



RFD-SPS Cryomodule: QA Lessons Learnt & Future Challenges.

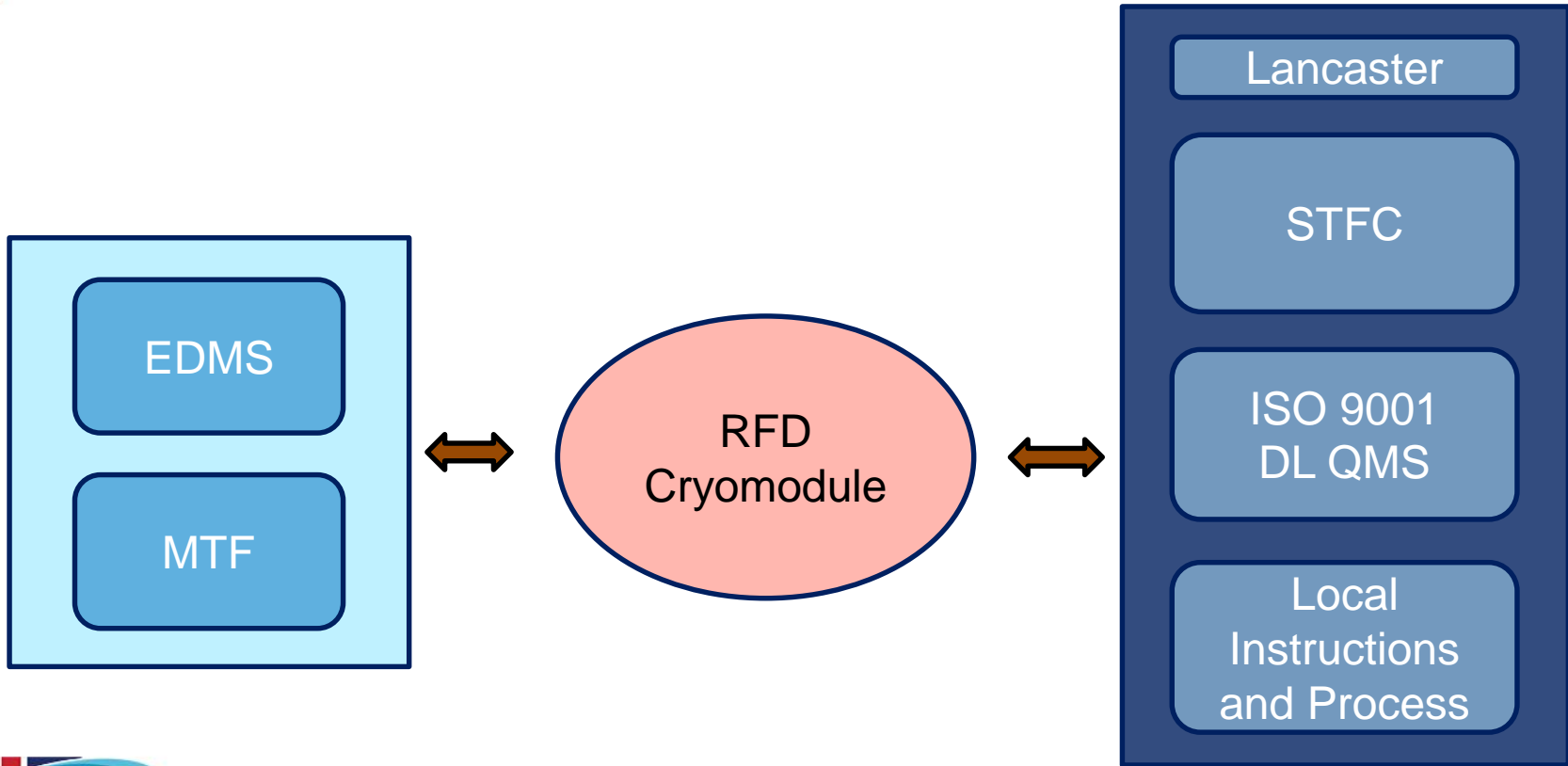
Carlos Granjeiro – on behalf of UK contribution to WP4

14th HL-LHC Collaboration Meeting – Genoa – 9th of October 2024

Contents

- RFD QA Evolution
- RFD QA Lessons
- Future QA Challenges

QA Scope

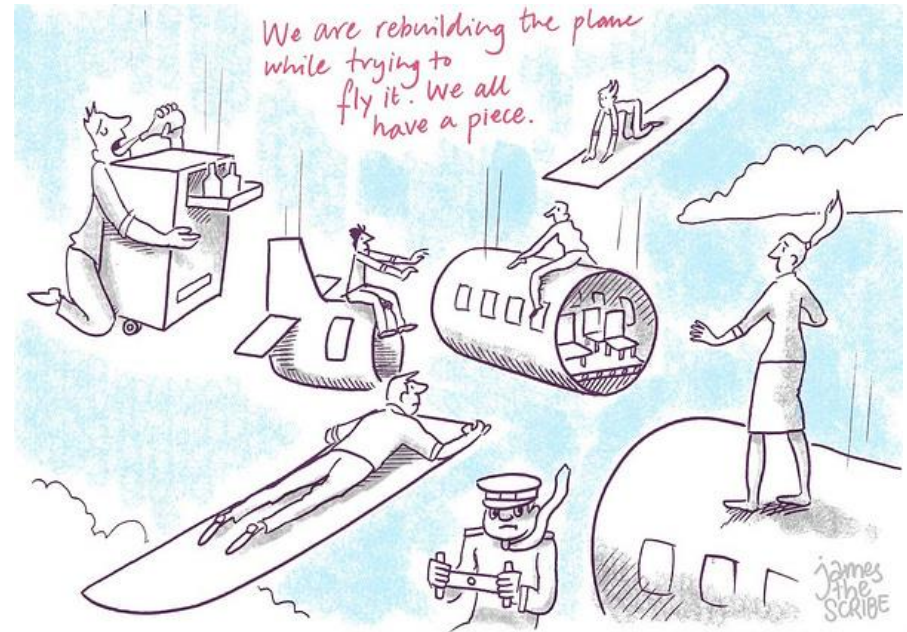


Early Days (Proto)

- The transition from prototype development to prototype production was a gradual learning process.
 - Informality in discussions and changes allowed for quick and fluid development but not without problems.
 - We evolved to a standardize way of working keeping the benefits of the early approach and combining the rigor of QA process.

How did it Look Building the RFD Cryomodule

- It was like flying a plane, while building it, while designing it, while improving it, while fixing it!



RFD QA in Numbers

TITLE	LINK	Status	AUTHOR	ORGANIZATION	SERVER (STFC)
NCR - Blade Support Assembly	https://edms.cern.ch/document/2659834/	Closed	Niklas Templeton	STFC	0001
NCR - Blade Support Bellows Materials	https://edms.cern.ch/document/2710303/	Closed	Niklas Templeton	STFC	0002
NCR - WMS Pre-Heat Treatment Dimensional Control	https://edms.cern.ch/document/2710335/	Closed	Niklas Templeton	STFC	0003
NCR - Cavity Support Assy Material	https://edms.cern.ch/document/2739632/	Closed	Niklas Templeton	STFC	0004
Material NCR - LHCAFQC0304 - BI-PHASE SUPPORT EQUIPED	https://edms.cern.ch/document/2771998/	Closed with Warnings	Niklas Templeton	STFC	0005
NCR RFD WMS Panel Flange Non-Perpendicularity	https://edms.cern.ch/document/2757314/	Closed	Niklas Templeton	STFC	0006
NCR - CWT Bellows Damage - Secondary Line Leak Test	https://edms.cern.ch/document/2794443/	Closed with Warnings	Niklas Templeton	STFC	0007
Inspection after transport to UK - HCACTS004-CR000001	https://edms.cern.ch/document/2802202/	Closed	Carlos Granjeiro	STFC	0009
Cavity String Stripped Threads	https://edms.cern.ch/document/2800829/	Closed	Carlos Granjeiro	STFC	0011
NCR - LHCAFQC0244 - BI-PHASE BOX 2	https://edms.cern.ch/document/2813970/	Closed	Andy May	STFC	0022
NCR - Bi Phase Bellows Pressure Test at DL	https://edms.cern.ch/document/2825542/	Closed with Warnings	Shrikant Pattalwar	STFC	0023
NCR - LHCAFQC0212 - Level probe bellows on Upper Cryoline	https://edms.cern.ch/document/2838948/	Closed	Andy May	STFC	0024
NCR - LHCAFQC0238 - BLANK EXTREMITY COLLARS	https://edms.cern.ch/document/2838931/	Closed	Andy May	STFC	0026
NCR - LHCAFQC0298 Tube end	https://edms.cern.ch/document/2839306/	Closed	Andy May	STFC	0027
Extremity Chamber M3 Threaded Holes	https://edms.cern.ch/document/2729803/	Closed	Carlos Granjeiro	STFC	0029
NCR Summary - Bi Phase Line acceptance at Daresbury	https://edms.cern.ch/document/2884804/3	Closed	Niklas Templeton	STFC	0030
NCR - LHCAFQC0237 and LHCAFQC0239 - Cyo Bellows Material	https://edms.cern.ch/document/2804858/	Closed	Andy May	STFC	0032
NCR - Mating between upper cryoline LHCAFQC and HOM bellows LHC	https://edms.cern.ch/document/2898853/2	Closed with Warnings	Andy May	STFC	0033
NCR - LHCAFQC0239 - Out of geometrical tolerance, incorrect number	https://edms.cern.ch/document/2907031/	Closed	Andy May	STFC	0035
NCR Weld HL-UK-014	https://edms.cern.ch/document/2908372/2	Closed	Carlos Granjeiro	STFC	0036
4-20K Cooling Line Tube End damaged	https://edms.cern.ch/document/2914462/	Closed	Carlos Granjeiro	STFC	0037
NCR - Cavity Support System Re-work - Galling	https://edms.cern.ch/document/3093588/	Closed	Carlos Granjeiro	STFC	0040
NCR - FPC & Cavity Support Plate Integration	https://edms.cern.ch/document/2953719/	Closed	Carlos Granjeiro	STFC	0041
Lower Coax Clash	https://edms.cern.ch/document/3093587/	Closed	Carlos Granjeiro	STFC	0044
NCR - Seam-welded tubes in LHCAFQC0212 and 0488	https://edms.cern.ch/document/2965347/	Closed	Andy May	STFC	0045
NCR - Blow-off Valve	https://edms.cern.ch/document/2966438/	Closed	Niklas Templeton	STFC	0046
RFD Short CW Transition LHCBMCC0033 Dent	https://edms.cern.ch/document/2719008/	Closed	Carlos Granjeiro	STFC	No Number
NCR-Welding lips reduction	https://edms.cern.ch/document/2512846/	Closed	Joel Bedolla	LANCASTER	N/A
NC CF flanges material	https://edms.cern.ch/document/2603819/	Closed	Joel Bedolla	LANCASTER	N/A
NC dimensional control	https://edms.cern.ch/document/2613253/	Closed	Joel Bedolla	LANCASTER	N/A
NC screws A4-100	https://edms.cern.ch/document/2671163/	Closed	Joel Bedolla	LANCASTER	N/A

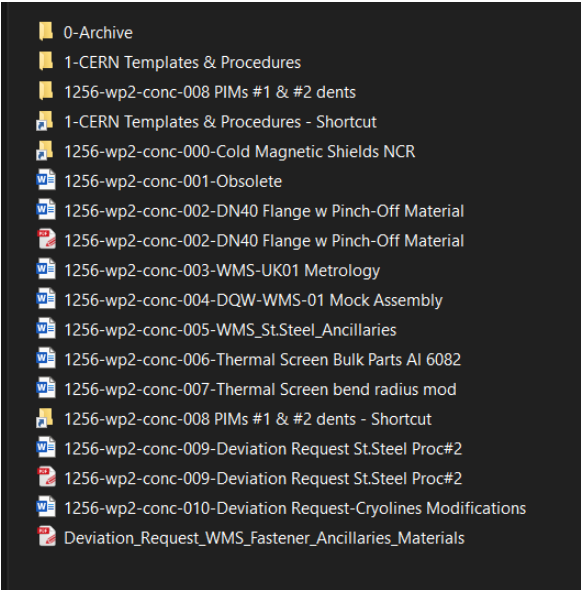
■ Totals (UK only):

58 EDMS Documents

31 NCR's

3 Deviation Requests

DQW QA: Deviation Requests vs NCR's



- 0-Archive
- 1-CERN Templates & Procedures
- 1256-wp2-conc-008 PIMs #1 & #2 dents
- 1-CERN Templates & Procedures - Shortcut
- 1256-wp2-conc-000-Cold Magnetic Shields NCR
- 1256-wp2-conc-001-Obsolete
- 1256-wp2-conc-002-DN40 Flange w Pinch-Off Material
- 1256-wp2-conc-002-DN40 Flange w Pinch-Off Material
- 1256-wp2-conc-003-WMS-UK01 Metrology
- 1256-wp2-conc-004-DQW-WMS-01 Mock Assembly
- 1256-wp2-conc-005-WMS_St.Steel_Ancillaries
- 1256-wp2-conc-006-Thermal Screen Bulk Parts Al 6082
- 1256-wp2-conc-007-Thermal Screen bend radius mod
- 1256-wp2-conc-008 PIMs #1 & #2 dents - Shortcut
- 1256-wp2-conc-009-Deviation Request St.Steel Proc#2
- 1256-wp2-conc-009-Deviation Request St.Steel Proc#2
- 1256-wp2-conc-010-Deviation Request-Cryolines Modifications
- Deviation_Request_WMS_Fastener_Ancillaries_Materials

■ 2 NCR's (minor)

- 1.Warm Magnetic Shield Dimension Control Pre-Heat Treatment
- 2.Warm Magnetic Shield Mock Assembly (Misalignment)

■ 5 Deviation Requests

1. Warm Magnetic Shield Fastener Ancillaries Materials
2. Thermal Screen Aluminium Grade
3. Thermal Screen Stiffener' s Bend Radius
4. St.Steel material grades for UK non-cryoline parts
5. Cryolines Modifications

Managing NCR's

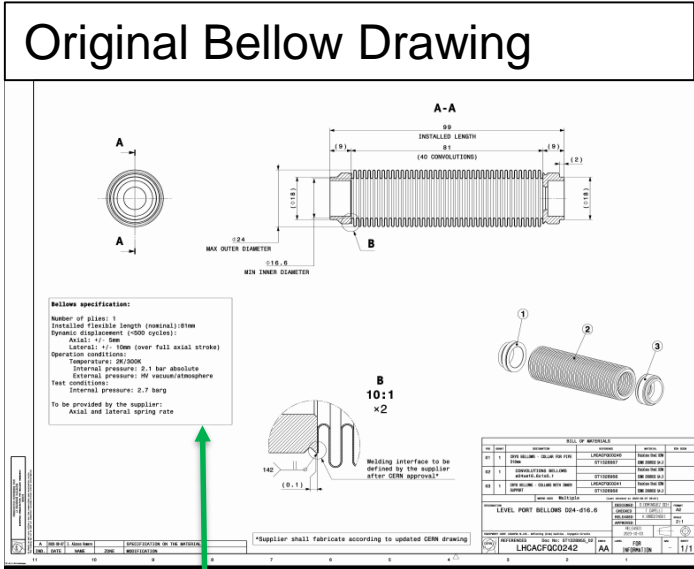
- Defining process owners
 - Initially there was some grey areas
- Developing the 2 route approach
 - (Informal Route) email for quick trouble shoot
 - (Formal Route) EDMS for capturing the actions

Notable NCR's

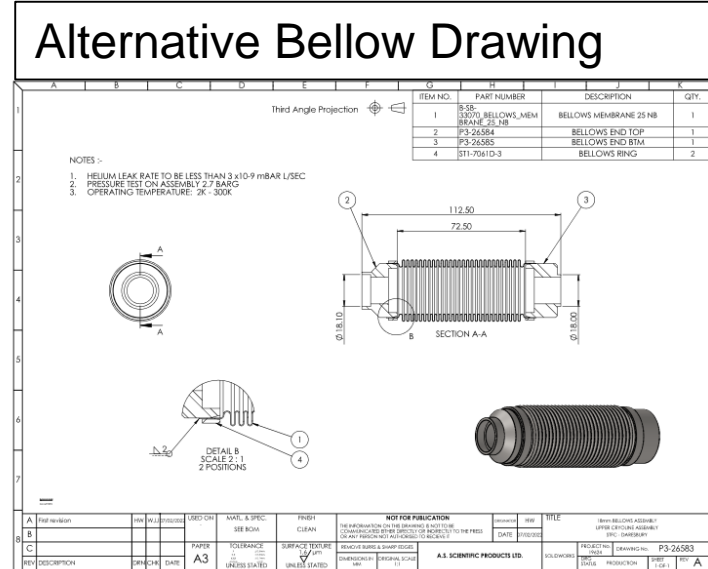
- Case Study: (2 ply bellows cryolines)
 - STFC Supplier could not source the bellows specified.
 - Deviation was asked for a stock bellows with machining of collars to match interfaces.
 - The proposed bellows were shown by the supplied drawing to be of similar (although not identical) size and construction and equivalent material specification.
 - Supplier failed to highlight 2 ply construction when submitting the request

Notable NCR's

Original Bellow Drawing

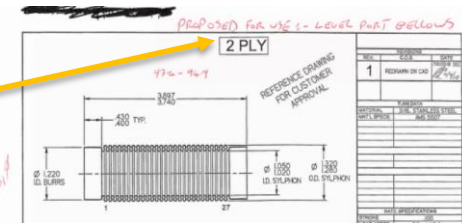


Alternative Bellow Drawing



Belongs specification:
 Number of plies: 1

"Buried" inside Material Certificates



Notable NCR's



Suppliers QA

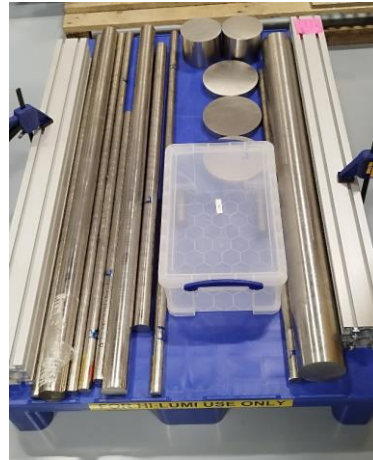
- Issues With Suppliers
 - Ignoring QA and requirements.
 - Lack of communication and engagement.
 - Risk aversion (tender and procurement)

Suppliers QA / Procurement Strategy

- Mitigation measures
 - Kick-start meetings and regular updates
 - RAW materials Sourcing (Plate, Bar and Tube)
 - Free issued Machined Subcomponents
 - Detailed Engineering Procurement specs
 - More QA effort (shared by the team) and oversight
 - Market survey to identify potential suppliers

Raw Materials

- STFC Sourced



- CERN Supplied



Free Issuing Subcomponents

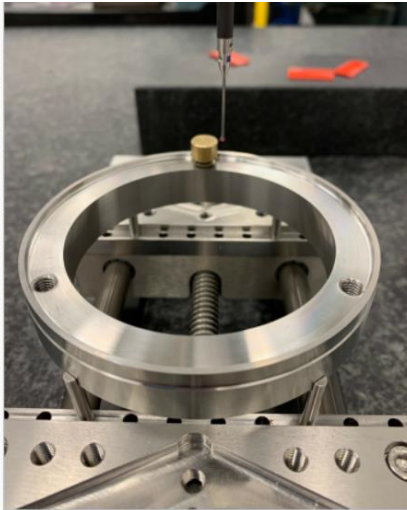
- Cryolines Subcomponents



Extensive Metrology Efforts

- STFC Manufactured

- STFC Outsourced



CMM Dimensional Metrology Report						
Drawing No: LHCACFC02288 v.03		Date: September 27, 2024	Part Name: Top Flange for Cryo Support D63			
CMM No: 480014		Time: 10:18:34 AM	Incremental Part Number: 1.27-09-24			
					Exceed Tol.	
	Actual	Nominal	Upper Tol.	Lower Tol.	Deviation	
	Flatness_Datum_A	0.0080	0.0000	0.2000	┆ 0.0080	
Feature Diameters						
	Diameter_Ø30mm	79.9893	80.0000	0.3000	-0.3000	┆ -0.0017
	Diameter_Ø100mm	99.9637	100.0000	0.1000	-0.1000	┆ -0.0363
	Diameter_Ø103mm	103.0342	103.0000	0.1000	-0.1000	┆ 0.0342
1.5mm Lip						
	1.5mm Lip Distance_X	1.5521	1.5000	0.1000	-0.1000	┆ 0.0521
	1.5mm Lip Distance_Y	1.5417	1.5000	0.1000	-0.1000	┆ 0.0417
3x M6 Threads						
Position Tolerance is only to Datum A which controls perpendicularity only. Best TEEs on 92.5 and 120° suggest location is required too so added Ø103mm for control						

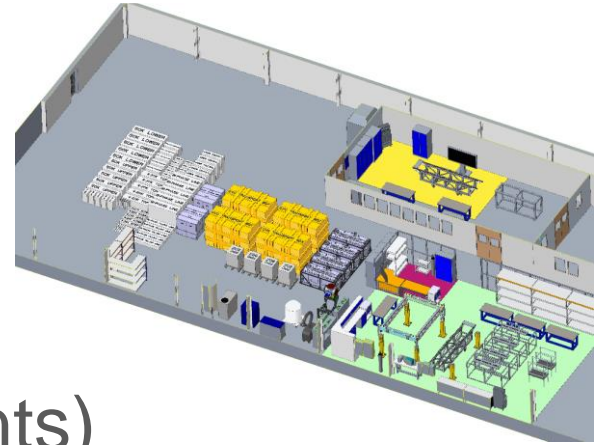
Inspection Report Metrosoft QUARTIS®							Beechwood Engineering	
Description: GRIFFE_F_Ø10-1MM							Beechwood Engineering Ltd	
Drawing Number: LHCACFC0222							Cocker Avenue	
WO: WO38688							Poulton Business Park	
Measurement ID: 2							Poulton-Le-Flyde	
Date/Time: 16.09.2024 10:59:57							Lancashire	
Machine: XD 87							PR8 8JU	
							Tel: 01253 893663	
ID	Element type	Reference	Probe points	Range				
ID	Feature type		Eff. length	Description				
	Nominal value	ISO 286	UTol	LTol	Actual value	Dev	%Dev	Graphics
PLN_2	Plane, Leastsquares, measured		271	0.002				
1	Position [z]			DATUM_A				
z	0.000		0.000	0.000				
2	Flatness			DATUM_A				
	0.000	0.200	0.002	0.002	1%			
CYL_1	Cylinder, Leastsquares, outside, measu		2518	0.011				
3	Position [x,y]			DATUM_B				
x	0.000		0.000	-0.000				
y	0.000		0.000	0.000				
4	Diameter Ø, outside			DATUM_B				
Ø	10.000	0.100	-0.100	10.019	0.019	19%		
CYL_1	Cylinder, Leastsquares, outside, measu		2518	0.011				
PLN_2	Plane, Leastsquares, measured		271	0.002				
5	Perpendicularity tolerance			DATUM_BA				
	0.100		0.005	-0.005	5%			
CYL_4	Cylinder, Leastsquares, outside, Linkage		2136	0.008				
6	Diameter Ø, outside			Ø34				
Ø	34.000	0.300	-0.300	34.003	0.003	1%		
PLN_4	Plane, Leastsquares, measured		4	0.001				
7	Positions tolerance [z]			21.561	27_FACE_TO_A			
x	0.000	0.100	0.079	0.079	79%			
y	-8.735		—	—				
z	27.000		27.039					

QA Issues and Mitigation Measures

- Previous Experience Showed that QA usually was lagging behind actual manufacturing/assembly.
- Lack of clarity regarding Area/Expertise owner
 - Creation of a responsible engineers list (similar to what CERN done)
- MTF Workflows were either too light or too detailed for usefulness
- Created a dedicated periodic meeting for UK actions involving QA.
 - EDMS document Status/Actions
 - MTF Status/Actions

Future Challenges: Assests Management

- Series Production
- Traceability
- Inventory
- Inspections (Quality Control points)



Inventory System

Inventory ↻ ↑ +

🔍 Search items

- 44
253-11449
LONG CWT CL IN TOOLING ASSEMBLY
T2 >
- 47
253-11473
BOTTOM CLAMP SUPPORT PEICE 2
MAGLAB >
- 48
253-11479
CLAMP SUPPORT PIECE 2
MAGLAB >
- 49
253-11415
SHORT CWT CANTILEVER SUPPORT ASSEMBLY
T2 >
- 50
253-11445
CWT FLANGE HANDING ASSEMBLY
T2 >
- 51
253-11481
CLAMP SUPPORT PIECE 2
T1 >
- 52
253-11482
CLAMP SUPPORT PIECE 2
T1 >

🔍

Inventory

Quantity

Part Lookup
4

Part Lookup:ST Number
ST1572401

Part Lookup:CERN Number
LHCACF_A0049

Part Lookup:DL Number
300-10081-00004

← →

Inventory

Metrology

Yes
 No

Metrology Image

Tap or click to add a picture

Inventory

Does the package pass visual inspection?

True
 False

Attach photo

Inventory

The item has failed the incoming acceptance tests.
Please place in Quarantine and contact the QA team.

Location
Quarantine

Inventory

Part Lookup:Magnetic Lookup
0

Magnetic
 Yes
 No

Magnetic Image

Tap or click to add a picture

Inventory

Part Lookup:Magnetic Lookup
0

Magnetic
 Yes
 No

Magnetic Image

Tap or click to add a picture

Find items

- N/A
- IV
- UHV
- V-LAB PROCESSED

Inventory

ID
44

Module

TOOLING X

TOOLING

- 2 (PURPLE)
- 3 (BROWN)
- 4 (BLUE)
- 5 (PINK)

TOOLING

MULTI-MODULE

Part Lookup:DL Number
253-11449

Part Lookup:ISO Number

Inventory System

HL LHC UK2 Inventory
Inventory ☆ ⓘ








Part Lookup Part Lookup:DL Number Part Lookup:CERN Number Part L... Part Lookup:Description Locati... BOX NUM... Module Step Assembly... Incoming

Part ID	DL Number	CERN Number	Description	Location	Box Num	Module	Step	Assembly	Incoming
4.692	253-11351		VALVE PLATE BASE SUPPORT	Installed On ...		TOOLING	AUXILIARY	300-10540	✓
4.692	253-11351		VALVE PLATE BASE SUPPORT	Installed On ...		TOOLING	AUXILIARY	300-10540	✓
4.717	253-11117		TOP PLATE CARRIAGE	T2	N/A	TOOLING	AUXILIARY		✓
3.882	300-10081-03882	LHCACFAH0043	ADJUSTMENT TIE ROD M20x1	OUTGOING	62	MULTI-MODULE	STEP 6		✓
3.882	300-10081-03882	LHCACFAH0043	ADJUSTMENT TIE ROD M20x1	OUTGOING	62	MULTI-MODULE	STEP 6		✓
3.882	300-10081-03882	LHCACFAH0043	ADJUSTMENT TIE ROD M20x1	OUTGOING	62	MULTI-MODULE	STEP 6		✓
3.882	300-10081-03882	LHCACFAH0043	ADJUSTMENT TIE ROD M20x1	OUTGOING	62	MULTI-MODULE	STEP 6		✓
3.882	300-10081-03882	LHCACFAH0043	ADJUSTMENT TIE ROD M20x1	OUTGOING	62	MULTI-MODULE	STEP 6		✓
3.882	300-10081-03882	LHCACFAH0043	ADJUSTMENT TIE ROD M20x1	OUTGOING	62	MULTI-MODULE	STEP 6		✓
4.718		LHCACFQC0451	COPPER BRAID 30x110	ML1	27	MULTI-MODULE	STEP 4		✓
4.718		LHCACFQC0451	COPPER BRAID 30x110	ML1	27	MULTI-MODULE	STEP 4		✓
4.718		LHCACFQC0451	COPPER BRAID 30x110	ML1	27	MULTI-MODULE	STEP 4		✓

Inventory System

HL LHC UK2 Inventory
Inventory ☆ ☆

Part Lookup Part Lookup:DL Number Part Lookup:CERN Number Part L... Part Lookup:Description Locati... BOX NUM... Module Step Assembly... Incoming... Incoming... Clean

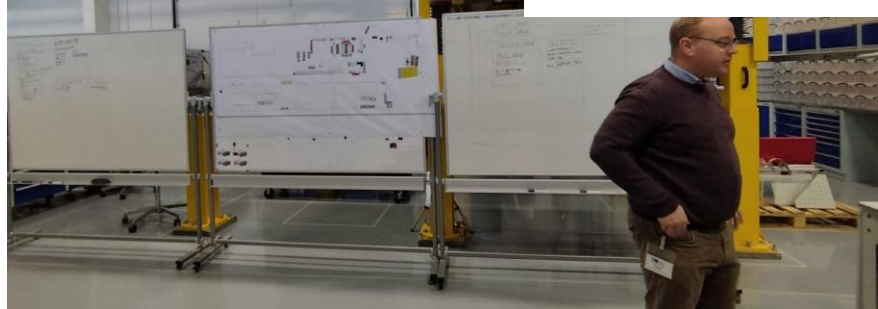
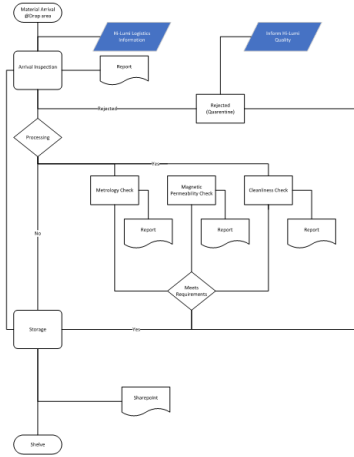
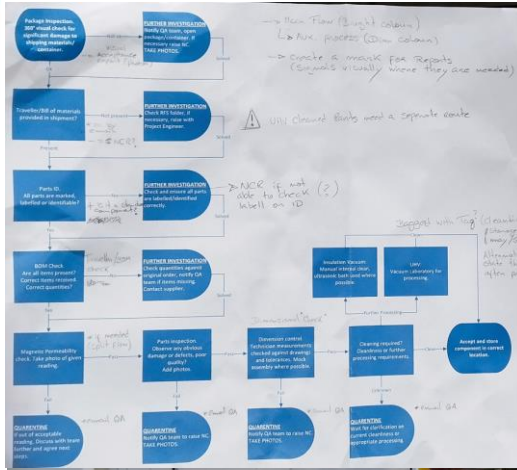
Part Lookup	Part Lookup:DL Number	Part Lookup:CERN Number	Part L...	Part Lookup:Description	Locati...	BOX NUM...	Module	Step	Assembly...	Incoming...	Incoming...	Clean
3.672	300-10081-03672	LHCACFQC0283		Jumper flange for cooling pipe DN15	OUTGOING	63	MULTI-MODULE	STEP 3				
<input type="radio"/> 3.672	300-10081-03672	LHCACFQC0283		Jumper flange for cooling pipe DN15	OUTGOING	63	MULTI-MODULE	STEP 3			V-LAB PROCESS	
3.672	300-10081-03672	LHCACFQC0283		Jumper flange for cooling pipe DN15	OUTGOING	63	MULTI-MODULE	STEP 3			V-LAB PROCESS	
3.672	300-10081-03672	LHCACFQC0283		Jumper flange for cooling pipe DN15	OUTGOING	63	MULTI-MODULE	STEP 3			V-LAB PROCESS	
3.672	300-10081-03672	LHCACFQC0283		Jumper flange for cooling pipe DN15	OUTGOING	63	MULTI-MODULE	STEP 3			V-LAB PROCESS	
4.069	300-10081-04069	LHCACFQC0262		Bellows restraints - Mobile ring	OUTGOING	63	MULTI-MODULE	STEP 3			V-LAB PROCESS	
4.069	300-10081-04069	LHCACFQC0262		Bellows restraints - Mobile ring	OUTGOING	63	MULTI-MODULE	STEP 3			V-LAB PROCESS	

Future (Current) Challenges : Workforce

- Workflows
- Processes
- Local Instructions



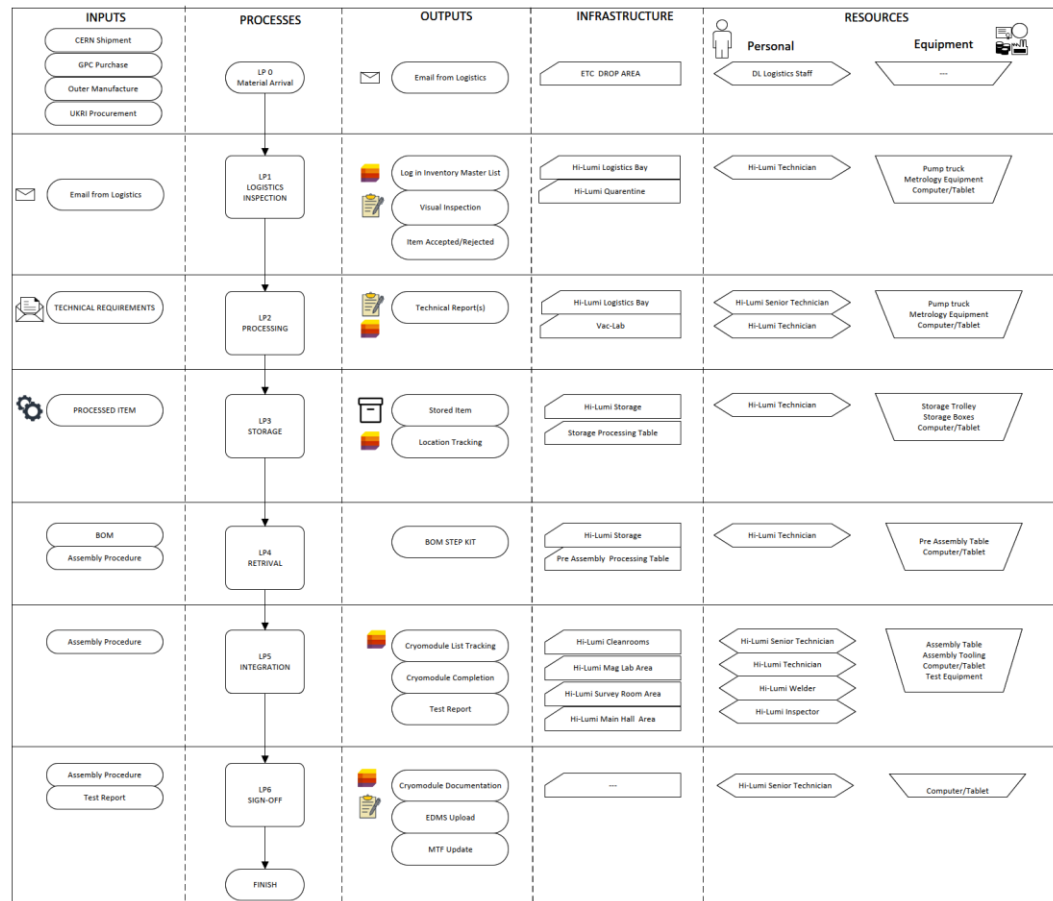
Process Mapping



Process Mapping

Logistics Processes:

- Material Arrival
- Arrival Inspection
- Processing
- Storage
- Retrieval
- Integration
- Sign-Off



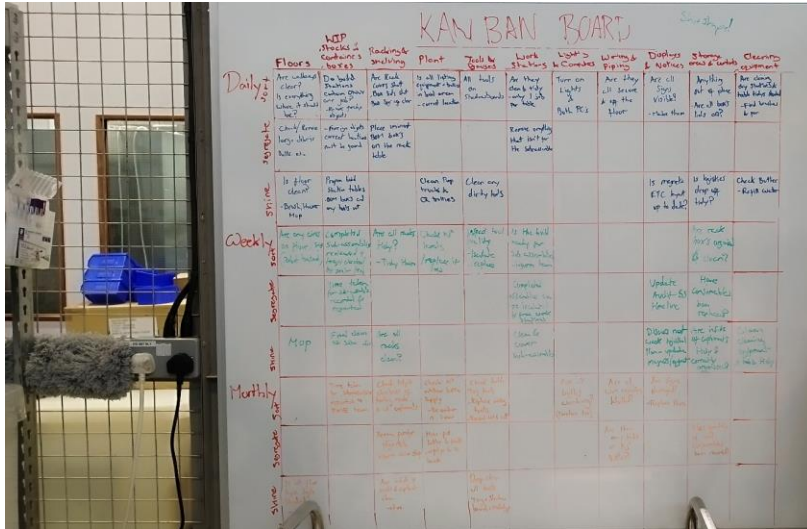
Future Challenges : Infrastructure

- 5S Build Space
- Equipment
- Storage Locations
- Outgoing Components Management



5S Methods

- Kanban Boards



5S Methods

- From Uncontrolled Chaos



- To Controlled Chaos



5S Methods

■ Color Coding

#2 DQW
Code Name: Hermit
CPM17



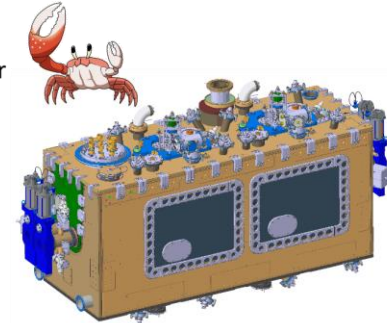
Violet



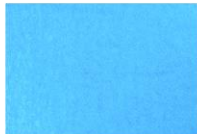
#3 DQW
Code Name: Fiddler
CPM09



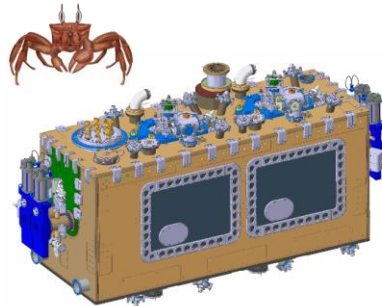
Brown



#4 DQW
Code Name: Ghost
CPM18



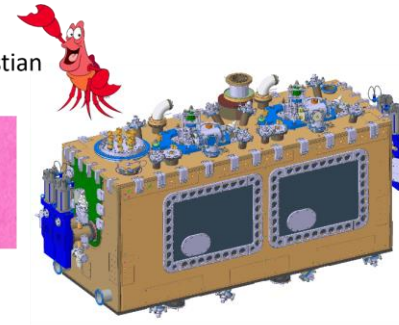
Blue



#5 DQW
Code Name: Sebastian
CPM23

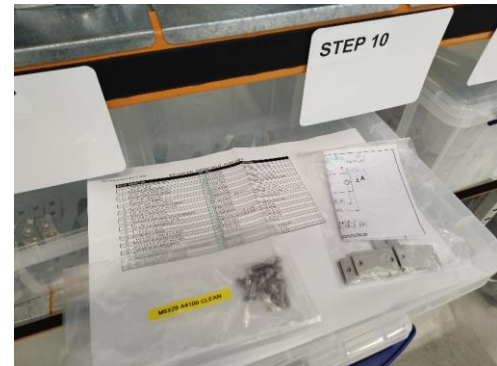


Pink



5S Methods

- Storage



The End... for now!

Questions?

HI-LUMI INVENTORY SYSTEM (Draft v 0.1)

