finalized, stated clearly

Table 4.1.1-1 Facility and System Requirements Review Criteria

Entrance Criteria	Success Criteria
<ol style="list-style-type: none"> 2. The facility development project has provided a complete set of requirements for the facility 3. The facility development project has provided safety analysis products: <ol style="list-style-type: none"> a. Preliminary hazard list for new work 4. The facility development project has provided other System engineering products (as applicable) for facility construction, hardware, software, and human system elements. <ol style="list-style-type: none"> a. Preliminary engineering assessment of requirements, including a summary of key trade studies and results b. Risk assessment and mitigations. c. Initial document tree or model structure. d. Preliminary verification and validation method identified for each requirement. e. Initial Human Rating Certification Package (as applicable). 	<ol style="list-style-type: none"> 2. Facility and system requirements comply with corresponding NASA ARC Center Critical Facility functional and performance requirements. 3. Facility and system requirements are achievable and sufficiently mature to support design activities. 4. Major risks have been identified and technically assessed, and viable mitigation strategies have been defined. 5. The project has complied with applicable government, NASA and implementing Center requirements, standards, processes, and procedures. 6. TBD and TBR items are clearly identified with acceptable plans and schedule for their disposition.

4.1.2 30-Percent Design Review

The 30-Percent Design Review for a center critical facility encompasses and expands upon the traditional facility development 30-Percent Design Review milestone as defined in NPR 8820.2, Facility Project Requirements. The expanded review criteria demonstrate that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design.

The center critical facility development project IRB shall conduct a 30-Percent Design Review per NPR 8820.2, Facility Project Requirements, and the criteria listed in Table 4.1.2-1.

Table 4.1.2-1 30-Percent Design Review Criteria

Entrance Criteria	Success Criteria
<ol style="list-style-type: none"> 1. The facility development project has provided facility construction design documentation required per NPR 8820.2. 2. The facility development project has provided a preliminary design that meets requirements, including: <ol style="list-style-type: none"> a. Subsystem hardware and software 	<ol style="list-style-type: none"> 1. The preliminary design is expected to meet the requirements at an acceptable level of risk. The operator organization has reviewed and concurred with this design solution. 2. Project cost and schedule are credible and within constraints. Adequate resources are available to complete development and

Table 4.1.2-1 30-Percent Design Review Criteria

Entrance Criteria	Success Criteria
<p>design specifications with supporting trade studies and data</p> <p>b. Engineering drawing tree</p> <p>c. Interface control documents (ICDs)</p> <p>3. The facility development project has provided safety analysis products:</p> <p>a. Updated hazard list</p> <p>b. Preliminary hazard analysis</p> <p>c. Energy Trace Barrier Analysis</p> <p>d. Preliminary FMEA</p> <p>e. Facility Safety Management Plan</p> <p>f. List of necessary subsystem and component inspections</p> <p>4. The facility development project has provided project and technical management products:</p> <p>a. Updated risk assessment and mitigation</p> <p>b. Updated schedule</p> <p>c. Updated project cost estimate</p> <p>d. Updated trending information on the closure of review actions (RFA, RID, and/or Action Items).</p> <p>e. Plans to respond to regulatory requirements (e.g., Environmental Impact Statement), as required</p> <p>f. For new software development, Software Classification and development plan</p>	<p>commissioning within budget, schedule, and known risks.</p> <p>3. The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them.</p> <p>4. Safety and mission assurance designs and products meet requirements, are at the appropriate maturity level, and indicate that the project safety/reliability residual risks will be at an acceptable level.</p> <p>5. Technical trade studies are mostly complete to sufficient detail and remaining trade studies are identified, plans exist for their closure, and potential impacts are understood.</p> <p>6. Preliminary subsystem analysis has been completed and summarized, highlighting performance and design margin challenges. Where appropriate, modeling and analytical results are available.</p> <p>7. The project complies with applicable government, NASA and Center requirements, standards, processes, and procedures.</p> <p>8. Heritage and benchmark designs have been suitably assessed for applicability and appropriateness.</p> <p>9. Plans and processes for new software development and testing are appropriate and technically sound</p> <p>10. TBD and TBR items are clearly identified with acceptable plans and schedule for their disposition.</p>

4.1.3 90-Percent Design Review

The 90-percent design review encompasses and expands upon the traditional facility development 90% design review milestone as defined in NPR 8820.2, Facility Project Requirements. The expanded review

criteria demonstrate that the maturity of the design is appropriate to support proceeding with construction, assembly, integration, and test. A construction permit will only be issued after successful completion of the 90-percent design review.

The center critical facility development project IRB shall conduct a 90-Percent Design Review per NPR 8820.2, Facility Project Requirements, and the criteria listed in Table 4.1.3-1.

Table 4.1.3-1 90-Percent Design Review Criteria

Entrance Criteria	Success Criteria
<ol style="list-style-type: none"> 1. The facility development project has provided design documentation required for a 90% design review as specified in NPR 8820.2. 1. The facility development project has provided safety analysis products: <ol style="list-style-type: none"> a. Updated hazard list b. Updated facility and system hazard analysis c. Updated FMEA d. Subsystem-level and preliminary operations safety analyses 2. The facility development project has provided project and technical management products <ol style="list-style-type: none"> a. Updated trending information on the closure of review actions (RFA, RID and/or Action Items). b. Defined operational limits and constraints. c. Acceptance plans d. Preliminary checkout and activation plan. e. Updated risk assessment and mitigation. f. Updated schedule g. Updated cost estimate h. Updated reliability analyses and assessments. i. Systems and subsystem certification plans and requirements (as needed). 	<ol style="list-style-type: none"> 1. The detailed design is expected to meet the requirements. The operator organization has reviewed and concurred with this design solution. 2. The project cost and schedule estimates are credible and within project constraints. Adequate margins and resources exist to complete the development within budget, schedule, and known risks. 3. High confidence exists in the design baseline, and adequate documentation exists to allow proceeding with construction, integration, and test. 4. Identified fabrication, construction, and assembly methods are sufficient to meet requirements. 5. The test approach is comprehensive, and the plan for system assembly, integration, test, and operations is sufficient to proceed with construction. 6. Safety and mission assurance have been adequately addressed in system and operational designs. Safety/reliability residual risks will be at an acceptable level. 7. The project complies with applicable government, NASA and Center requirements, standards, processes, and procedures. 8. Engineering test units, life test units, and/or modeling and simulations have been developed and tested per plan. 9. The operational concept has been considered in test planning.

4.1.4 Integrated System Safety Review (ISSR)

The ISSR assesses the overall safety of the facility and its planned operation, confirms the facility supports intended operational characteristics, ensures that hazard controls have been validated, and confirms that plans reflect a systematic approach to demonstrate the full operational capability. The ISSR is held before facility Integrated System Test to ensure that appropriate safety measures are in place to support the test.

The center critical facility development project IRB shall conduct an Integrated System Safety Review per the criteria listed in Table 4.1.4-1.

Table 4.1.4-1 Integrated System Safety Review Criteria

Entrance Criteria	Success Criteria
<ol style="list-style-type: none"> 1. The facility development project has provided final project and technical products: <ol style="list-style-type: none"> a. Facility / system requirements and design b. List and assessment of critical functions and components c. Analysis of primary load paths d. Comparison of as-built vs. design, summarized by subsystem (Redlines, Non-Compliance Reports) e. Description and status of unmodified systems, specifying interaction and effect of modified and unmodified systems on one another. f. Summary of previous review findings with associated closures and list of open items 2. The facility development project has provided documentation of subsystem-level verification and validation tests and results: <ol style="list-style-type: none"> a. Sequence to prepare for IST b. Test objectives, envelopes, constraints c. Off-nominal response requirements verification d. Requirements verification capture process and results e. Anomaly resolution process 3. The facility development project has provided Integrated System Test Plan materials that define: <ol style="list-style-type: none"> a. Test objectives, envelopes, constraints b. Redlines, margins, assumptions, model validation c. Standard operating procedures d. Emergency procedures e. Training requirements f. Test-specific hardware/software g. Anomaly resolution process 	<ol style="list-style-type: none"> 1. Safety analyses are complete and correct. 2. Hazard controls are adequate and their operation has been verified. 3. Contingency conditions and responses have been defined and included in operator training, including: <ol style="list-style-type: none"> a. Operational redline values b. Emergency shutdown procedures c. Contingency procedures 4. Personnel are adequately trained and properly equipped to operate the facility / system and appropriately respond to anomalies and emergencies. 5. Systems, processes and procedures are in place to support test.

<ul style="list-style-type: none"> h. IST specific requirements verification <p>4. The facility development project has provided completed safety analyses that have been reviewed by the Office of Safety and Mission Assurance, including</p> <ul style="list-style-type: none"> a. FMEA, OHA, HAZOP b. Facility, System and software hazard analyses and controls c. Procedural hazards and controls d. Hazard control verification 	<p>6. Test plans and procedures adequately address the intended facility range of operation</p> <p>7. Hazard mitigations have been validated; associated verification plans are acceptable</p> <p>8. Hazard residual risks have been identified and accepted by management.</p>
---	---

4.1.5 Operational Readiness Review (ORR)

Transition from the facility development phase to the facility operations phase is marked by successful completion of an Operational Readiness Review (ORR). The ORR verifies the completeness of the facility and system development and test efforts, accuracy and completeness of associated documentation, compliance to stakeholder expectations, and technical maturity to authorize its transfer to the operating organization.

The center critical facility development project IRB shall conduct an Operational Readiness Review per the criteria listed in Table 4.1.5-1.

Table 4.1.5-1 Operational Readiness Review Criteria

Entrance Criteria	Success Criteria
<p>1. The facility development project has provided key facility documentation to the operator organization and to reviewers:</p> <ul style="list-style-type: none"> a. As-built facility, hardware and software documentation. b. Commissioning test results. c. Documentation that the system complies with the established acceptance criteria. d. Documentation that the system will perform properly in the expected operational environment. e. Applicable operating certification documents. f. Required checkout and operational plans and procedures. 	<ul style="list-style-type: none"> 1. Required tests and analyses are complete and indicate that the system will perform properly in the expected operational environment. 2. Risks are known and manageable. 3. The system meets established acceptance criteria. 4. The facility complies with applicable government (including OSHA and EPA), NASA and Center requirements, standards, processes, and procedures. 5. Adequate provisions (i.e., safety related materials and critical spare parts) are in hand and effective.

<p>g. Updated risks and mitigations</p> <ol style="list-style-type: none"> 2. The facility operations organization confirms that all operational supporting and enabling products necessary to support operations (e.g., facilities, equipment, documents, software tools, databases) necessary for nominal and contingency operations have been tested and delivered/installed. 3. The facility development project has successfully completed all planned commissioning testing. 4. The facility development project has reviewed and resolved all test failures and anomalies from verification and validation testing. Results/mitigations/work-arounds have been incorporated into operational products. 5. The facility development project and the facility operations organization both agree that all hazard mitigation have been verified and hazard reports are closed. 	<ol style="list-style-type: none"> 6. The technical data package and other required delivery documentation is complete and reflects the delivered system. 7. Safe operating limits are well-defined, appropriate, and ensure that that permissible stress limits will not be exceeded; reliable controls are in place to prevent exceeding these safe operating limits. 8. Adequate measures have been taken to ensure the safety of the facility and its operators over the design range of the facility or device. 9. Operational procedures are documented, clear and complete 10. Operations personnel are properly trained and, where necessary, certified per formal certification requirements. 11. Applicable lessons learned for organizational improvement and system operations are captured. 12. Agreements with contractor organizations are complete and correct.
--	--

4.2 Operational Life Cycle Reviews

Periodic verification of facility protective systems, hazard controls and redundant systems are important steps in ensuring that the facility and its systems continue to meet safety, reliability and availability needs.

Independent audits already in place, such as Institutional/Facility/Operational (IFO) audits required per NPR 8705.6, fulfil this need. Center critical facility and infrastructure operating organizations should report the results of critical hazard control verification 20activities in conjunction with these audits.

APPENDIX A. DEFINITIONS

None.

APPENDIX B. ACRONYMS

AMS	Ames Management System
APD	Ames Policy Directive
APR	Ames Procedural Requirement
ARC	Ames Research Center
CDMS	Center Directives Management System
CM	Configuration Management
CoF	Construction of Facilities
DGA	Designated Governing Authority
EPA	Environmental Protection Agency
FCB	Facility Control Board
FHA	Facility Hazard Analysis
FMEA	Failure Mode Effects Analysis
FOM	Facility Operations Manager
FRI	Facility Risk Indicator
FSMP	Facility Safety Management Plan
FSRR	Facility and System Requirements Review
FTE	Full Time Equivalent
FURB	Facility Utilization Review Board
HATI	Hazard Analysis Tracking Index
HAZOP	Hazard and Operability Study
HVTL	Hazard Verification Tracking Log
IRB	Independent Review Board
ISSR	Integrated System Safety Review
KDP	Key Decision Point
NASA	National Aeronautics and Space Administration
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
O&M	Operations and Maintenance
ORR	Operational Readiness Review
O&SHA	Operating and Support Hazard Analysis
OSHA	Occupational Safety and Health Administration
PCB	Project Control Board
PHA	Preliminary Hazard Analysis
PHL	Preliminary Hazard List
PPBE	Planning, Programming, Budgeting, and Execution
SAR	System Acceptance Review
SRR	System Requirements Review
TBD	To Be Determined
TBR	To Be Reviewed
WYE	Work Year Equivalent

APPENDIX C. VERIFICATION MATRIX OR REFERENCES

None

APPENDIX D. ADDITIONAL GRAPHICS

NASA Life-Cycle Phases	Formulation		Approval		Implementation			
	<i>Pre-System Acquisition</i>		<i>Systems Acquisition</i>		<i>Operations</i>		<i>Decommissioning</i>	
Project Life-Cycle Phases	Pre-Phase A: <i>Concept Studies</i>	Phase A: <i>Concept Development</i>	Phase B: <i>Preliminary Design</i>	Phase C: <i>Final Design and Build</i>	Phase D: <i>System Assembly, Integration and Test</i>	Phase E: <i>Deployment, Operations, and Sustainment</i>	Phase F: <i>Decommissioning</i>	
CoF Project Life-Cycle	Project Planning/Development	Design		Construction		Activation	O&M	Decommissioning
Critical Facility Life Cycle Milestone	▲ Facility Utilization Review Board	▲ Facility and System Requirements Review	▲ 30 Percent Design Review	▲ 90 Percent Design Review	▲ Integrated System Safety Review	▲ Operational Readiness Review	▲ Periodic Institutional Reviews (IFO)	

Figure D-1 Center Critical Facility Life Cycle Reviews