

Center Stack Structures - Integrated Machine Operations ICD

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REVISION 1

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National Spherical Torus Experiment Upgrade

Interface Control Document

CENTER STACK STRUCTURE: INTEGRATED MACHINE OPERATIONS

NSTX-U-ICD-CSS-IMO-0

**Revision 0
June 18, 2019**

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Change Record

| Revision | Date | Description of Change |
|----------|---------------|-----------------------|
| 0 | June 18, 2019 | Initial Release |
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References

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

[2] SYSTEM REQUIREMENTS DOCUMENT, VACUUM VESSEL AND INTERNAL HARDWARE, NSTX-U-RQMT-SRD-004-01.

[3] SYSTEM REQUIREMENTS DOCUMENT, Diagnostics, NSTX-U-RQMT-SRD-011-01.

1. Purpose

This document describes the various interfaces between the following subsystems: Center Stack Structure and the Integrated Machine Operations. The interface locations and boundaries that connect the Center Stack Structure to the Integrated Machine Operations are identified based on different interface types.

2. Scope

The Center Stack Structures include the Center Stack Casing, Pedestal, PF-1a Support Structures, PF-1b Support Structures, and PF-1c Support Structures. The Integrated Machine Operations consists of the Machine Instrumentation and Real-Time Control and Protection Systems such as the Digital Coil Protection System, and the Shorted Turn Protection System. The scope of this ICD focuses on Machine Instrumentation. The scope of this document addresses any defined interfaces between these identified system elements.

3. Responsibilities

The interfaces are managed between the following organizations:

- VVIH
- Diagnostics
- Systems Engineering and Integration

4. Interfaces

Interface requirements in the following sections are identified with a requirement number, ICD, followed by a number [ICD-CSS-IMO-X] where “X” is a sequential count beginning with 001, CSS represents Center Stack Structure, and IMO represents Integrated Machine Operations. There is also a unique identifier for all interfaces in the format [#####-#####-X]. The identifier is a concatenation of two level 5 WBS 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 Structure | Me,Di, Pe | | | Th | | | Me,Th, Pe | Me | | Me, Di, Pe | | | Di | | |
| | | Vacuum Vessel Structure | | | Me,Va | Me | Me | Me, Th, Pe | Me | Me,Va | Me,Di, Va | | Si | Di, Si | | |
| | | Va | Centerstack Structure | | | Va, Th | Me, Gf | Me | Me | | | | | Di | | |
| | | Me | Me, Th, Ep | Magnets | | | Gf | Me | | | Di | | Si | Di | Me | |
| Si | | Va | | | Heating Systems | | Gf | Th | | Me | | Gf, Si | Si | Si | Si | |
| | | | | | Si, Va, Me, Sw | Vacuum Pumping System | | Si | Si | Gf, Si | Si | | Si, Va | Si | Si | |
| | | | | Gf, Si | | | Coolant System | Gf | | | | Gf, Sw | Si, Sw | Si | | |
| | Th, Gf | Ep, Di, Th, Va | Ep, Gf, Th, Pe | | Si | | Si | Bakeout System | | | | | | | Si, Me | |
| | | | Gf, Va | | Ep | Gf, Si | | Gas Delivery System | Me | Va | | | Si, Sw | Si | Me | |
| | | Gf | | | | Si, Gf, Va | | Gf | Wall Conditioning System | | | | Si, Sw | Si | 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 | Power Systems | Ep, Si | Ep, Si | Ep, Si, Di, Gf | Ep | |
| | | | | | Si | | | | Me, Si | Si | | Centralized Instrumentation and Control | Si, Me | | | |
| | | | | | | | | | Sw | | Si | Si, Sw | Integrated Machine Operations | Me | | |
| | | | | | | | | 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.

| | |
|------------------------|-------------------------------|
| Center Stack Structure | Di |
| | Integrated Machine Operations |

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 |
|------------|-----------|------------|
| N/A | | |

4.2.2. Spatial Interface

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

| Identifier | Interface | References |
|------------|-----------|------------|
| N/A | | |

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 |
|------------|-----------|------------|
| N/A | | |

4.2.4. Wall/Floor Penetration Interfaces

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

| Identifier | Interface | References |
|------------|-----------|------------|
| N/A | | |

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 |
|---------------------------|--|---------------------|
| 1.1.3.3.13- 1.7.3.4-D | Lateral forces/displacements of the CS lateral support structures are measured via instrumentation across the upper bellows gap. | See Paragraph 4.5.1 |
| 1.1.3.3.8- 1.7.3.4.4-D | Voltage monitors measure the time evolving (and transient) voltage on the ceramic break assembly , on the inner-vessel side. | See Paragraph 4.5.2 |
| 1.1.3.3.11- 1.7.3.4-D | Measure the pre-load on the PF-1a coil at the assembly . | See Paragraph 4.5.4 |
| 1.1.3.3.12- 1.7.3.4-D | Measure the pre-load on the PF-1b coil at the assembly . | See Paragraph 4.5.5 |

4.5.1. Instrumentation – Lateral Support

Interface Notes:

- A temperature sensor shall be placed on top of the lateral supports (see Figure 1 below).

ICD-CSS-IMO-001: Optical Fiber Bragg strain gages will be placed on either side of the lateral supports, to get an average strain on the lateral supports. Figure 1 provides the approximate location of these sensors. A sensor has not yet been selected. As such, the detailed design will be completed at a later date.

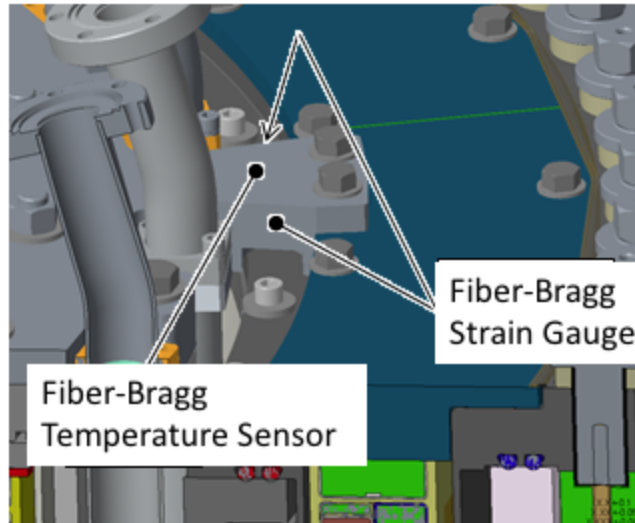


Figure 1: Lateral Support Force Measurement

4.5.2. Voltage Monitor - Ceramic Break

ICD-CSS-IMO-002: Instrumentation will be attached around the ceramic break to measure voltage. The instrumentation has not yet been selected. As such, the detailed design will be completed at a later date.

4.5.3. Preload Strain Sensor - PF-1a

ICD-CSS-IMO-003: Strain sensors will be placed on the outer dimension (OD) of the PF-1a sling as shown in Figure 2. The figure below shows only the sling (grey) and magnet (yellow) assembly. A sensor has not yet been selected. As such, the detailed design will be completed at a later date.

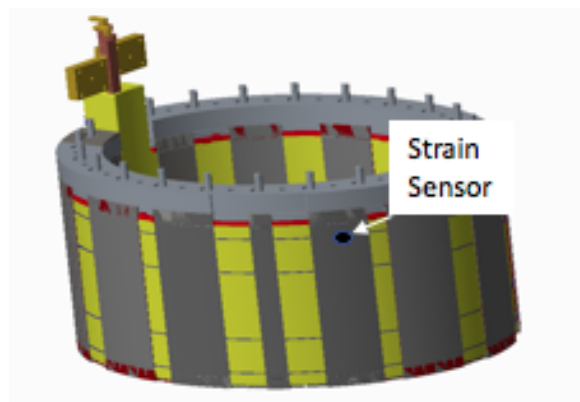


Figure 2. Notional Preload Strain Sensor on PF-1a.

4.5.4. Preload Strain Sensor - PF-1b

ICD-CSS-IMO-004: Strain sensors will most likely be placed on the Inner Dimension (ID) of the PF-1b slings as shown in Figure 3. The figure below shows only the sling (grey) and magnet (yellow) assembly. A sensor has not yet been selected. As such, the detailed design will be completed at a later date.

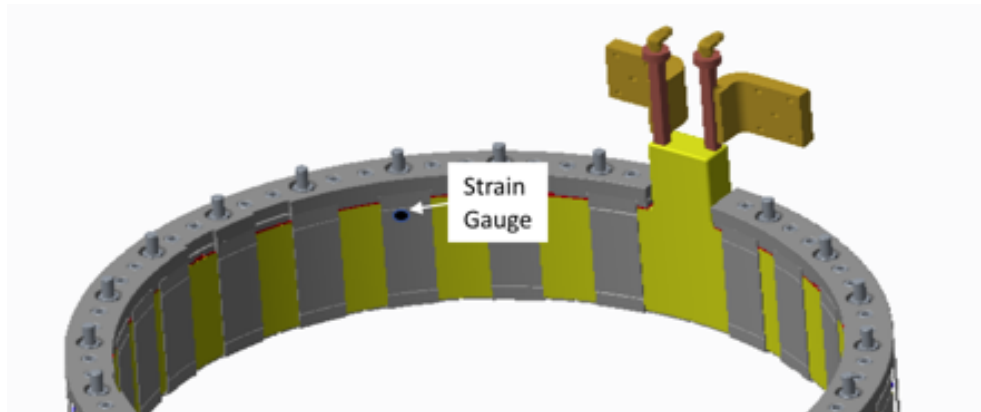


Figure 3. Notional Preload Strain Sensor on PF-1b

4.5.5. Gas/Fluid Interfaces

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

4.5.6. Gas Interfaces

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

| Identifier | Interface | References |
|------------|-----------|------------|
| N/A | | |

4.5.7. 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 | | |
|-----|--|--|

4.6. Vacuum Interfaces

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

| Identifier | Interface | References |
|------------|-----------|------------|
| N/A | | |

4.7. 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 | | |

4.8. Thermal Interfaces

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

| Identifier | Interface | References |
|------------|-----------|------------|
| N/A | | |

4.9. Plasma Interfaces

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

4.9.1. Plasma Interfaces

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

| Identifier | Interface | References |
|------------|-----------|------------|
| N/A | | |

4.9.2. 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.