PPUP-800-PN0001-R02

PROTON POWER UPGRADE (PPU) PROJECT

TRANSITION TO OPERATIONS PLAN

July 2021

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

PROTON POWER UPGRADE (PPU) PROJECT
Transition to Operations Plan

July 2021

Prepared by: Johns, Glen Digitally signed by Johns, Glen Date: 2021.08.20 12:51:14 -04'00'

Glen Johns, P.8 Pre-Ops Level 2 Manager

Approved by: Digitally signed by John D. Galambos Date: 2021.08.20 13:07:11 -04'00'

John Galambos, PPU Project Director

Approved by: Fulvia Pilat Digitally signed by Fulvia Pilat Date: 2021.08.20 14:32:25 -04'00'

Fulvia Pilat, RAD Division Director

Approved by: _____

Wendy Cain, Federal Project Director

Prepared by
OAK RIDGE NATIONAL LABORATORY, P.O. Box 2008, Oak Ridge, Tennessee 37831-6285
managed by UT-Battelle, LLC for the U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

TABLE OF CONTENTS

Page

1 Scope

This Transition to Operations Plan identifies and describes the process for ensuring a smooth transition from the Proton Power Upgrade (PPU) project to routine accelerator operations by the Neutron Sciences Directorate (NScD) Research Accelerator Division (RAD). It is prepared in accordance with DOE Guide DOE G 413.3-16A, *Project Completion/Closeout Guide*. This plan provides an overall structure and is integrated with the PPU Project Management Plan, the Project Execution Plan, the resource loaded project schedule, the Risk Management Plan, the Quality Assurance Plan, and the PPU Beam Commissioning Plan.

2 References

10 CFR 851 Worker Safety and Health Program

10 CFR 835 Occupational Radiation Protection Program

DOE O 413.3B Program and Project Management for the Acquisition of Capital Assets

DOE G 413.3-16A Project Completion/Closeout Guide

DOE O 420.2C Safety of Accelerator Facilities

DOE G 420.2-1A Accelerator Facility Safety Implementation Guide

DOE O 422.1 Conduct of Operations

ORNL Standards Based Management System

MPO-PM-505 Project Turnover and Acceptance

PPU Project Execution Plan

PPU Project Management Plan

PPU Risk Management Plan

PPU Quality Assurance Plan

SNS Operations Procedures Manual

3 Transition to Operations Plan

The sections below describe how the PPU project is managing the transition to operations in alignment with the elements specified in DOE G 413.3-16A, *Project Completion/Closeout Guide.*

3.1 Project Description and Mission

Oak Ridge National Laboratory (ORNL) operates and develops world-leading neutron scattering user facilities as centers of scientific excellence to advance scientific discovery and solve challenging technical problems that are best addressed using neutrons. As the first megawatt-class pulsed neutron source, the ORNL SNS generates world-class high-peak-brightness neutron beams, providing US researchers with capabilities that are unique in the world. The PPU project is critical to keep SNS at the international forefront and ensure continued leadership by maximizing the neutron flux available at the First Target Station (FTS) and providing the capability to drive the future Second Target Station (STS). The PPU will upgrade the SNS accelerator complex to double its current proton beam power capability from 1.4 to 2.8

MW. The 2 MW delivered to the FTS will improve performance across the entire existing and future instrument suite and the remaining power delivered to the future STS will provide a wholly new capability in the form of a transformative new source optimized to produce the world's highest peak brightness of cold neutrons.

The SNS PPU project is to design, build, install and test the equipment necessary to double the accelerator power from 1.4 MW to 2.8 MW and to deliver a 2.0 MW qualified target. PPU also includes the provision for a stub-out in the SNS accumulator ring to target tunnel to facilitate a rapid connection to a new proton beamline for the STS project. Doubling of the power will be achieved by increasing the proton beam energy by 30% and peak beam current by 50%, relative to the current accelerator performance. The project also includes modifications to some buildings and services and upgrades to the Cryogenic Moderator System.

PPU will accomplish the energy upgrade by fabricating and installing new superconducting RF cryomodules, with supporting RF equipment, in the existing linac tunnel and klystron gallery respectively. The High Voltage Converter Modulators (HVCM) and klystrons for some of the existing installed RF equipment will be upgraded to handle the higher beam current. The target's ability to handle the increased beam power of 2 MW will be enabled by the addition of a new high-volume gas injection system for pressure pulse mitigation in the mercury target and a redesigned mercury target vessel.

3.2 Planning Management, Organization, and Control

This plan describes the process to successfully transfer scope from the project to the appropriate Neutron Sciences Directorate organizations. These organizations include the Research Accelerator Division and the Neutron Technologies Division. The details of the transition are outlined in various sections of this document. Additional documents such as the Project Management Plan (PMP), Project Execution Plan (PEP), beam commissioning plan, and Plans of Action to be developed for readiness reviews provide additional direction to both project and operations personnel. Documentation is maintained within the SNS document management system.

3.3 DOE Orders and Program Guidance

DOE orders and guidance documents are referenced in Section 2 of this document.

3.4 Key Transition Phase Steps and Deliverables

PPU project implementation will occur over several years. The installation, testing, and commissioning activities will occur within the normal SNS operations running and maintenance outage cycles.

There are three phases of approval for beam commissioning. These phases span 4 separate outage periods. The three phases relative to the currently envisioned operating periods are shown in Figure 1.

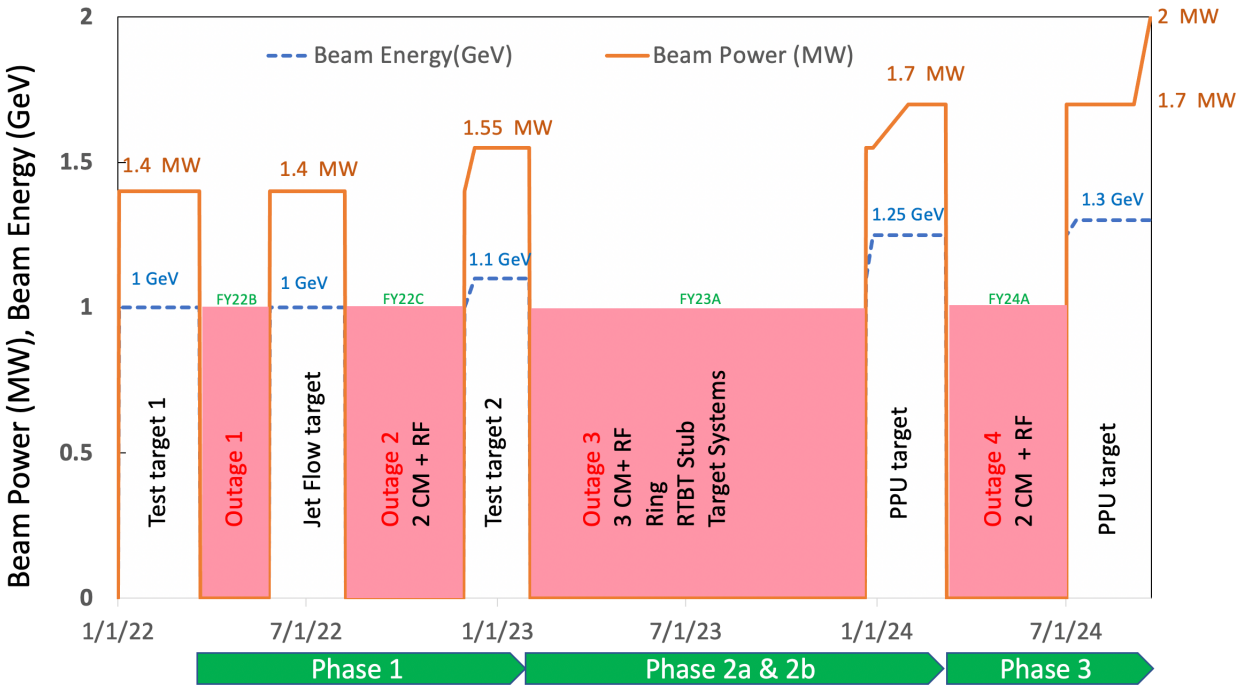

Figure 1. Planned installation schedule and approval phases.

The details of what equipment will be installed during each outage is outlined in each individual WBS sections of the project. The PPU project will partner with the SNS Operations Manager to define the acceptance criteria that must be met prior to transitioning the installed equipment to operations responsibility. As installation and commissioning activities will be primarily conducted by matrixed NScD operations personnel, the hand-off to operations will be straightforward. For the newly constructed builds, the formal laboratory process will be used as outlined in Section 3.19. Once systems have been transferred to operations, responsibility and costs for maintaining and operating the systems will be borne by SNS Operations.

Phase 1 encompasses the first two outage periods indicated in Fig. 1 and the 2 run periods following each outage. The first PPU Test Target will be installed in the outage prior to the FY22B outage. The Beam Power Limiting System (BPLS) will be installed during the first PPU outage (FY22B). The BPLS will be tested with beam in a non-credited fashion during the following operating period to confirm proper performance. The first 2 cryomodules along with all supporting systems will be installed during the second outage (FY22C). The BPLS will be certified for use as a credited engineered control and PPU Test Target 2 will also be installed during this outage. Once approval for commissioning is received, the newly installed equipment will be commissioned via the PPU commissioning plan. Once complete, the facility will operate at 1.1 GeV and 1.55 MW until the next outage.

Phase 2 encompasses the long outage (FY23A) and subsequent run period. This is the outage when the bulk of the tunnel equipment will be installed. These systems include 3 additional cryomodules and their associated support equipment, ring injection/extraction magnets and power supplies, ring injection dump upgrades, the stub-out added to the Ring to Target Beam Transport (RTBT) beam tunnel, cryogenic moderator system, gas injection system modifications, and PPU Production Target 1. Due to the nature of the changes, the

commissioning approval process is split into 2 parts. The first approval is specific to allow testing of the gas injection system without beam. This has the advantage of being able to characterize and evaluate performance of the mercury loop system while executing other PPU work scope. This serves to compress the installation schedule and reduce the complexity of the last approval process. This is followed by approval to commission all the installed equipment with beam. Once both approvals have been received, the newly installed systems will be commissioned via the PPU commissioning plan. Once complete, the facility will operate at 1.25 GeV and up to 1.7 MW until the next outage.

Phase 3 is the final phase and encompasses the last PPU outage (FY24A) and run period that follows. The last 2 cryomodules and supporting systems will be installed during this fourth outage period along with PPU Production Target 2. After receiving commissioning approval, the new cryomodules will be commission via the PPU commissioning plan. Once complete, the facility will operate at 1.3 GeV and 1.7 MW until the 1250 hours at 1.7 MW KPP has been reached. At that point, SNS will push the beam power up to 2 MW.

There are a number of key activities that are common across all three phases. These include the following types of activities:

- Installation of PPU equipment
- Component and subsystem testing
- Controls integration to allow operations of equipment from control room
- Individual system readiness reviews
- Integrated high-power system tests without beam
- Documentation collection including system test results, requirements from QA process, final drawings, and updated operating procedures
- Development of operator training material followed by implementation and documentation of completed training
- Perform internal readiness review and resolve any issues found

Once the internal readiness reviews are complete and action items resolved, SNS will be ready to perform either an External Readiness Review (ERR) or a full Accelerator Readiness Review (ARR) in accordance with DOE O 420.2C depending on the phase. The internal readiness review process will utilize ORNL personnel who are not directly part of the PPU project. The review team will ensure that personnel, documentation, and equipment are ready to be safely commissioned or operated. This review is intended to be a dry-run for the following ERR or ARR and will utilize the same agenda.

3.5 Strategy

The three phases outlined in Section 3.4 culminate in either an ERR or ARR to verify readiness prior to obtaining approvals for SNS to begin beam commissioning activities. The approval process for each phase is dependent on the equipment being installed. The two types of reviews are discussed in more detail in Section 3.12. The approval process (and required safety documentation) for each phase is given below.

Phase 1

- Internal Readiness Review complete and pre-start action items resolved
- Safety Documentation ready
    - Final Safety Assessment Document (FSAD) approved
    - Approval ready Accelerator Safety Envelope (ASE) outlining new BPLS credited control submitted to DOE
    - Approval ready Operating Envelope (OE) supporting new ASE in place
- Project Office and SNS Operations Manager declare readiness to Associate Laboratory Director (ALD)
- ALD declares readiness for commissioning with beam
- ERR is performed and all pre-start action items complete
- ALD issues letter to DOE requesting ASE approval and notifies DOE of start of commissioning
- DOE ORNL Site Office (OSO) Manager transmits approved ASE to SNS
- ALD authorizes SNS Operations Manager to begin commissioning with beam

Phase 2

(Part A)

- Gas injection Internal Readiness Review complete and pre-start action items resolved
- Safety Documentation ready
    - Final Safety Assessment Document (FSAD) approved
    - Approval ready Accelerator Safety Envelope (ASE) outlining new credited controls for gas injection and CMS submitted to DOE
    - Approval ready Operating Envelope (OE) supporting new ASE in place
- Project Office and SNS Operations Manager declare readiness for commissioning the gas injection system without beam to Associate Laboratory Director (ALD)
- ALD declares readiness for commissioning the gas injection system without beam
- ARR is performed focused on pre-beam gas injection and all pre-start action items complete
- ALD issues letter to DOE requesting ASE approval and pre-beam gas injection commissioning
- DOE ORNL Site Office (OSO) Manager transmits approved ASE to SNS and grants commissioning approval
- ALD authorizes SNS Operations Manager to begin pre-beam gas injection commissioning

(Part B)

- Internal Readiness Review for remaining scope complete and pre-start action items resolved
- Project Office and SNS Operations Manager declare readiness to Associate Laboratory Director (ALD)
- ALD declares readiness for commissioning with beam
- ARR is performed and all pre-start action items complete
- ALD requests approval for commissioning and routine operations from DOE
- DOE ORNL Site Office (OSO) Manager grants approval for commissioning and routine operations
- ALD authorizes SNS Operations Manager to begin commissioning with beam

Phase 3

- Internal Readiness Review complete and pre-start action items resolved
- Project Office and SNS Operations Manager declare readiness to Associate Laboratory Director (ALD)
- ALD declares readiness for commissioning with beam and routine operations
- ERR is performed and all pre-start action items complete
- ALD notifies DOE of intent to begin commissioning and routine operations
- ALD authorizes SNS Operations Manager to begin commissioning with beam

3.6 Operation or Long Term Stewardship Costs

The incremental DOE-BES annual cost for operating the SNS facility associated with this power upgrade is estimated to be in the range of $9.325M. The incremental increase in operating costs is due to the increased staffing to support the additional equipment and experiments (~$5.6M), increased target change outs (~$1.8M) and increased utility costs (~$1.9M). More detailed analysis is provided in the PPU Acquisition Strategy document. Once equipment has been turned over to operations, ongoing costs will be borne by the SNS Operations Budget Field Work Proposal (FWP) funded by DOE-BES.

3.7 Organizations, Stakeholders and Public Interfaces

The principle organization and stakeholder interfaces associated with the PPU Project include the DOE Office of Science/Office of Basic Energy Sciences, the DOE Oak Ridge Site Office, UT-Battelle, ORNL Laboratory Director, Neutron Sciences Directorate and its Director, and the SNS User Community. Interfaces to the public are handled through the Laboratory Communications Office. The PEP and PMP have full descriptions of these interfaces. The PPU project organization chart is given below.

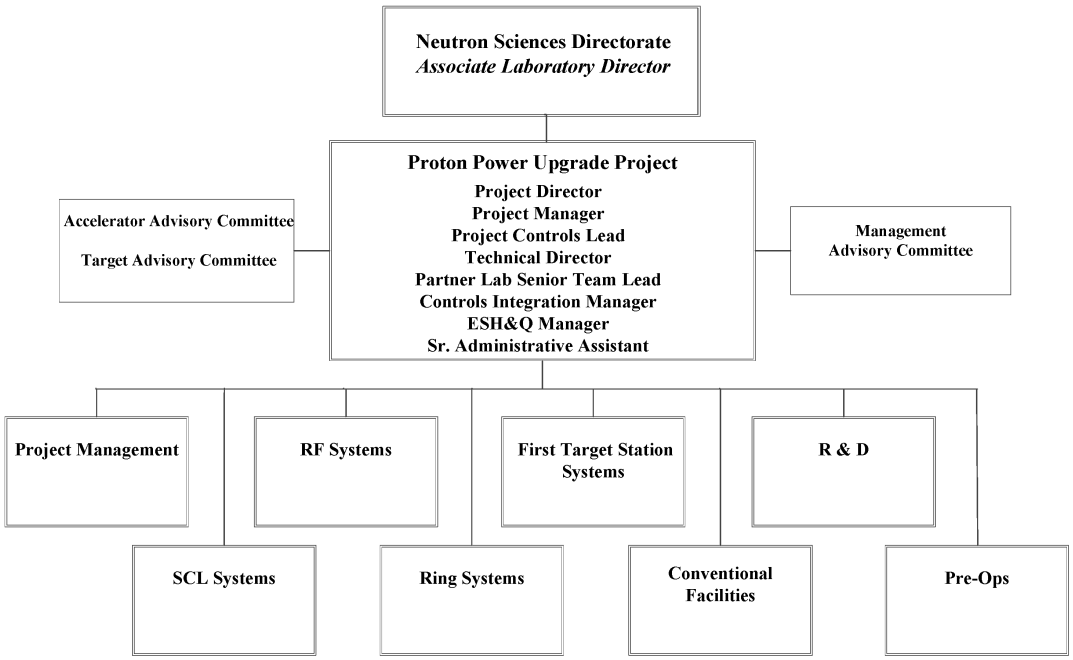

Figure 1. ORNL PPU Organization Chart

3.8 Transition Team Roles and Responsibilities

Installation activities are managed or performed by existing SNS engineering and technical staff who are matrixed to the project. PPU has an Installation Coordinator who interfaces with operations and whose role is described in the Project Management Plan. Commissioning activities will be performed by current staff with many years of experience in operations and beam physics at the SNS.

3.9 Configuration Control

The process for the configuration of the baseline scope is well defined for the PPU Project and will be followed during the transition to operations phase until the approval of CD-4 is granted. When changes are needed, the change control process, as outlined in Section 8 of the PPU Project Management Plan, will be followed.

Upon project completion, configuration control of equipment and documentation turned over to operations will be maintained in accordance with SNS OPM 9.A-1, *SNS Configuration Management Policy*.

3.10 Project Key Performance Elements and Completion Criteria

Project KPPs are specified in the PEP and are reproduced in Table 1 below. As PPU installation activities occur in a phased manner, the achievement of each KPP will also be phased. Three of the Threshold KPPs will be attained as a direct result of the execution of the PPU Commissioning plan. Demonstration of the 1250 hour target operational KPP will depend upon

overall facility performance. Data from the control system will be used to demonstrate completion of each KPP.

Table 1 – Key Performance Parameters

Key Performance Parameter	Thresholds (Performance Deliverable)	Objectives
Beam power on target[1]	1.7 MW at 1.25 GeV	2.0 MW at 1.3 GeV
Beam energy[2]	1.25 GeV	1.3 GeV
Target operational time without failure	1,250 hours at 1.7 MW	1,250 hours at 2.0 MW
Stored beam intensity in ring[3]	$\geq 1.6 \times 10^{14}$ protons at 1.25 GeV	$\geq 2.24 \times 10^{14}$ protons at 1.3 GeV

[1] The single target lifetime threshold requirement will be operation at 1.7 MW at 1.25 GeV and 60 Hz for 1,250 hours.

[2] Beam energy will be measured with time-of-flight instrumentation at the end of the linac.

[3] Stored beam intensity will be measured by a current monitor in the ring.

3.11 Schedule and Key Milestones

The integrated summary schedule is given in the PEP and is included in Figure 2 below. Level 1 and 2 Project Management and Control milestones are outlined in the PEP. The detailed schedule is comprised of logically linked resource-loaded activities necessary to achieve the project scope as defined in the WBS dictionary.

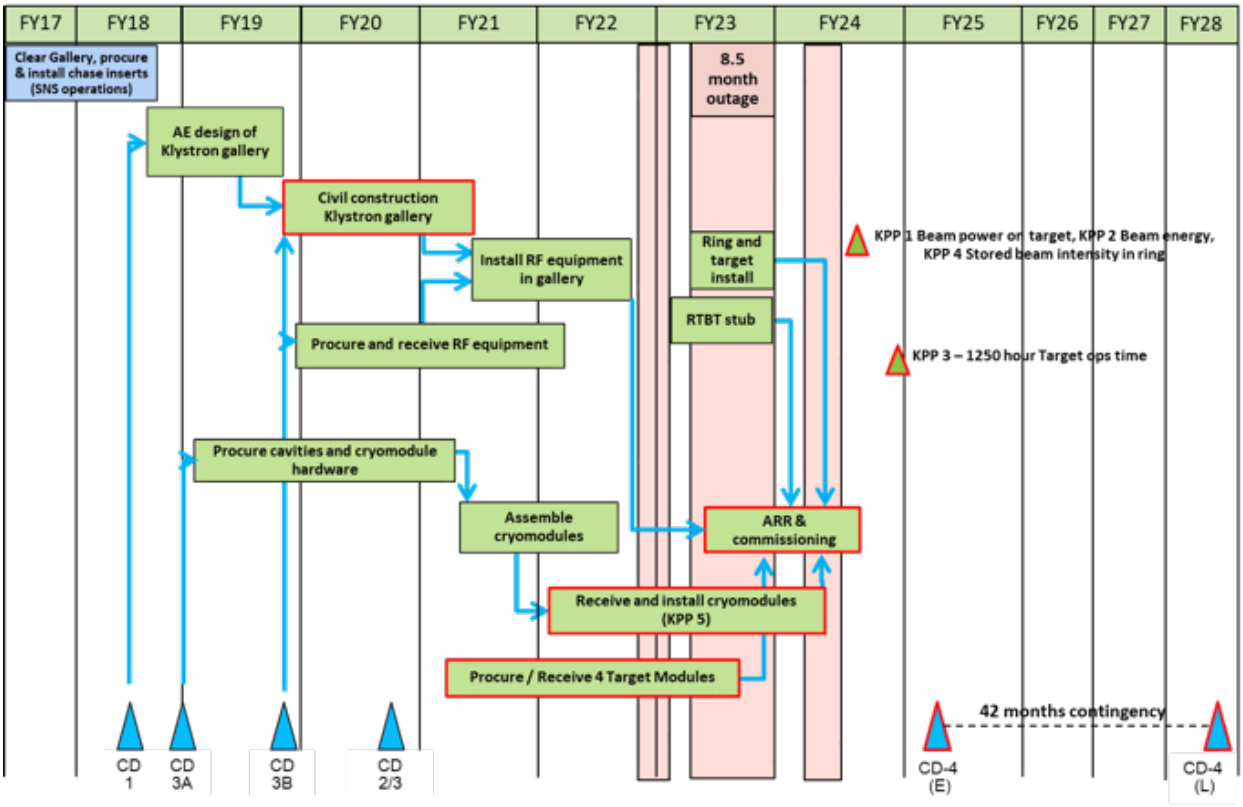

Figure 2 – Project Summary Schedule

3.12 Readiness Review

As noted in DOE G 420.2-1A, *Accelerator Facility Safety Implementation Guide*, the accelerator readiness review (ARR) "provides a means to verify that an accelerator facility's personnel, documentation, and equipment are adequate to safety support the full scope of activities proposed for commissioning and/or routine operations. Specifically, from DOE O 420.2C, *Safety of Accelerator Facilitie*s, the ARR must demonstrate the following processes are in place:

- A Contractor Assurance System that maintains in internal assessment process
- A Facility Configuration Management Program that is related to accelerator safety
- Credited controls and appropriate administrative processes related to accelerator safety (e.g. training, procedures, etc.).

The readiness reviews outlined in Section 3.5 will follow the guidelines set forth in DOE G 420.2-1A, Accelerator Facility Safety Implementation Guide. The Guide notes a tailored approach should be utilized based on the size, complexity and hazards associated with the accelerator facility. A phased approach to the readiness review process is needed to match the phased approach to PPU installation activities.

A team of Subject Matter Experts (SMEs) from peer facilities will be assembled to form the ARR team. During the initial construction of SNS, the Accelerator Safety Review Committee was used to conduct all of the ARRs. Use of ASRC members will be considered during the development of the PPU review team. The same team will be used to conduct both ERRs and ARRs for the PPU project. A specific Plan of Action will be developed prior to each ERR/ARR

that identifies the scope for that particular review.

An external readiness review will be conducted at the end of Phase 1 and Phase 3. While not designated as an ARR, the review will be conducted in accordance with Implementation Guide and will utilize the same review team (to the extent possible) to conduct the review as will be used in the full ARR. The scope of each of these outages involves the addition of 2 new cryomodules which is basically an extension of the existing facility. There are no modifications planned to the ASE specific to these installations. The installation of the BPLS will require a modification to the ASE and subsequent DOE approval as part of Phase 1.

A full ARR will conducted as part of Phase 2. The ARR will be divided into 2 parts. The same review team will be utilized to conduct these reviews. The first ARR will focus on implementation of gas injection and the associated credited controls needed to allow pre-beam gas injection testing. The second part of the ARR will review the results of the pre-beam gas injection testing and all of the remaining scope that was installed during the long outage. The ASE that will be proposed during the second ARR will encompass all controls needed to allow beam commissioning and routine operations after both Phase 2 and Phase 3.

3.13 Operations and Maintenance Management

Current operations and maintenance of the accelerator and target technical systems resides within NScD, primarily in RAD and NTD. The newly installed PPU equipment is similar in nature to the currently installed equipment. In some cases, the new equipment is simply an extension of existing equipment. Operations of the new equipment will continue to be performed in accordance to the existing SNS Operations Procedures Manual, modified to reflect the new components. All operations and maintenance will continue to be governed by the Chestnut Ridge Operations, Maintenance, and Services (OM&S) Work Control procedure.

3.14 Facility Support, Operations and Maintenance Training

As noted throughout this document, the PPU project is being executed in a matrixed fashion utilizing existing staff with operations and maintenance responsibilities. This has the benefit of allowing the staff that will ultimately operate and maintain the equipment, to be intimately involved in the design and installation of the equipment. Each WBS element will provide specific training material to operations staff as part of the process to gain approval for commissioning activities. This training will be documented using the laboratory's training system and operator qualification standards will be updated as needed.

3.15 Environment, Safety and Health (ES&H), and Quality Assurance

ORNL maintains a comprehensive quality management system (QMS), environmental management system (EMS), and Worker Safety and Health Program (WSHP). The QMS and EMS and WSHP are assessed annually by the lab to conformance and effectiveness of their respective systems. QMS implements DOE O 414.1D through ISO 9001, EMS implements ISO 14001 and WSHP implements ISO 18001. DOE O 851 is fully implemented through SBMS and operational procedures. SNS maintains an organization-level Quality Assurance Manual based on a combination of labwide (Standards-Based Management System) and organizational procedures. The PPU Project works to this QAM with an additional Quality Assurance Plan that is an extension of the QAM and provides more PPU-specific detail.

3.16 Safeguards and Security (S&S)

As noted in the Project Execution Plan, a safeguards and security and vulnerability assessment was performed, and the conclusion was that the safeguards and security issues for this project are considered an extension of the existing facility and manageable with standard practices. The project will not introduce additional security requirements that are not already addressed by current Oak Ridge National Laboratory policies and procedures and the project will use those policies and procedures.

3.17 Permits and Licenses

No additional permits or licenses from regulatory authorities are required for full operation of the PPU. Authority to operate is granted by the DOE ORNL Site Office subject to the DOE Orders and Guidance noted elsewhere in this document as well as the terms and conditions of DOEs contract with UT-Battelle.

3.18 Authorization and Notification

Notification to or approval by the DOE Site Office for beam commissioning will occur after completion of each phase of the readiness review process outlined in Section 3.12. SNS OPM 6.F-1.2, *RAD Operational Readiness Management Self Assessment (MSA)*, will be used to authorize beam operations after each outage period as is currently done. This will ensure all pre-start action items are complete and RAD management agrees with beginning beam commissioning actvities.

Project completion (CD-4) will be accomplished once all scope has been delivered and the threshold key performance parameters have been met. As the KPPs are reached, SNS Operations will notify the Project Office and provide any needed documentation.

3.19 Project Acceptance, Beneficial Occupancy, and Transfer to Operations

An overall Project Closeout Report will be generated as described in the Project Execution Plan There are 2 construction projects that will be formally transferred to UT-Battelle as part of the PPU project. Transfer of the Klystron Gallery and RTBT Stubout construction projects will be done in accordance with the Modernization Project Office procedure MPO-PM-505, *Project Turnover and Acceptanc*e.

As PPU scope is being installed in a phased fashion, the turnover to operations will also be phased. Once the beam commissioning activities have been completed and a sufficient period of time has elapsed to allow for infant mortality failures, the project will request acceptance of the installed equipment from RAD management. As it is in the best interest of both parties, RAD management and the Project Office will agree on the length of the burn-in period.

3.20 Business Functions

PPU uses the same functional business systems as used by NScD and ORNL. All necessary business functions are already in place at NScD (e.g. finance, HR, communications, IT support document management, etc.) and used in a matrixed fashion by PPU staff presently. No business function issues are foreseen as PPU transitions to operations.

3.21 Project Information and Records Turnover

The PPU Project is utilizing the Neutron Sciences Document repository, ProjectWise, for document retention. The typical types of documents produced over the life of the project are design basis documents, specifications, as-built drawings, equipment manuals, test reports, acceptance documents, non-conformance reports, operations procedures, and ARR documentation.

3.22 Transition to Operations Reporting

Incremental progress on transition to operations activities will be communicated to the PPU Project Director via regularly scheduled meetings. Formal reporting to the Federal Project Director will be done in accordance with the PEP.

3.23 User/Operating Organization Staff Planning

PPU is upgrading an operational user facility. No new instruments are being added as part of this project, so the impact on users is minimal. There is already a fully staffed and well-functioning user support group at SNS. No plans are included in the transitions to operations for additional user support. PPU is part of the NScD outage planning committee, so a well-established channel exists for communicating planned outages influenced by the upgrade process to the various user groups.

3.24 Lessons Learned and Process Improvement

A PPU Lessons Learned Report will be generated as part of required CD-4 documentation. Lessons Learned Reports were submitted after both CD-3A and CD-3B approvals. Any lessons learned during the ERR/ARR process as well as during the commissioning activities will be captured as part of the Lessons Learned Report.

3.25 Project Organization De-staffing Planning Done

The majority of personnel involved in the PPU Project are matrixed from various ORNL organizations. Most of these staff will transition back to their respective organizations once installation activities are complete. Commissioning activities will utilize existing operations personnel who will continue in their respective roles once the KPPs are reached. Subcontracts will be closed out upon completion. Some staff may transition to other projects such as STS. For staff that do not have an existing position, the Project Manager will work with the respective Division Director to evaluate skill sets against open positions to develop a placement strategy which may include working the Human Resources to find suitable work elsewhere in the laboratory. PPU management participates with other NScD leadership in succession planning and other longer range staff planning exercises.

4 Acronyms

ALD	Associate Laboratory Director
ARR	Accelerator Readiness Review
ASE	Accelerator Safety Envelope
ASRC	Accelerator Safety Review Committee

BES	Basic Energy Sciences
BPLS	Beam Power Limiting System
CD	Critical Decision
CFR	Code of Federal Regulations
DOE	Department of Energy
EMS	Environmental Management System
ERR	External Readiness Review
ES&H	Environment, Safety, and Health
FPD	Federal Project Director
FSAD	Final Safety Assessment Document
FTS	First Target Station
FWP	Field Work Proposal
GeV	Giga-electron Volts
HPRF	High Power Radio Frequency
HVCM	High Voltage Converter Modulator
ISM	Integrated Safety Management
KPP	Key Performance Parameter
MW	Megawatt
NScD	Neutron Sciences Directorate
NTD	Neutron Technologies Division
OE	Operating Envelope
OM&S	Operations, Maintenance, and Services
OPM	Operations Procedures Manual
ORNL	Oak Ridge National Laboratory
OSO	ORNL Site Office
PEP	Project Execution Plan
PMP	Project Management Plan
PPU	Proton Power Upgrade
QA	Quality Assurance
QAM	Quality Assurance Manual
QMS	Quality Management System
RAD	Research Accelerator Division
RF	Radio Frequency
RTBT	Ring to Target Beam Transfer
SME	Subject Matter Expert
SNS	Spallation Neutron Source
STS	Second Target Station
WBS	Work Breakdown Structure
WSHP	Worker Health and Safety Program