PRINCETON PLASMA PHYSICS LABORATORY

ENG-064 - ICD - INTERFACE CONTROL DOCUMENT

Test Cell - Gas Delivery System Interface Control Document

NSTXU_1-8-1-1_ICD_100

Work Planning #:
Effective Date: **12/05/2019**
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National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

Interface Control Document

TEST CELL :
GAS DELIVERY SYSTEM

NSTX-U-TCS-GDS-ICD

Revision 0
November 15, 2019

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Change Record

Revision	Date	Description of Change
0	November 15, 2019	Initial Release

References

[1] GENERAL REQUIREMENTS DOCUMENT, NSTX-U-RQMT-GRD-001-01

[2] SYSTEM REQUIREMENTS DOCUMENT, Test Cell, NSTX-U-RQMT-SRD-010-02

[3] SYSTEM REQUIREMENTS DOCUMENT, AUXILIARY SYSTEMS, NSTX-U-RQMT-SRD-005-01

1. Purpose

This document describes the various interfaces between the following subsystems: Test Cell and the Gas Delivery System. The interface locations and boundaries that connect the Test Cell to the Gas Delivery System are identified based on different interface types.

2. Scope

The Test Cell consists of the platforms, cable trays, racks, penetrations, floor, and crane. The Center Stack Structures include the Center Stack Casing, Pedestal, PF-1a Support Structures, PF-1b Support Structures, and PF-1c Support Structures. he Gas Delivery and Injection System consists of an Outboard Divertor injections system, Massive Gas Injectors, High Field Side Injectors, and Private Flux Region Fueling. The scope of this document addresses any defined interfaces between these identified system elements.

3. Responsibilities

The interfaces are managed between the following organizations:

- Test Cell
- Gas Delivery System
- Systems Engineering and Integration

4. Interfaces

Interface requirements in the following sections are identified with a requirement number, ICD followed by a number [ICD-TCS-GDS-X] where X is a sequential count beginning with 001, TCS represents Test Cell and GDS represents Gas Delivery System. There is also a unique identifier for all interfaces in the format [#####-#####-X]. The identifier is a concatenation of two level 5 SBS values and the interface type. This is followed by an interface description and a list of references. References provide evidence pertaining to interfaces include but are not limited to drawings, calculations, or specifications. Reference also include a reference to a paragraph that identifies the set of interface definitions.

4.1. Interface Types

The top-level interface types are defined in Table 1. Within each heading there are sub-headings to address any special sub-elements that need consideration. For example, the Mechanical has four sub-elements that need to be addressed: Structural, Spatial, Location, and Wall/Floor Penetration. For those interface types with sub-interfaces there are corresponding sub-sections.

Table 1. Interface Types

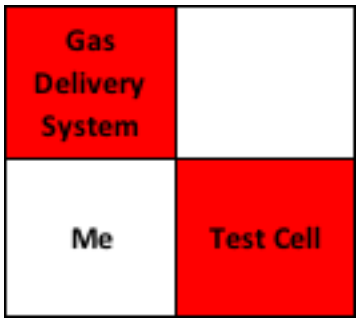
Heading	Abbreviation	Name
4.2	Me	Mechanical
4.3	Ep	Electrical Power
4.4	Si	Signal
4.5	Di	Diagnostics
4.6	Gf	Gas/Fluid
4.7	Va	Vacuum
4.8	Sw	Software
4.9	Th	Thermal
4.10	Pe	Plasma/Eddy/ Halo Current

Table 2 provides the N2 Diagram identifying all the interfaces for NSTX-U while Table 3 provides the specific details of the interface.

Table 2. N2 Diagram Interface types

Plasma Facing Components	Me,Th, Pe		Me,Th, Va,Pe						Me	Me	Me, Pe		Me			
	In-Vessel Structures	Me,Di, Pe			Th			Me,Th, Pe	Me		Me, Pe			Di		
		Vacuum Vessel Structure			Me,Va	Me, Va	Me	Me, Th, Pe	Me	Me,Va	Me,Di, Va		Si	Di, Me		
		Va	Centerstack Structures			Va, Th	Me, Gf	Me	Me					Di		
		Me	Me, Th, Ep	Magnets				Me			Di		SI	Di	Me	
Si		Me, Va			Heating Systems		Gf	Th		Me		Si	Si	Si	Si	
					Si, Va, Me, Sw, Gf	Vacuum Pumping System		Si	Si	Si	Si		Si,Va	Si	Si	
				Gf,Si			Coolant System	Gf				Gf,Sw	Si, Sw	Si	Si	
	Th, Gf	Ep,Di, Th, Va	Ep, Gf, Th, Pe		Si		Si	Bakeout System							Si, Me	
			Gf,Va			Me, Gf,Si			Gas Delivery System	Gf	Va		Si,Sw	Si	Si	
		Gf				Si,Gf,Va			Me	Wall Conditioning System			Si,Sw		Si	
		Me,Va	Me,Va	Me	Me	Gf,Si	Gf			Va, Ep	Diagnostics		Si,Sw	Si	Si, Me	Si
				Ep	Ep	Ep	Ep	Ep	Ep	Ep	Ep	Power Systems	Ep,Si	Ep, Si	Me, Ep, Si, Di, Gf	Ep
					Si					Me, Si	Si		Centralized Instrumentation and Control	Si, Me		
												Si	Si,Sw	Integrated Machine Operations		
								Ep							Operations & Safety Systems	
Me		Me	Me	Me	Me	Me		Me	Me	Me	Me	Me	Me	Me	Me, Ep	D-Site Locations (Test Cell

Table 3. Callout



The remainder of this document addresses each of the interfaces. Note the template includes a paragraph heading for each interface and a table for each interface type. In the event there is no interface, the table will remain blank with a blank row.

The following paragraphs in Section 4 address each of the interfaces, and Section 5 addresses any off-project interfaces. Off-project interfaces are those external interfaces that interact with the NSTX-U system.

4.2. Mechanical Interfaces

This paragraph addresses any type of mechanical interfaces that include a structural, spatial, location dependent interfaces or areas where penetrations into a wall or floor are required. These are identified independently as interface parameters will likely be different.

4.2.1. Structural Interfaces

This identifies any interfaces between system elements that require a structural interface. This could be based on various forces placed on the system and by the system.

Identifier	Interface	References
1.8.1.1.1-1.3.4.2.2-S	SGI is on a stand that resides on the platform	See Paragraph 4.2.1.1,
1.8.1.1.1-1.3.4.3.2-S	MGI valve assembly on outboard side resides on floor	See Paragraph 4.2.1.2
1.8.1.1.4-1.3.4.4-S	Argon purge system supported by the NTC walls	See Paragraph 4.2.1.3, EA3505
1.8.1.1.1-1.3.4.4-S	Argon purge system supported from platforms	See Paragraph 4.2.1.4, EA3505
1.8.1.1.2-1.3.4.4-S	Argon Purge System tubing supported from trays	See Paragraph 4.2.1.5, EA3505, EA3524
1.8.1.1.2-1.3.4.2.1-S	Trays support piezo injector Main Chamber Fueling cables	See Paragraph 4.2.1.6, EA3505, EA3509
1.8.1.1.2-1.3.4.2.2-S	Trays support piezo Supersonic Gas Injectors cables	See Paragraph 4.2.1.7, EA3518
1.8.1.1.2-1.3.4.2.3-S	Trays support piezo Outboard Divertor injector cables	See Paragraph 4.2.1.8, 9D1219
1.8.1.1.2-1.3.4.2.4-S	Trays support piezo GPI and Impurity injector cables	See Paragraph 4.2.1.9, 9D11477

1.8.1.1.2-1.3.4.2.5-S	Trays support piezo Private Flux Region Fueling injector cables	See Paragraph 4.2.1.10
1.8.1.1.2-1.3.4.3.2-S	Trays support cabling for the MGI system	See Paragraph 4.2.1.11, 8AG653

4.2.1.1. SGI - Platform

Interface Notes:

- Interface is defined via a walkthrough with a subject matter expert
- This Interface will be updated as the SGI is a future capability.

ICD-TCS-GDS-001: Supersonic Gas Injection skid was located behind the racks at the mid-plane level and has been removed and relocated for installation in another location

4.2.1.2. MGI - Floor

Interface Notes:

- Interface location is defined via a walkthrough with a subject matter expert
- This Interface will be updated as the MGI assembly is re-assembled on the floor

ICD-TCS-GDS-002: The MGI injector is mounted to the floor in a rack located in the east wall of the South High Bay.

4.2.1.3. Argon - Walls

ICD-TCS-GDS-003: The Argon bottles are stored in the test cell and are mounted to the wall as shown in Figure 1.

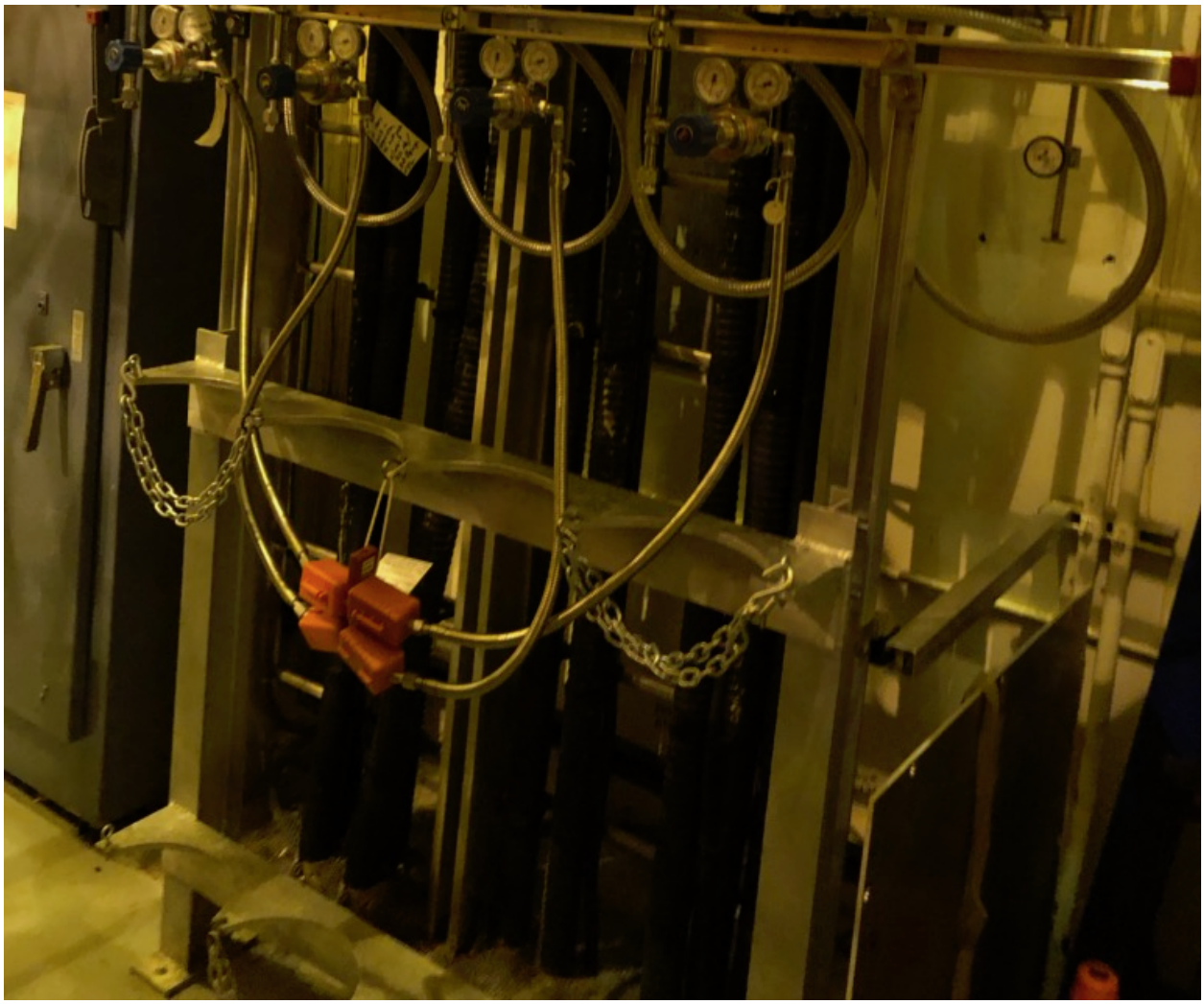


Figure 1. Argon tank storage

ICD-TCS-GDS-004: The interface is connected using systems of bent ¼" OD tubing secured using channels as shown in drawing EA3505.

4.2.1.4. Argon - Platform

ICD-TCS-GDS-005: The argon pipes are mounted to the bottom of the platform as shown in Figure 2.

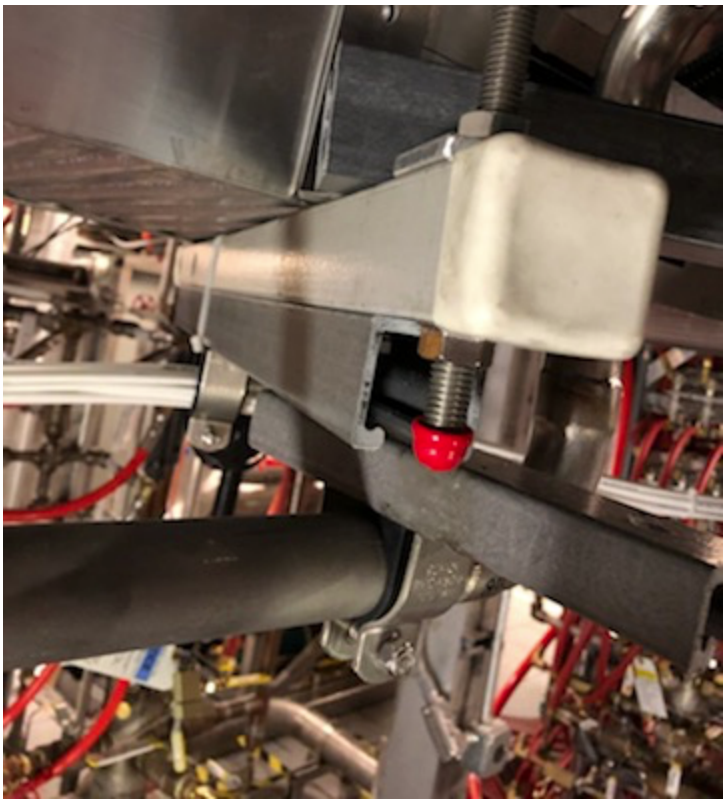


Figure 2. Argon Purge Mounts

4.2.1.5. Argon - Trays

ICD-TCS-GDS-006: Argon Purge System tubing is laid under Conduit Tray 473 as shown in drawing EA3505 as shown in Figure 2.

ICD-TCS-GDS-007: Argon Purge System tubing is laid in 18” open bottom fiberglass cable trays without covers as shown in Drawing EA3524.

4.2.1.6. Main Chamber - Trays

ICD-TCS-GDS-008: Main Chamber system tubes run from the northeast Gallery to the injector location and the tubes are supported from cable trays as shown in drawing EA3505 and shown in Figure 3.

Figure 3. Gas lines attached to cable trays

4.2.1.7. Supersonic Gas- Trays

ICD-TCS-GDS-09: Supersonic Gas System tubes run from the northeast Gallery to the injector location and the tubes are supported from cable trays as shown in drawing EA3505 and shown in Figure 3.

4.2.1.8. OBD - Trays

ICD-TCS-GDS-010: Tubes run from the northeast Gallery to the injector location and the tubes are supported from cable trays as shown in drawing EA3505 and shown in Figure 3.

4.2.1.9. GPI - Trays

ICD-TCS-GDS-011: GPI tubes run from the northeast Gallery to the injector location and the tubes are supported from cable trays as shown in drawing EA3505 and shown in Figure 3.

4.2.1.10. Private Flux Region - Trays

ICD-TCS-GDS-012: PFR tubes run from the northeast Gallery to the injector location and the tubes are supported from cable trays as shown in drawing EA3505 and shown in Figure 3.

4.2.1.11. MGI - Trays

ICD-TCS-GDS-013: MGI System tubes run from the northeast Gallery to the injector location and the tubes are supported from cable trays as shown in drawing EA3505 and shown in Figure 3.

4.2.2. Spatial Interface

This identifies any interfaces between the system elements pertaining to spatial restrictions or constraints.

Identifier	Interface	References
1.8.1.1.1-1.3.4.1-Sp	Numerous gas delivery tubes are supported from platforms and other structures	See Paragraph 4.2.2.1, EA3505

4.2.2.1. Gas Tubes - Platform

ICD-TCS-GDS-014: The gas delivery tubes are routed from the northeast wall through a penetration using a ceramic break and then supported by Unistrut connecting to conduit trays such as 473 as shown on drawing EA3505 Sheet 2. This Unistrut is mounted to various platforms at elevation 106”8” as part of a field installation.

4.2.3. Location Interfaces

This identifies any interfaces between the system elements that have any particular dependencies on element location or location constraints.

Identifier	Interface	References
1.8.1.3-1.3.4.1-L	Gas bottles for system reside in a cage in the gallery	See Paragraph 4.2.3.1, EA3505

1.8.1.3-1.3.4.5-L	Valve driver system resides in a cage in the gallery	See Paragraph 4.2.3.2, EA3505

4.2.3.1. Gas Bottles - Gallery

ICD-TCS-GDS-015: The gas bottle system is located inside the northeast gallery as shown in drawing EA3505. Figure 4 shows the gallery with the Valves. Note that the gas battles as not installed in the picture.

Figure 4. Gallery Gas Delivery Bottle locations

4.2.3.2. Valve Driver - Gallery

ICD-TCS-GDS-016: The valve driver system is held in the gallery and is controlled using a system of valves connected to a manifold as shown in drawing EA3505 Sheet 4, Detail J. Figure 4 shows the valves that reside above the bottles in the Gallery.

4.2.4. Wall/Floor Penetration Interfaces

This identifies any interfaces between the system elements any penetrations or modifications to the wall or floor of the D-Site building.

Identifier	Interface	References
1.8.1.1.5-1.3.4.2.1-W	Main Chamber Fueling cables and tubes pass through penetrations	See Paragraph 4.2.4.1, Drawing EA3505, FA1030
1.8.1.1.5-1.3.4.2.2-W	Supersonic Gas Injector cables and tubes pass through penetrations	See Paragraph 4.2.4.2, Drawing EA3505, FA1030
1.8.1.1.5-1.3.4.2.3-W	Outboard Divertor cables and tubes pass through penetrations	See Paragraph 4.2.4.3, Drawing EA3505, FA1030
1.8.1.1.5-1.3.4.2.4-W	GPI and Impurity Injectors cables pass through penetrations	See Paragraph 4.2.4.4, Drawing EA3505,FA1030
1.8.1.1.5-1.3.4.2.5-W	Private Flux Region cables pass through penetrations	See Paragraph 4.2.4.5, Drawing EA3505, FA1030
1.8.1.1.5-1.3.4.3.1-W	High Field Side Injector cables and tubes pass through penetrations	See Paragraph 4.2.4.6, Drawing EA3505,FA1030
1.8.1.1.5-1.3.4.3.2-W	Massive Gas Injectors cables and tubes pass through penetrations	See Paragraph 4.2.4.7, Drawing EA3505,FA1030

4.2.4.1. Main Chamber - Penetrations

ICD-TCS-GDS-017: Gas cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively. Drawing FA1030 identifies Penetration 1635 as the Conduit and cables for the Glow Discharge Cleaning system.

Figure 5. Cable penetration to test cell

Figure 5. Cable penetration inside test cell

ICD-TCS-GDS-018: Main Chamber gas tubes run through the Gallery through penetration 1636. The penetration included ceramic breaks at the penetration per Sheet 1 of Drawing EA3505 and is shown in Figure 6. Drawing FA1030 Sheet 4 consists of eight ¼" and ½" stainless steel tubes.

Figure 4. Gas tube penetrations

4.2.4.2. Supersonic - Penetrations

ICD-TCS-GDS-019: Supersonic cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively.

ICD-TCS-GDS-020: Supersonic gas tubes run through the Gallery through penetration 1636. The penetration included ceramic breaks at the penetration per Sheet 1 of Drawing EA3505 and is shown in Figure 6.

4.2.4.3. OBD - Penetrations

ICD-TCS-GDS-021: OBD Gas cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively.

ICD-TCS-GDS-022: OBD gas tubes run through the Gallery through penetration 1636. The penetration included ceramic breaks at the penetration per Sheet 1 of Drawing EA3505 and is shown in Figure 6.

4.2.4.4. GPI - Penetrations

ICD-TCS-GDS-023: GPI gas cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively.

4.2.4.5. Private Flux - Penetrations

ICD-TCS-GDS-024: Private Flux gas cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively.

ICD-TCS-GDS-025: Gas Lines run through the Gallery through penetration 1636. The penetration included ceramic breaks at the penetration per Sheet 1 of Drawing EA3505.

4.2.4.6. High Field Side - Penetrations

ICD-TCS-GDS-026: High field side gas cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively.

ICD-TCS-GDS-027: Gas tubes run through the Gallery through penetration 1636. The penetration included ceramic breaks at the penetration per Sheet 1 of Drawing EA3505 and is shown in Figure 6.

4.2.4.7. MGI - Penetrations

ICD-TCS-GDS-028: Gas cables penetrate the wall above the gallery to the test cell using Penetration 1635. Figures 4 &5 show the penetration from the gallery to the test cell, respectively.

ICD-TCS-GDS-029: Gas tubes run through the Gallery through penetration 1636. The penetration included ceramic breaks at the penetration per Sheet 1 of Drawing EA3505 and is shown in Figure 6.

4.3. Electrical Power Interfaces

This identifies any interfaces between the system elements requiring AC, DC, rectification or power conditioning.

Identifier	Interface	References
N/A		

4.4. Signal Interfaces

This identifies any interfaces between the system elements and signals that are used to either send or receive control information or data. It explicitly includes the type of physical interface such as Ethernet or Fiber Optic or any specific protocols.

Identifier	Interface	References
N/A		

4.5. Diagnostic Interfaces

This identifies any interfaces between the system elements with any instrumentation or diagnostic equipment to collect performance data.

Identifier	Interface	References
N/A		

4.6. Gas/Fluid Interfaces

This paragraph has two different types of interfaces: Gas and Fluid.

4.6.1. Gas Interfaces

This identifies any interfaces between the system elements that use any type of gas (e.g., He).

Identifier	Interface	References
N/A		

4.6.2. Fluid Interfaces

This identifies any interfaces between the system elements that use any type of fluid (e.g., ionized water).

Identifier	Interface	References
N/A		

4.7. Vacuum Interfaces

This identifies any interfaces between the system elements that pertain to the Vacuum.

Identifier	Interface	References
N/A		

4.8. Software Interfaces

This identifies any interfaces between the system elements that use software that may exchange interfaces with other software components. This includes application programming interfaces (APIs) or any other exchange of information between different software applications.

Identifier	Interface	References
N/A		

4.9. Thermal Interfaces

This identifies any interfaces between the system elements that pertain to Thermal characteristics.

Identifier	Interface	References
N/A		

4.10. Plasma Interfaces

This paragraph has two different types of interfaces: Plasma and Eddy/Halo Current.

4.10.1. Plasma Interfaces

This identifies any interfaces between the system elements with the Plasma.

Identifier	Interface	References
N/A		

4.10.2. Eddy/Halo Current Interfaces

This identifies any interfaces between the system elements with the Eddy/Halo Currents.

Identifier	Interface	References
N/A		

5. Off-Project Interfaces

The off-project interfaces are components that are not specifically part of the NSTX-U system. They may include external systems and interfaces where the program has little control on part of the interface. They are provided for completeness.

There are no external interfaces.