DREAM Motion Safety System
- Implementation and Left to Do

Instrument Safety Readiness Review DREAM

PRESENTED BY JACOB GILLIES
(ON BEHALF OF THE MOTION CONTROL & AUTOMATION GROUP)

2026-03-26

DREAM Motion Safety

Instrument Hazard Analysis & Handover to Motion Safety

- 2 risks in the IHA identified.
- Collimator risk relates to areas not accessible except during prescribed maintenance events.
- Polariser translation arm (Aka Guide changer) is in a controlled but accessible area and is addressed by motion safety
- Sample stage assessment not included during this phase

Hazard number	Building	Instrument Area	Instrument Sub-area	Instrument System Designation	Sub-System Designation	Nr	Hazard Category (mechanical, chemical, ergon	Person affected	Initiating event	Accident description	Consequence
ConHaz23	D01	Secondary Spectrometer	Collimator slits	Beam_Transport_and_Spatial_Conditioning	Beam geometry conditioning	23	HazMechanical	ESS Staff	Slits moving under maintenance	Pinched finger	Injury
Polar	D01	Secondary Spectrometer	Polarizer translation arm	Beam_Transport_and_Spatial_Conditioning	Beam geometry conditioning	58	HazMechanical	ESS Staff	Polarizer translation arm moving under maintenance	Motorized components	Injury

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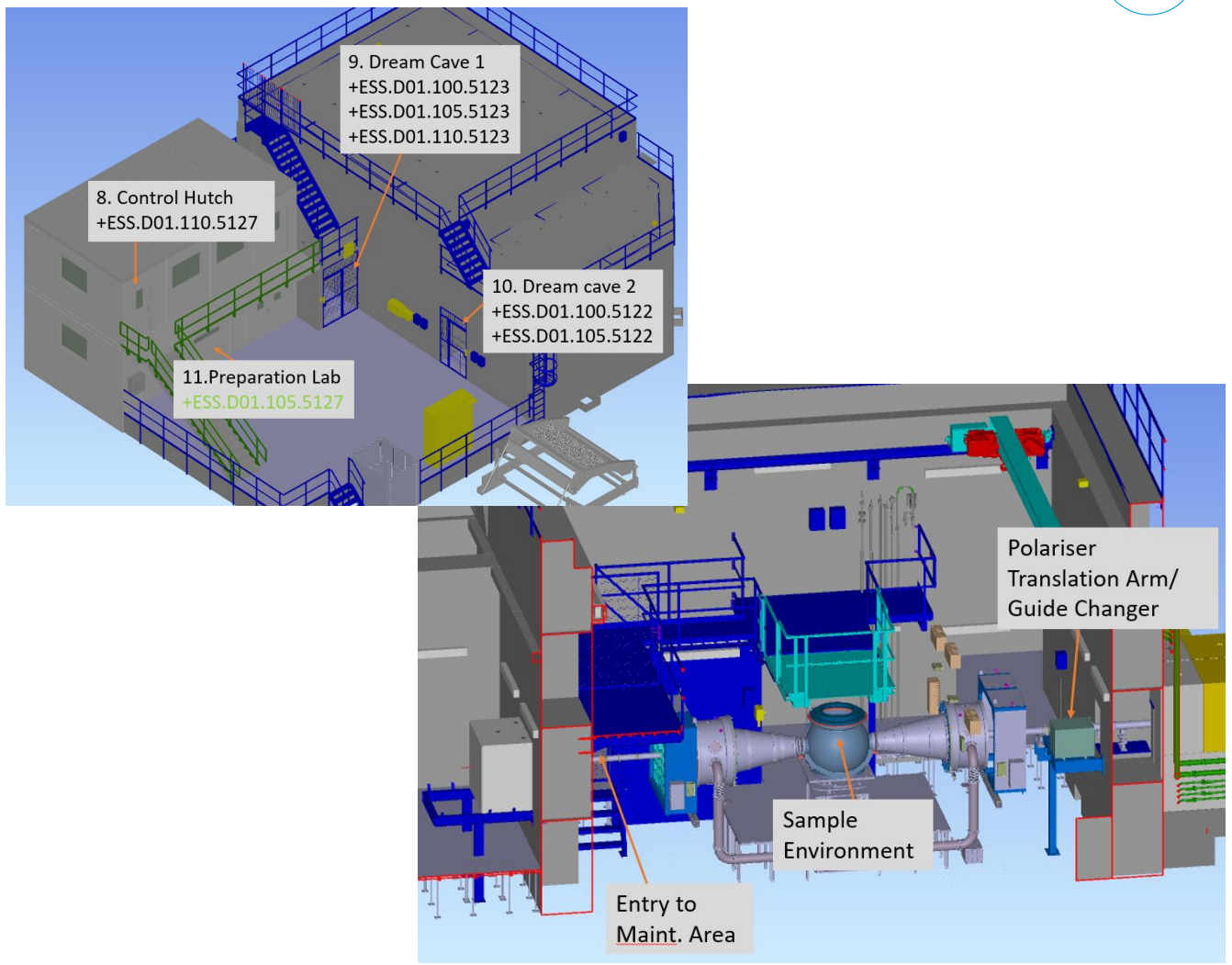
Areas: Cave 1

- Accessibility Experimental Cave 1:
  - PSS Sensed manual Door
  - Access to Sample Area
- Accessibility Guide Changer:
  - Behind locked door within Cave 1; access only for maintenance.
- PSS Access Control is for both areas
- Main Hazards:
  - Unexpected motion of Guide changer during maint. and setup



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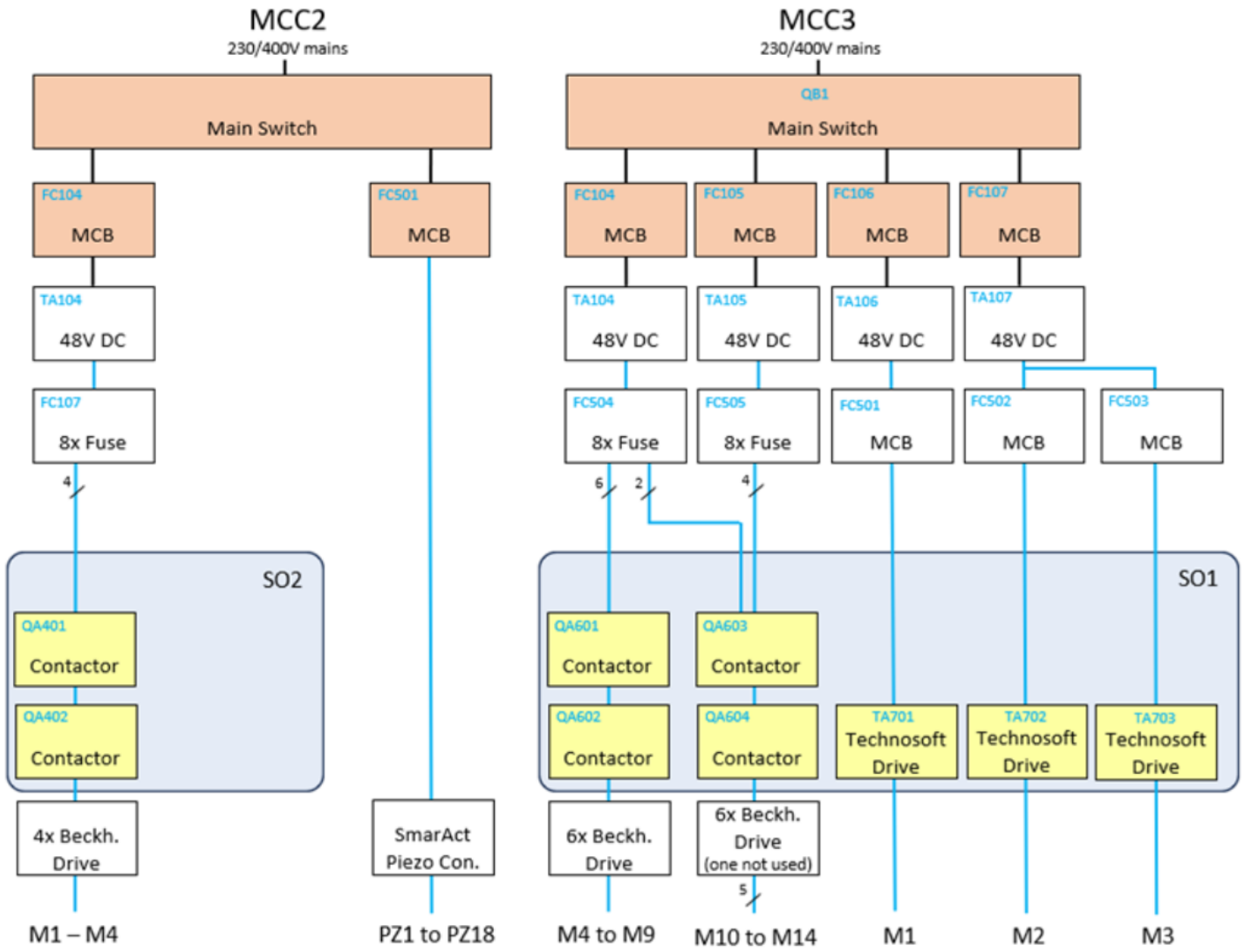
Safety Output Groups (SO)

- SO1 (in Cave 1):
  - Sample Environment axes connected to E-Stop bus to support future installation
  - To be reviewed during installation
- SO2 (in Cave 1):
  - Axes identified as hazardous within an accessible space.
  - Linked to special safety function.
  - Covers also maintenance scenario.
  - Special procedures apply when maintenance work makes it necessary to override these safety functions.



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Safety Output Groups (SO)

DREAM Motion Safety System – Axis List

MCC2

QA401/2

SO2

Pin	ID	Axis Description
13	M1	Polariser Guide Changer
23	M2	Spare Axis 1
33	M3	Spare Axis 3
43	M4	Spare Axis 2
53	N/A	N.C.
83	N/A	N.C.

MCC3

STO

SO1

Drive	Axis	Name
1	M1	Ancillary Axis SE 1
2	M2	Ancillary Axis SE 2
3	M3	Ancillary Axis SE 3

QA601/2

Pin	ID	Axis Description
13	M4	Ancillary Axis SE 4
23	M5	Ancillary Axis SE 5
33	M6	Ancillary Axis SE 6
43	M7	Ancillary Axis SE 7
53	M8	Ancillary Axis SE 8
83	M9	Spare Axis 1

QA603/4

Pin	ID	Axis Description
13	M10	Spare Axis 2
23	M11	Spare Axis 3
33	M12	Spare Axis 4
43	M13	Spare Axis 5
53	M14	Spare Axis 6
83	N/A	Drive connected but not used

Safety Function	SO1	SO2
SF1 - E-Stop	X	X
SF2 – PSS Cave Access		X
SF3 – Access override		X

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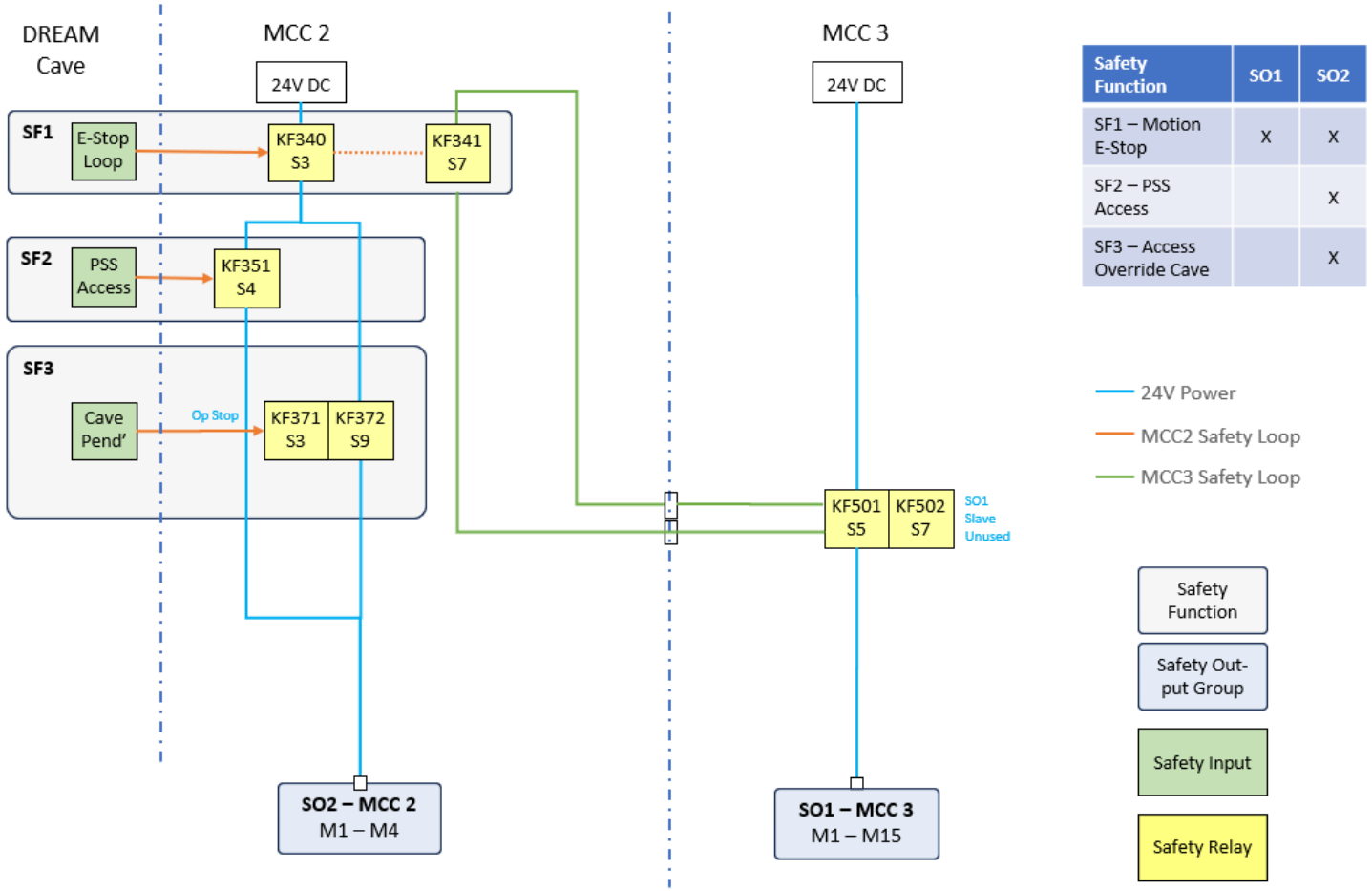
Safety Functions (SF)

- SF1: Motion E-Stop
  - Stops all MCA axes in cave 1
- SF2: PSS Access
  - Stops all MCA axes in cave 1 identified as hazardous and grouped in SO2.
- SF3: Cave Pendant
  - Overrides SF2 and enables all axes in SO2
  - Pendant is located adjacent to SF2 axes to support maintenance tasks

DREAM Motion Safety System – Inputs and Logic (Safety Functions (SF))



Safety Function	SO1	SO2
SF1 – Motion E-Stop	X	X
SF2 – PSS Access		X
SF3 – Access Override Cave		X

DREAM Motion Safety

Cave Pendant

- SF3: Cave Pendant
  - Green indicator light shows that the pendant is connected and in control of SO2 Axes.
  - Push the illuminated white push button to activate SF3 and enable the axes.
  - Button will be illuminated during the period SF3 is active
  - Black operator stop button stops safely SF3 at any time pressed.

Operator Stop
- Twist or pull to reset

Connected
- Pendant is connected and in control
- Turns off when:
  - PSS signal goes high
  - Pendant disconnected
  - MCC2 switched off

Enable
- Press to Enable
- Illuminated when enabled

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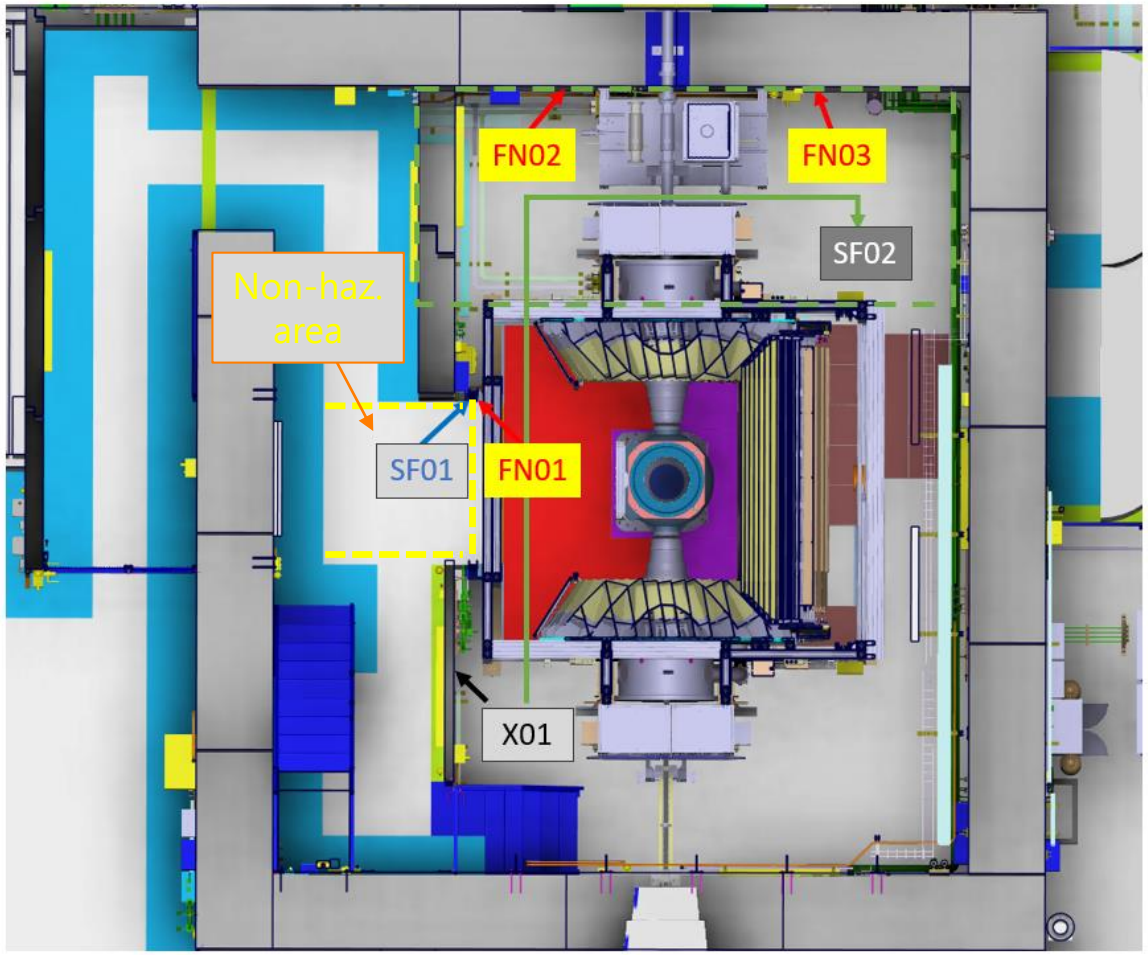
Implementation



E-Stop

FN01

Reset

SF01

Op-Control

SF02

Junction Box

X01

Validation Workflow

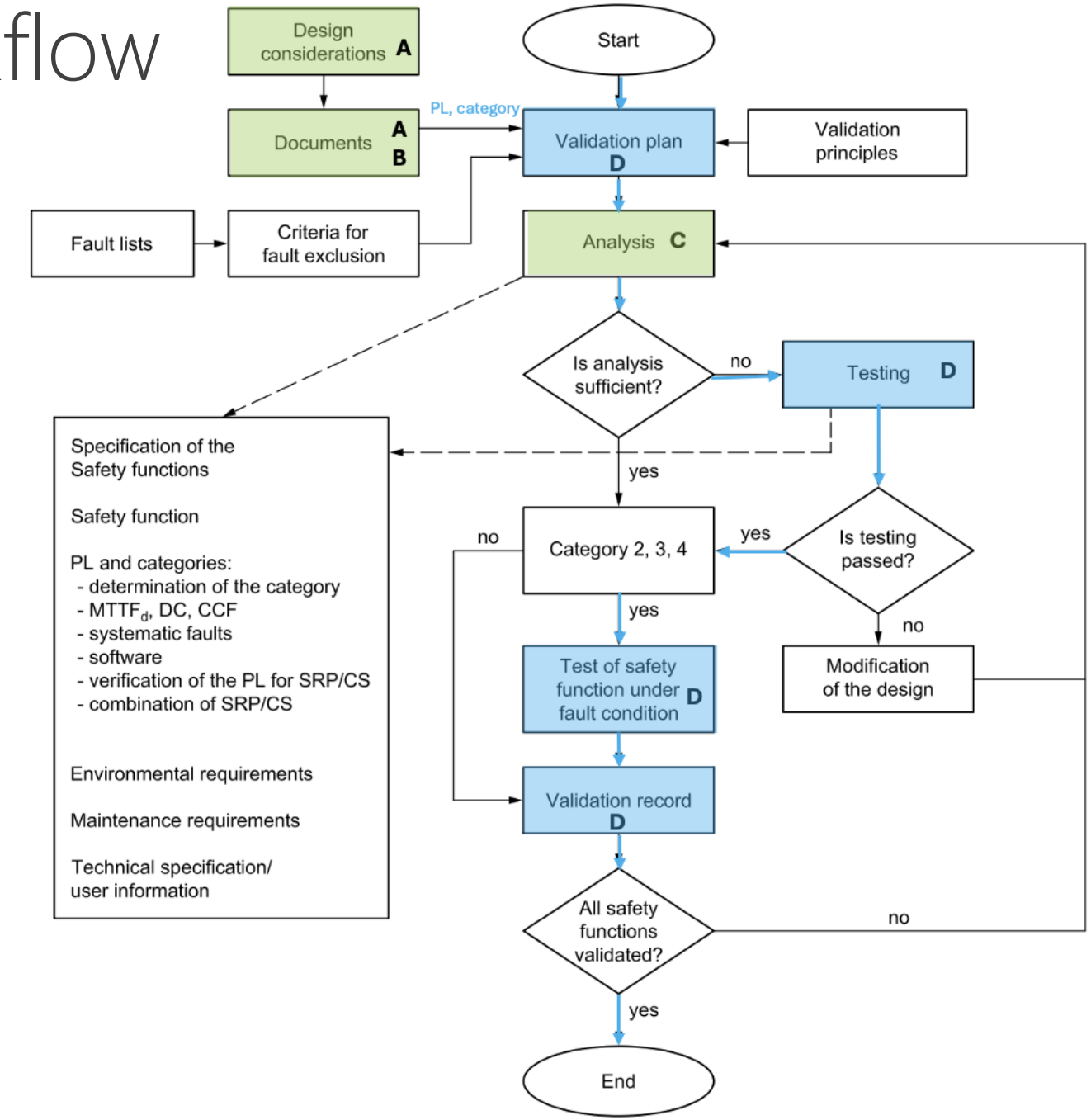
SS-EN ISO 13849-2

A. ESS-5467337 - Motion Risk Analysis of Neutron Instruments.

B. ESS-3482344 - DREAM Table-of-Motion, sheet 3

C. ESS-6020377 - Design Verification Calculation (SISTEMA) for DREAM Motion Safety

D. ESS-6017650 - Motion Safety Validation Plan for DREAM
ESS-6017649 - Motion Safety Validation Report for DREAM



DREAM Motion Safety

Validation Test Plan / Validation Test Report

Validation test has been passed and approved:

- No test case failed
- 1 Punch List item converted to an NIT
- NIT-703 TA701/2/3 STO not validated
  - Requires installation of sample env. axes

ITEM	DESCRIPTION / TEST CASE REFERENCE	NCR / NIT	CATEG.	RESPONSIBLE	COMPLETION DATE
1	TA701/2/3 STO not validated. To be validated during installation of sample stack motors.	NIT-703	e	Jacob Gillies	ORR

TEST SUMMARY & APPROVAL

Validation Test Execution [X] Approved [ ] Rejected
Date: 2026-03-16 **Signature:**
Comment: All listed test cases passed. Recommend for approval

Validation Approval [X] Approved [ ] Rejected
Date: Mar-13, 2026 **Signature:** Jacob Gillies
Comment: No Safety relevant issues have been raised. NIT raised for outstanding STO test. Recommend for approval

Test Cases performed		Summary Findings					
		Pass	Fail	N/A	Signatures of testers	Date	Comments
1	Hardware Check	X			Manuel Regoli Erdinch Ahmed Jacob Gillies	Mar 11, 2026	Cabinet drawings out of date, V4 digital drawings used
2	Output Tests MCC3	X			Manuel Regoli Erdinch Ahmed Jacob Gillies	Mar 11, 2026	
3	Fault Tests MCC3	X			Manuel Regoli Erdinch Ahmed Jacob Gillies	Mar 11, 2026	Output test wiring was in place. Operation re-confirmed during 6-Functional Tests. TA70x STOs to be validated during install/commissioning of the Sample Stack. NIT added.
4	Output Tests MCC2	X			Manuel Regoli Erdinch Ahmed Jacob Gillies	Mar 11, 2026	
5	Fault Tests MCC2	X			Manuel Regoli Erdinch Ahmed Jacob Gillies	Mar 11, 2026	
6	Functional Tests	X			Manuel Regoli Erdinch Ahmed Jacob Gillies	Mar 11, 2026	Confirmed PSS relay activated by "Searched and Locked" on Mar 12, 2026

DREAM Motion Safety

Exclusions

- MCC1 (for in bunker):
  - Instrument Shutter (Pneumatics): Access only for maintenance, trained personnel, LOTO, RAMS; provision to temporarily connect an operator stop (Motor only).

- MCC2 (Cave 1):
  - Collimation Slit Sets (Sealed within collimation tube): Access only for maintenance, trained personnel, LOTO, RAMS.

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Left to do

- Current situation
  - Largest generic hazard is the “Unexpected Startup/Motion of Axes” while people are working on or near the Polariser guide changer.
  - This is addressed by PSS Access and Override/Enable functions.
  - Awaiting Installation of the sample environment to complete STO tests and assess for new hazards
  - This is good and safe enough for next phase (trial operation = hot commissioning) with skilled and trained users familiar with the system.

- Next steps
  - Be available and support the hot commissioning phase for troubleshooting.
  - Evaluate the suitability of the system for daily routine.
  - Get feedback from the users of the acceptance and the user-friendliness of the system.

- Improvements: A question for all T1 instruments
  - Design improvements for the safety control system are in the pipeline for later instruments.
  - Decide how much of this is worth to retrofit (and when) on T1 instruments.

DREAM Motion Safety

Reference Documents

Analysis & Requirements	ESS-0544185 - DREAM Instrument Hazard Analysis (IHA) ESS-5467337 - Motion Risk Analysis of Neutron Instruments ESS-3482344 - DREAM Table-of-Motion, sheet 3
Design	ESS-5513694 - System Block Diagram for DREAM Motion Control ESS-4230734 - DREAM Motion Control 1 ePlan ESS-4230737 - DREAM Motion Control 2 ePlan ESS-4230739 - DREAM Motion Control 3 ePlan ESS-5516369 - System Design Description - DREAM Motion Control System ESS-6020377 - Design Verification Calculation (SISTEMA) for DREAM Motion Safety
Installation	ESS-5594310 - Electrical inspection DREAM MC Cabinets ESS-6016375 - MCA Self-Inspection Report for DREAM Motion Control ESS-5513741 - Inspection and Test Report for DREAM Motion Control
Validation	ESS-6017650 - Motion Safety Validation Plan for DREAM ESS-6017649 - Motion Safety Validation Report for DREAM
Operation	ESS-5669198 - Operation Manual - MCU5001: 16Ax. Motion Control Cabinet ESS-5669200 - Operation Manual - MCU5003: Piezo Motion Control Cabinet ESS-5166392 - Motion Control Risk Assessment (RAMS)

DREAM Motion Safety

Applicable Directives and Standards

- EU Directive 2006/42/EC (European Machinery Directive)
- Replaced by: Regulation (EU) 2023/1230 of the European Parliament and of the Council of 14 June 2023 on machinery

- SS-EN ISO 12100 Safety of Machinery – General Principles for design – Risk Assessment and Risk Reduction
- SS-EN ISO 13849 Safety of Machinery – Safety Related Parts of the Control System (Parts 1 and 2)
- SS-EN ISO 13850 Safety of Machinery - Emergency stop function - Principles for design

- SS-EN EN 60204-1 Safety of Machinery – Electrical Equipment of Machines

- SS-EN 61800-5-2 Adjustable Speed Electrical Power Drive Systems Part 5-2: Safety Requirements - Functional


Thank You!
2025-12-18

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Additional Information

Safety Requirements Specification

Table-of-Motion, Sheet 3

Axis description

ConHaz ID

Risk assessment & Treatment for Operation

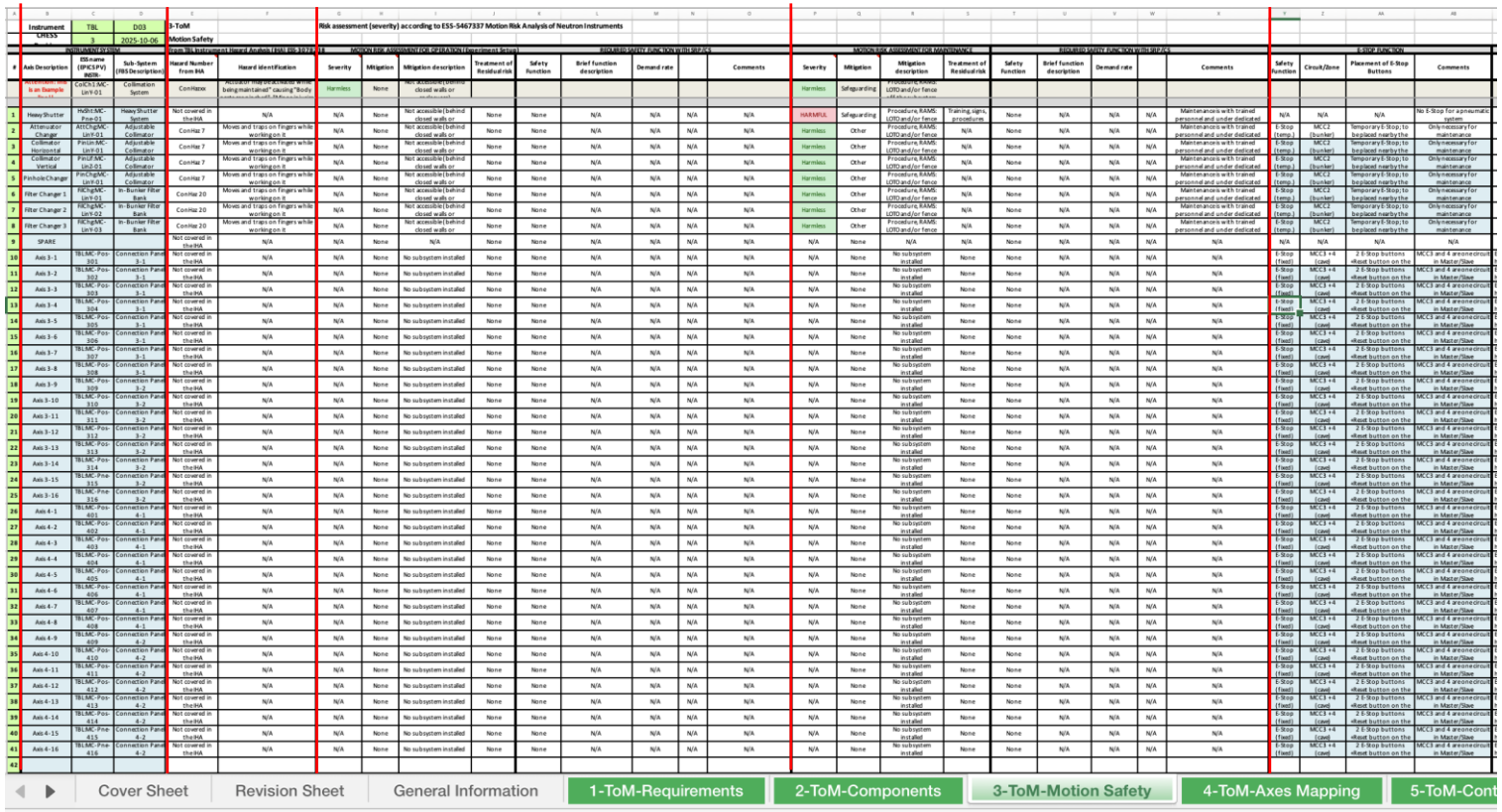
Risk assessment & Treatment for Maintenance

E-Stop

Bunker Area

Axes listing

Cave Area



Instrument	TBL	D03	3-ToM
DRESS	3	2025-10-06	Motion Safety

Risk assessment (severity) according to ESS-5467337 Motion Risk Analysis of Neutron Instruments

#	Axis Description	ESS-name (IPHICSV) INSTR-	Sub-System (YBS Description)	Hazard Number from RA	Hazard identification	Severity	Mitigation	Mitigation description	Treatment of Residual risk	Safety Function	Brief function description	Demand rate		Comments	Severity	Mitigation	Mitigation description	Treatment of Residual risk	Safety Function	Brief function description	Demand rate		Comments	Safety Function	Circuit/Zone	Placement of E-Stop Buttons	Comments
	Axis description	ESS-name (IPHICSV) INSTR-	Sub-System (YBS Description)	ConHazxx	Hazard identification	Harmless	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	HARMFUL	Safeguarding	Procedure, RAMS: LOTO and/or fence	Training, signs, procedure	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	N/A	N/A	N/A	No E-Stop for apneumatic system
1	HeavyShutter	HvShtrMC-Pre01	HeavyShutter System	Not covered in the HA	N/A	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
2	Attenuator Changer	AttChgMC-Lin01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
3	Collimator Horizontal	PosInMC-Lin01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
4	Collimator Vertical	PosZMC-Lin02-01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
5	PinholeChanger	PinChgMC-Lin01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
6	Filter Changer 1	FilChgMC-Lin01	In-Bunker Filter Bank	ConHaz 20	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
7	Filter Changer 2	FilChgMC-Lin02	In-Bunker Filter Bank	ConHaz 20	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
8	Filter Changer 3	FilChgMC-Lin03	In-Bunker Filter Bank	ConHaz 20	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure, RAMS: LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
9	SPARE			Not covered in the HA	N/A	N/A	None	N/A	None	None	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	Axis 3-1	TBLMC-Pos-301	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
11	Axis 3-2	TBLMC-Pos-302	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
12	Axis 3-3	TBLMC-Pos-303	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
13	Axis 3-4	TBLMC-Pos-304	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
14	Axis 3-5	TBLMC-Pos-305	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
15	Axis 3-6	TBLMC-Pos-306	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
16	Axis 3-7	TBLMC-Pos-307	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
17	Axis 3-8	TBLMC-Pos-308	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
18	Axis 3-9	TBLMC-Pos-309	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
19	Axis 3-10	TBLMC-Pos-310	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
20	Axis 3-11	TBLMC-Pos-311	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
21	Axis 3-12	TBLMC-Pos-312	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
22	Axis 3-13	TBLMC-Pos-313	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
23	Axis 3-14	TBLMC-Pos-314	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
24	Axis 3-15	TBLMC-Pos-315	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
25	Axis 3-16	TBLMC-Pos-316	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
26	Axis 4-1	TBLMC-Pos-401	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
27	Axis 4-2	TBLMC-Pos-402	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
28	Axis 4-3	TBLMC-Pos-403	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
29	Axis 4-4	TBLMC-Pos-404	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
30	Axis 4-5	TBLMC-Pos-405	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
31	Axis 4-6	TBLMC-Pos-406	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
32	Axis 4-7	TBLMC-Pos-407	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
33	Axis 4-8	TBLMC-Pos-408	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
34	Axis 4-9	TBLMC-Pos-409	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
35	Axis 4-10	TBLMC-Pos-410	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
36	Axis 4-11	TBLMC-Pos-411	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
37	Axis 4-12	TBLMC-Pos-412	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
38	Axis 4-13	TBLMC-Pos-413	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
39	Axis 4-14	TBLMC-Pos-414	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
40	Axis 4-15	TBLMC-Pos-415	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
41	Axis 4-16	TBLMC-Pos-416	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
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Cover Sheet | Revision Sheet | General Information | 1-ToM-Requirements | 2-ToM-Components | 3-ToM-Motion Safety | 4-ToM-Axes Mapping | 5-ToM-Cont

Safety Requirements Specification

Evaluation

Mitigation	Mitigation description
None	Not accessible (behind closed walls or enclosures)

Severity	Mitigation	Mitigation description	Treatment of Residual risk
HARMFUL	Safeguarding	Procedure, RAMS: LOTO and/or fence off	Training, signs, procedures
Harmless	Other	Procedure, RAMS: LOTO and/or fence off	N/A

ConHaz 7 + 20

Operation

Maintenance

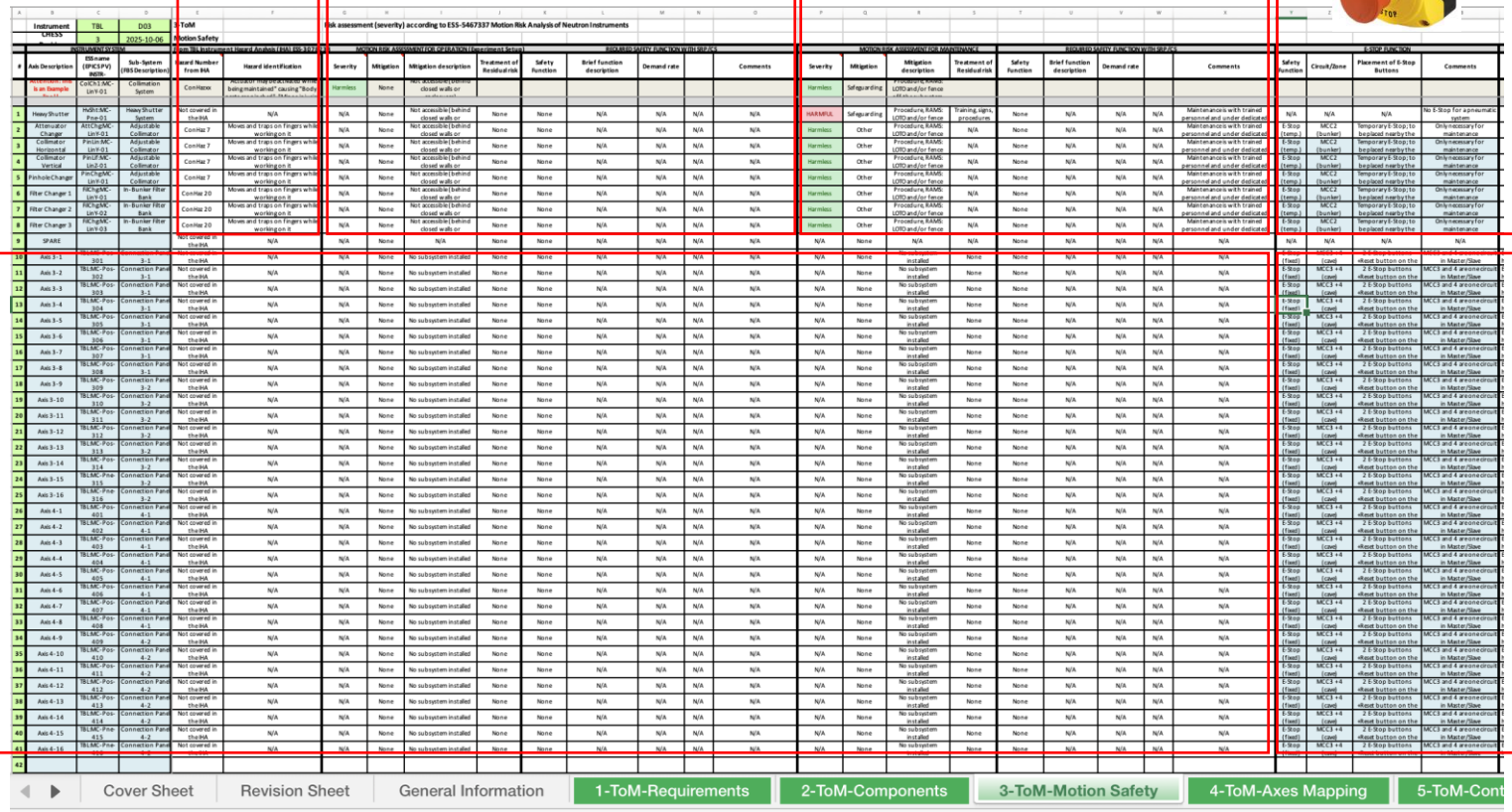
Circuit/Zone	Placement of E-Stop Buttons
MCC2 (bunker)	Temporary E-Stop; to be placed nearby the motion

Bunker Area

Mitigation	Mitigation description
None	No subsystem installed

Cave Area

Circuit/Zone	Placement of E-Stop Buttons
MCC3 + 4 (cave)	2 E-Stop buttons +Reset button on the cave table

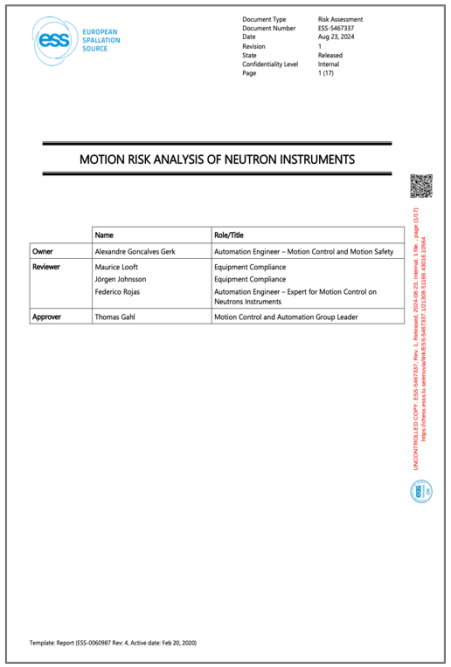


Risk Analysis & Treatment

ESS-5467337 - Motion Risk Analysis of Neutron Instruments

- Limits of System
  1. Area: Motion Safety focusses on areas accessible to instrument users (typically in the cave).
  2. Life phases: Experiment Setup & Local Maintenance considered.

Life phases	Cave (User Access, controlled by PSS)	Cave (Service & Maintenance Access, controlled by PSS)	Beam Line, Bunker (Service & Maintenance Access, controlled by procedures)
TBL Areas	TBL Cave	TBL Cave	TBL In-bunker area
Installation, commissioning and testing	excluded	excluded	excluded
Experiment Run	no risks	no risks	no risks
Experiment Setup	included	N/A (no access)	N/A (no access)
Local maintenance	included	included	excluded
External maintenance (in workshop)	excluded	excluded	excluded


MOTION RISK ANALYSIS OF NEUTRON INSTRUMENTS

ESS-5467337

Risk Analysis & Treatment

ESS-5467337 - Motion Risk Analysis of Neutron Instruments

- Simplified approach for hazard analysis and mitigation.
  1. Motion Safety focusses on areas accessible to instrument users (typically in the cave).
  2. Only two levels defined following the severity path; required Performance Levels a/b and c/d.

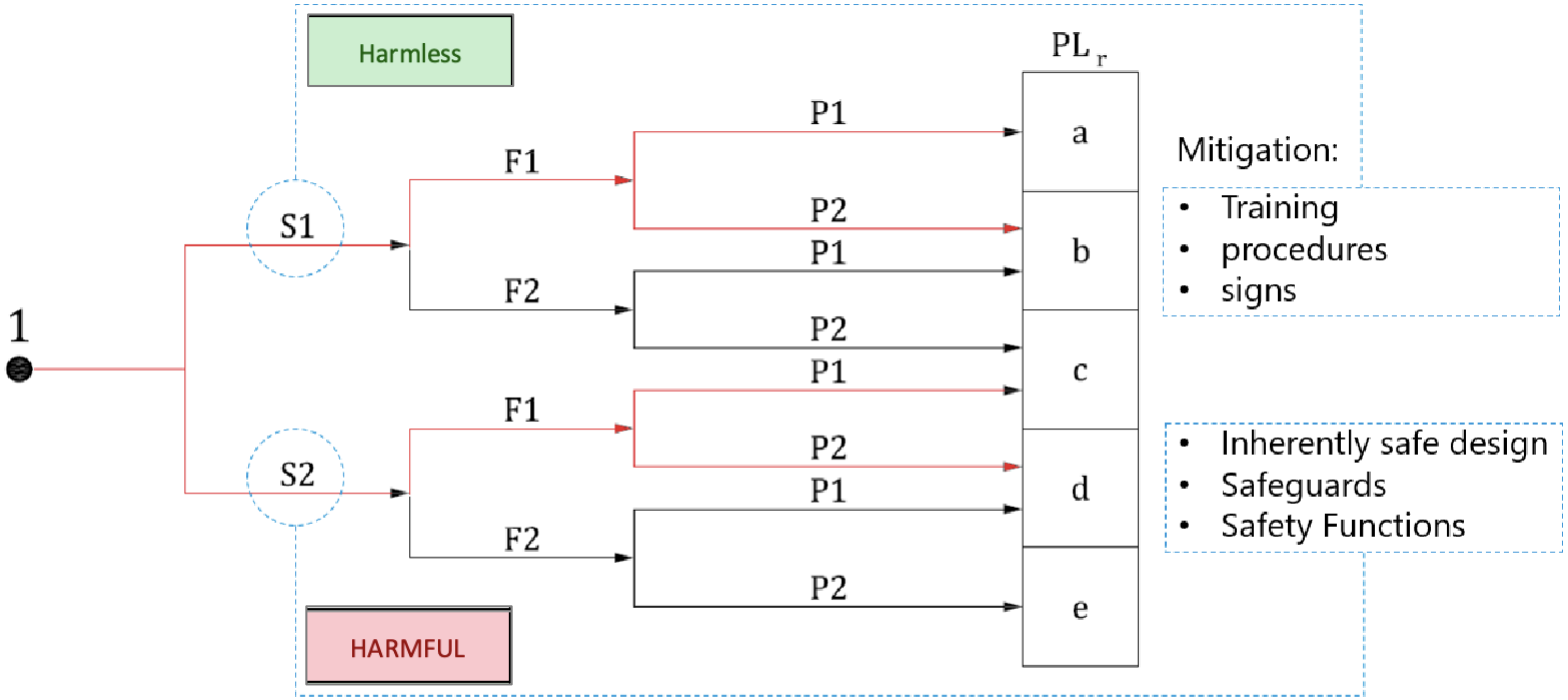
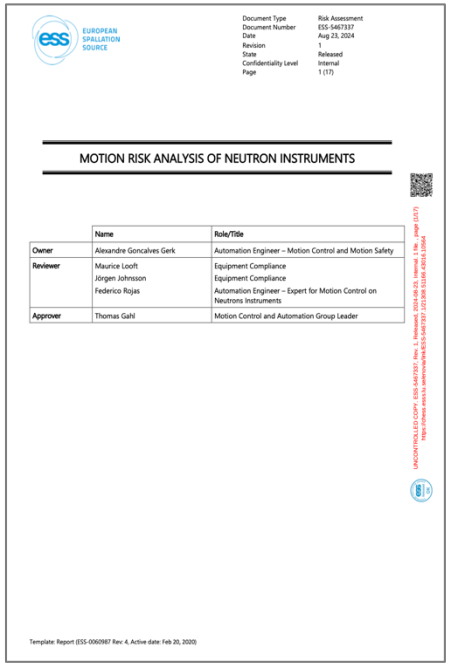


Figure 8 - Risk evaluation



ESS-5467337

E-Stop Design

Design Principle

- Modularity: Define different areas; match the area with the respective control cabinets; this includes standardised circuits in the cabinet and and a Master/Slave hierarchy between (if applicable).
- Scalability: A scalable number of fixed installed E-Stop buttons + one Reset button in the areas accessible to normal users (i.e. the cave).
- Performance Level d as a matter of principle.

- Currently Stop Category 0 (STO); design work is ongoing for Stop Category 1 (SS1).

EN 60204-1	**EN 61800-5-2**
Stop category 0	Safe torque off (STO)
Stop category 1	Safe stop 1 (SS1)
Stop category 2	Safe stop 2 (SS2)

Design Verification

SISTEMA calculation

The SISTEMA analysis for the Motion Safety – E-Stop Circuit has been successfully completed according to EN ISO 13849-1:2023 and ISO 13850:2015.

- The required Performance Level determined by the risk graph was PLd, with a calculated PFH = 1.45E-7 [1/h]; PLd was achieved.
- All subsystems (Pilz E-Stop Boxes, Pilz PNOZ relay, and Siemens SIRIUS contactor relays) demonstrated compliance with relevant requirements for Category 3 or 4 architectures, with high MTTFD values, diagnostic coverage ≥ 90%, and fulfilled Common Cause Failure (CCF) measures.
- No warnings or non-conformities were reported in SISTEMA's evaluation.
- Design of the Motion Safety E-Stop function meets the required safety integrity level.