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SECOND TARGET STATION (STS) PROJECT

Global Requirements Document

January 2022

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

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REVISION RECORD

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Revision	Description
00	Initial Release
01	Requirement R1, changed “will” to “shall”. Added Requirement R12 “Equipment shall be designed to be removable for decommissioning. Added SSC to acronym list.

CONTENTS

ACRONYMS

KPP	Key Performance Parameter
PPEP	Preliminary Project Execution Plan
PPU	Proton Power Upgrade
SNS	Spallation Neutron Source
SSC	System, Structure or Component
STS	Second Target Station
TTOP	Transition to Operations Plan
WBS	Work Breakdown Structure

DEFINITIONS

Shall, must, will, may, and should are used to define each individual requirement. The definitions of these terms are as follows:

- *Shall* – is a requirement that is binding and must be implemented
- *Must* – is an absolute, binding alternative to "shall" or "requirement"
- *Will* – is used to inform intent or declaration of purpose
    - This is not a requirement; the author must use the word 'shall' to indicate that a requirement is binding and must be implemented
- *May* – is used to indicate a desire or goal of a requirement
    - This can also be interpreted 'as nice to have' and is not binding
- *Should* – is used to indicate a desire or goal of a requirement
    - This can also be interpreted 'as nice to have' and is not binding

"Not" is used in combination with the above terms to indicate the opposite; that is, "shall not" and "must not" describe prohibited

CD-2
DOE Critical Decision 2 – Approve Performance Baseline

CD-4
DOE Critical Decision 4 – Approve Start of Operations or Project Completion

1. INTRODUCTION

The Global Requirements Document defines the highest-level, L1 requirements of the Second Target Station (STS) Project technical baseline. Several of these requirements flow naturally from the project Key Performance Parameters (KPPs) that are detailed in the *S01010000-PN0001 Preliminary Project Execution Plan (PPEP) for the Second Target Station (STS) Project*) and in Table 2 below. These requirements establish the basis for the Work Breakdown Structure (WBS) L2 Requirements established by the WBS Managers in their technical areas. Each technical area uses the L2 Requirements to generate L3 and L4 Requirements where appropriate.

2. STS PROJECT SCOPE

The STS Project substantially expands the capabilities of Spallation Neutron Source (SNS) to meet global needs for a high-intensity source of cold (long-wavelength) neutrons and sustain US leadership in neutron scattering for decades to come.

The STS Project includes the design, construction, installation, and commissioning of the facilities and equipment necessary to create a world-leading source of cold neutrons of unprecedented peak brightness at SNS. The project leverages the capacity of the existing SNS accelerator, accumulator ring, and infrastructure and takes full advantage of the performance gains delivered by the Proton Power Upgrade (PPU) Project that will double the power of the SNS accelerator complex to 2.8 MW.

3. GLOBAL REQUIREMENTS

The proposed high-level requirements are listed in Table 1 below. Also, a more detailed explanation of each requirement is discussed.

Table 1. STS Project Global Requirements

ID	Requirement Description
R1	The STS Project will demonstrate independent controls of the proton beam on the two target stations
R2	STS Project shall deliver a facility with the capability to operate 700 kW proton beam power to STS
R3	STS Project shall deliver a facility with the capability to operate with a peak brightness of $\geq 2x10^{14}$n/cm^2/sr/Å/s at 5 Å
R4	The STS shall provide world-leading capabilities for science using cold neutrons with more than a 10x gain relative to comparable First Target Station instruments
R5	STS Project shall transition to operations ≥8 beamlines that successfully pass the integrated functional testing per the Transition to Operations Plan (TTOP)
R6	STS facility shall be designed to accommodate 22 neutron beamlines
R7	STS facility shall be designed to support a lifetime of 40 years
R8	STS facility shall be designed to support > 5000 hrs of proton beam on target per year
R9	STS facility shall be designed to support an availability of > 90%
R10	STS facility shall be designed to maintain compatibility with the SNS Facility
R11	STS facility shall be designed in accordance with the DOE Order 420.2C Safety of Accelerator Facilities
R12	Systems, Structures and Components for the STS shall be designed for decommissioning

R1 – The STS Project shall demonstrate independent controls of the proton beams on the two target stations:

- The SNS linac and ring operate at 60 Hz. At the completion of the STS Project, in typical operation, one of out every four proton pulses will be directed to the STS target to produce neutrons for the STS neutron instruments, and three out of four to FTS. In this operating mode, the STS will receive 15 proton pulses per second at 15 Hz, and the FTS will receive 45 pulses per second delivered on a 60 Hz periodicity. In order to support maintenance, repair, tune up, and machine studies, it will be possible to independently control the repetition rate and proton beam power to the FTS and STS. The facility will support operation of beam to the FTS only, and beam to the STS only. Operation at less than 15 pulses per second to the STS and less than 45 pulses per second to the FTS will be supported. It will also be possible to vary the proton charge per pulse of the beam delivered to FTS or STS independently. The STS will not operate at greater than 15 pulses per second. It is not expected that FTS will operate at greater than 45 pulses per second, but operation of FTS at 60 pulses per second with no beam to STS may be supported.

R2 – STS Project shall deliver a facility with the capability to operate 700 kW proton beam power to STS:

- The current configuration of SNS operates at a nominal beam power of 1.4 MW, averaged over one second. After completion of the PPU project this will be doubled to 2.8 MW. When the Second Target Station is in operation, proton pulses will be extracted from the accumulator ring at a frequency of 60Hz, with every fourth pulse being delivered to the second target. The remaining pulses will be delivered to the first target. The second target station accelerator and target systems shall therefore be designed to receive a nominal beam power of 700 kW (averaged over 1 second).

R3 – STS Project shall deliver a facility with the capability to operate with a peak brightness of $\geq 2x10^{14}n/cm^2/sr/Å/s$ at 5 Å:

- The STS is optimized as a high peak brightness source of cold (long-wavelength) neutrons enabling time-of-flight based neutron scattering instruments. At the specified peak brightness, STS will have higher peak brightness than any current or planned neutron source in the world. The source design takes advantage of recently developed, low-dimensional moderators that are closely coupled to a relatively compact neutron production zone to achieve this world-leading peak brightness.

R4 – The STS shall provide world-leading capabilities for science using cold neutrons with more than a 10x gain relative to comparable First Target Station instruments:

- The STS is designed to enable time-resolved measurements of kinetic processes and beyond-equilibrium matter, more intense neutron beams with smaller cross-sections, and simultaneous measurements over large ranges of length and energy scales. Where comparable, STS instruments shall provide improvements in science capabilities relative to their First Target Station counterparts by enabling >10x faster measurements, measurements of >10x smaller sample volumes, or accessing >10x larger range of length or energy scales simultaneously. Gains in these science capabilities can be achieved either singly or in combination through higher neutron source intensity or brightness, improvements in neutron transport, greater efficiency in measuring scattered neutrons, establishing new limits for extreme sample conditions, or reducing sample sizes.

R5 – STS Project shall transition to operations ≥8 beamlines that successfully pass integrated functional testing per the Transition to Operations Plan (TTOP):

- The STS Project shall construct ≥8 neutron scattering instruments which demonstrate by physical measurement to have individually met or exceeded its performance parameters as described in the STS TTOP. The TTOP document shall be developed and approved prior to CD-2. The goal of the STS Project is to complete construction of ≥8 neutron scattering instruments ready to begin commissioning with source-produced neutrons by the end of the project. The TTOP document will include neutron brightness goals (n/cm^2/sr/Å/s/MW) defined for each instrument which will be measured using source-produced neutrons transported by the instrument neutron optics system to the sample location.

R6 – STS facility shall be designed to accommodate 22 neutron beamlines:

- The facility will provide 22 beam ports with an angular separation of nominally 11 degrees. Each beamline will point directly at one of the two close coupled moderators. The instrument halls will provide 5.5 degrees of unobstructed space on either side of each beamline. The instrument halls will not obstruct the conveyance of neutrons along any of the 22 nominal beam paths from the moderators to the exterior walls of the facility.

R7 – STS facility shall be designed to support a lifetime of 40 years:

- The facility design will support an operational lifetime of 40 years. This is especially important in areas of the facility that are captive once the facility has been built. The project team will use experience and lessons learned from SNS and other similar facilities to ensure that designs meet this criterion. Where this is not possible the project team will design to allow for replacement where appropriate.

R8 – STS facility shall be designed to support > 5000 hours of proton beam on target per year:

- Similar to SNS, the STS will be designed to support 5000 hours per year of neutron production. STS source design will seek to minimize the replacement time (<3 months) for key components in order to minimize impact to the user program.

R9 – STS facility shall be designed to support an availability of > 90%:

- The STS neutron production availability goal is 90%. That is, neutron production shall occur during 90% of the 5000 scheduled neutron production hours. STS neutron production relies on operability of the following 3 sections of the machine: (1) the existing linear accelerator and accumulator ring, (2) the STS Ring to Second Target, and (3) the STS Target Systems. In order to meet 90% availability for STS neutron production, availability for each of these systems must be above 90%. Lower-level requirements documents will allocate availability requirements to the STS subsystems based on expected availability of the existing systems.

R10 – STS facility shall be designed to maintain compatibility with the SNS Facility:

- Once completed the STS will transition back into the Neutron Sciences Directorate and will be operated in conjunction with the SNS facility. Consequently, it is imperative that designs of technical systems are compatible with the existing systems on the SNS facility. The STS management team and technical managers liaise continuously with their SNS facility counterparts and include them in design reviews to ensure compatibility.

R11 – STS facility shall be designed in accordance with the DOE Order 420.2C Safety of Accelerator Facilities:

- The STS facility shall be designed in accordance with DOE Order 420.2C, Safety of Accelerator Facilities. The Order defines accelerators and establishes accelerator facility specific safety requirements and approval authorities which, when supplemented by other applicable safety and health requirements, promote safe operations to ensure protection of workers, the public, and the environment for Department of Energy (DOE). The following elements shall be included in the STS accelerator facility safety program: (1) an approved accelerator safety envelope (ASE); (2) a safety assessment document (SAD); (3) clearly defined roles and responsibilities for accelerator facility activities including those for training and procedures; (4) an unreviewed safety issue (USI) process; (5) an accelerator readiness review (ARR) program that ensures the STS facility is adequately prepared for safe commissioning and/or operations; and (6) identification of the STS facility on the current listing/inventory of accelerator facilities under this Order and exemptions or equivalencies granted in accordance with paragraph 3.c.(2) and 3.c.(3) of this Order.

R12 – Systems, Structures and Components (SSCs) for the STS shall be designed for decommissioning:

- The STS shall be designed considering the life cycle of the work and ultimate fate of the systems, processes, and/or facilities used to accomplish the work, inclusive of the facility's end of life. Use or addition of any SSCs should be evaluated not only against potential safety benefits and implementation costs, but also in terms of potential hazards associated with decontamination and disassembly. Thus, components must be designed so that they can be safely transported away from the facility to a disposal site. Materials used in the construction of SSCs may not impose any long-time harm to the environment because of activation, toxicity, or any other reason. Material activation or toxicity shall be below worker exposure limits during the decommissioning process. Materials which would require time to decay more than 6 months before removal shall not be chosen. Resource Conservation and Recovery Act (RCRA) listed materials and materials that activate with long-lived isotopes shall be minimized. SSCs shall not prevent other SSCs from being removable. SSCs shall be designed in such a way that decommissioning is not prohibitively expensive.

4. KEY PERFORMANCE PARAMETERS

The Global Requirements listed in Section 3 incorporate the proposed objective values for the KPPs, as described in the PPEP and listed in Table 2. The Threshold KPPs are the minimum parameters that need to be satisfied for the project completion at CD-4. Objective KPPs are not required to be satisfied to achieve CD-4, but form the basis for key requirements that drive the STS design. The ID number for the Global Requirements corresponding to each KPP are identified in the table.

The KPPs listed below are proposed KPPs and will be finalized at CD-2.

Table 2. STS Project Key Performance Parameters

Key Performance Parameter	Thresholds (Performance Deliverable)	Objectives	Global Req ID#
Demonstrate independent control of the proton beam on the two target stations	Operate beam to FTS at 45 pulses/s, with no beam to STS Operate beam to STS at 15 Hz, with no beam to FTS Operate with beam to both target stations 45 pulses/s at FTS and 15 Hz at STS		R1
Demonstrate proton beam power on STS at 15 Hz	100 kW beam power	700 kW beam power	R2
Measure STS neutron brightness	peak brightness of 2×10^{13} n/cm^2/sr/Å/s at 5 Å	peak brightness of 2×10^{14} n/cm^2/sr/Å/s at 5 Å	R3
Beamlines transitioned to operations	8 beamlines successfully passed the integrated functional testing per the TTOP acceptance criteria	≥ 8 beamlines successfully passed the integrated functional testing per the TTOP acceptance criteria	R5

5. PROJECT UPGRADEABILITY

The project scope, cost and schedule are clearly defined in the PPEP and do not include scope for upgrading the facility later. However, the project team is cognizant of potential opportunities within the design and will address these throughout the design process. If opportunities do arise that could give added flexibility to the facility, at little or no extra cost, each will be analyzed and reviewed by the management team.