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# HL-LHC-UK PhD & Graduate Showcase

Supporting Project & Mechanical Engineers at STFC with Digital Tools / Howard Cheng

# Agenda

**1 Introduction**

Working as a CAD & IT Engineer

**2 HL-LHC-UK Involvement**

Building an Online Inventory System

**3 Future Plans**

Custom Web App


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# Brief History

2017-2021 – BEng in Materials Science & Engineering from University of Sheffield

2019-2021 – Volunteer at iForge Makerspace

2019 – Summer research placement at Insigneo Institute for in Silico Medicine

2020 – Summer placement at Committee on Radioactive Waste Management

2022 – Graduate CAD & IT Engineer at STFC TD-TDL-PME

2024 – Graduate CAD & CAE Systems placement at Diamond Light Source

2024 – Graduate Materials Engineer placement at STFC RAL BID

2024 – CAD & IT Engineer at STFC TD-TDL-PME

# TD-TDL-PME Group

## Projects & Mechanical Engineering Group at Daresbury Laboratory

"…team of **technical Project Managers and Mechanical Engineers**, experienced in delivering multimillion-pound international **projects that enable world-class science and technological innovation**."

"With decades of experience supporting the global science community in the design and delivery of **particle accelerators and bespoke scientific instrumentation,** we specialise in facility design, high-precision design, UHV, lasers, RF, cryogenic systems, system integration, handling equipment, and transportation."

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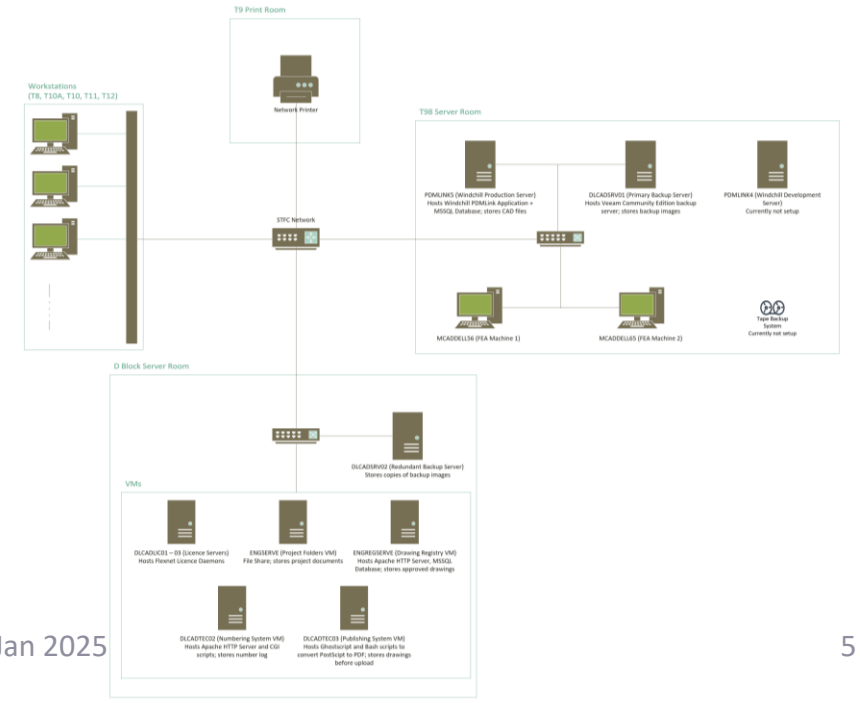
# CAD & IT Engineer

## Enable the engineering that enables the world-class science

Manage and maintain the CAD & IT systems used by the PME group

- CAD: **Creo**, Solid Edge, AutoCAD
- PLM: **Windchill**
- FEA: Ansys
- Backup & Recovery: Veeam
- Internal Tools: Numbering System, Publishing System, Drawing Registry

Note: Procurement for Solid Edge, AutoCAD, and Ansys is mainly managed by other groups/departments



# Continuous Improvement

- Work with software vendor to migrate and upgrade Windchill PDMLink server
- Establish robust Backup & Recovery processes
- Benchmark and procure computer hardware
- Explore VR/AR/Animation tools
- Streamline and automate workflows (publishing, library parts)

| | | Machine1 | Machine2 | | |
|---|---|---|---|---|---|
| | Name | MCADDELL68 | DDTEC0123 | | |
| | Make | Dell | Dell | | |
| | Model | Precision 5820 | Precision 5820 | | |
| | Processor | Xeon W-2235 | Xeon W-2235 | | |
| | RAM | 64 GB | 64 GB | | |
| | Graphics | NVIDIA Quadro P2000 | NVIDIA Quadro T1000 | | |
| | Operating System | Windows 10 | Windows 10 | | |
| | Version | Creo 9.0.6.0 | Creo 9.0.6.0 | | |
| | Test | Result1 | Result2 | Diff Abs | Diff % |
| 1 | Retrieve assembly 1 (CP) | 52 | 53 | 1 | 1.92% |
| 2 | Retrieve assembly 2 (CP) | 52 | 54 | 2 | 3.85% |
| 3 | Retrieve assembly 3 (CP) | 53 | 53 | 0 | 0.00% |
| 4 | Retrieve assembly 4 (CP) | 53 | 54 | 1 | 1.89% |
| 5 | Retrieve assembly 5 (CP) | 56 | 54 | -2 | -3.57% |
| 6 | Retrieve large assembly (GR) | 2 | 2 | 0 | 0.00% |
| 7 | 20 exploded views (GR) | 20 | 20 | 0 | 0.00% |
| 8 | 300 shaded view redraws (GR) | 12 | 11 | -1 | -8.33% |
| 9 | 400 shaded view redraws with edges (GR) | 10 | 10 | 0 | 0.00% |
| 10 | 100 shaded view redraws with edges and datums (GR) | 12 | 12 | 0 | 0.00% |
| 11 | 300 wireframe view redraws (GR) | 8 | 8 | 0 | 0.00% |
| 12 | 100 wireframe view redraws with DTMS (GR) | 17 | 18 | 1 | 5.88% |
| 13 | 2 hidden view redraws (GR) | 32 | 31 | -1 | -3.13% |
| 14 | 200 hidden view redraws with Fast HLR (GR) | 12 | 13 | 1 | 8.33% |
| 15 | 300 shaded redraws with selection (GR) | 8 | 9 | 1 | 12.50% |
| 16 | 15 shaded pan and zoom (GR) | 8 | 9 | 1 | 12.50% |
| 17 | 15 full screen zooms (GR) | 10 | 11 | 1 | 10.00% |
| 18 | initiate advanced shaded mode (CP) | 13 | 13 | 0 | 0.00% |
| 19 | 200 shaded spins with reflection (GR) | 20 | 22 | 2 | 10.00% |
| 20 | 100 shaded spins with scene (GR) | 14 | 16 | 2 | 14.29% |
| 21 | 20 advanced shaded zooms (GR) | 20 | 22 | 2 | 10.00% |
| 22 | 400 shaded spins (GR) | 11 | 13 | 2 | 18.18% |
| 23 | 3 perspective zooms (GR) | 36 | 39 | 3 | 8.33% |
| 24 | 10 save tiff (CP+DI) | 31 | 33 | 2 | 6.45% |
| 25 | 25 save jpg (CP+DI) | 30 | 32 | 2 | 6.67% |
| 26 | 15 screen translates (GR) | 13 | 15 | 2 | 15.38% |
| 27 | 250 perspective views (GR) | 10 | 10 | 0 | 0.00% |
| 28 | 150 x-section views (GR) | 23 | 23 | 0 | 0.00% |
| 29 | end advanced shaded mode (CP) | 11 | 9 | -2 | -18.18% |
| 30 | 15 automatic regenerates (CP) | 38 | 39 | 1 | 2.63% |
| 31 | 2 mass prop calculations (CP) | 10 | 10 | 0 | 0.00% |
| 32 | 4 global interference checks (CP) | 25 | 26 | 1 | 4.00% |
| 33 | 2 IGES exports (CP+DI) | 20 | 20 | 0 | 0.00% |
| 34 | 3 STEP exports (CP+DI) | 55 | 55 | 0 | 0.00% |
| 35 | 15 drawing creations (CP) | 35 | 37 | 2 | 5.71% |
| 36 | 6 regen views HIDDEN LINE (CP) | 20 | 20 | 0 | 0.00% |
| 37 | 4 regen views NO HIDDEN (CP) | 12 | 12 | 0 | 0.00% |
| 38 | 1 PDF file creations (CP+DI) | 79 | 80 | 1 | 1.27% |
| 39 | 2 DXF File creations (CP+DI) | 14 | 15 | 1 | 7.14% |
| 40 | Erase all from memory (MEM) | 4 | 4 | 0 | 0.00% |
| | Total | 961 | 987 | 26 | 2.71% |
| | Graphics | 298 | 314 | 16 | 5.37% |
| | CPU | 659 | 669 | 10 | 1.52% |
| | Disk | 229 | 235 | 6 | 2.62% |

| | | Machine1 | Machine2 | | |
|---|---|---|---|---|---|
| | Name | MCADDELL68 | DDTEC0155 | | |
| | Make | Dell | Dell | | |
| | Model | Precision 5820 | Precision 3660 | | |
| | Processor | Xeon W-2235 | i9 13900K | | |
| | RAM | 64 GB | 64 GB | | |
| | Graphics | NVIDIA Quadro P2000 | NVIDIA RTX A5000 | | |
| | Operating System | Windows 10 | Windows 10 | | |
| | Version | Creo 9.0.6.0 | Creo 9.0.6.0 | | |
| | Test | Result1 | Result2 | Diff Abs | Diff % |
| 1 | Retrieve assembly 1 (CP) | 52 | 28 | -24 | -46.15% |
| 2 | Retrieve assembly 2 (CP) | 52 | 29 | -23 | -44.23% |
| 3 | Retrieve assembly 3 (CP) | 53 | 29 | -24 | -45.28% |
| 4 | Retrieve assembly 4 (CP) | 53 | 29 | -24 | -45.28% |
| 5 | Retrieve assembly 5 (CP) | 56 | 29 | -27 | -48.21% |
| 6 | Retrieve large assembly (GR) | 2 | 1 | -1 | -50.00% |
| 7 | 20 exploded views (GR) | 20 | 11 | -9 | -45.00% |
| 8 | 300 shaded view redraws (GR) | 12 | 5 | -7 | -58.33% |
| 9 | 400 shaded view redraws with edges (GR) | 10 | 4 | -6 | -60.00% |
| 10 | 100 shaded view redraws with edges and datums (GR) | 12 | 5 | -7 | -58.33% |
| 11 | 300 wireframe view redraws (GR) | 8 | 4 | -4 | -50.00% |
| 12 | 100 wireframe view redraws with DTMS (GR) | 17 | 8 | -9 | -52.94% |
| 13 | 2 hidden view redraws (GR) | 32 | 14 | -18 | -56.25% |
| 14 | 200 hidden view redraws with Fast HLR (GR) | 12 | 5 | -7 | -58.33% |
| 15 | 300 shaded redraws with selection (GR) | 8 | 4 | -4 | -50.00% |
| 16 | 15 shaded pan and zoom (GR) | 8 | 3 | -5 | -62.50% |
| 17 | 15 full screen zooms (GR) | 10 | 4 | -6 | -60.00% |
| 18 | initiate advanced shaded mode (CP) | 13 | 6 | -7 | -53.85% |
| 19 | 200 shaded spins with reflection (GR) | 20 | 6 | -14 | -70.00% |
| 20 | 100 shaded spins with scene (GR) | 14 | 4 | -10 | -71.43% |
| 21 | 20 advanced shaded zooms (GR) | 20 | 6 | -14 | -70.00% |
| 22 | 400 shaded spins (GR) | 11 | 4 | -7 | -63.64% |
| 23 | 3 perspective zooms (GR) | 36 | 10 | -26 | -72.22% |
| 24 | 10 save tiff (CP+DI) | 31 | 14 | -17 | -54.84% |
| 25 | 25 save jpg (CP+DI) | 30 | 19 | -11 | -36.67% |
| 26 | 15 screen translates (GR) | 13 | 4 | -9 | -69.23% |
| 27 | 250 perspective views (GR) | 10 | 4 | -6 | -60.00% |
| 28 | 150 x-section views (GR) | 23 | 10 | -13 | -56.52% |
| 29 | end advanced shaded mode (CP) | 11 | 5 | -6 | -54.55% |
| 30 | 15 automatic regenerates (CP) | 38 | 18 | -20 | -52.63% |
| 31 | 2 mass prop calculations (CP) | 10 | 5 | -5 | -50.00% |
| 32 | 4 global interference checks (CP) | 25 | 14 | -11 | -44.00% |
| 33 | 2 IGES exports (CP+DI) | 20 | 10 | -10 | -50.00% |
| 34 | 3 STEP exports (CP+DI) | 55 | 23 | -32 | -58.18% |
| 35 | 15 drawing creations (CP) | 35 | 18 | -17 | -48.57% |
| 36 | 6 regen views HIDDEN LINE (CP) | 20 | 11 | -9 | -45.00% |
| 37 | 4 regen views NO HIDDEN (CP) | 12 | 5 | -7 | -58.33% |
| 38 | 1 PDF file creations (CP+DI) | 79 | 28 | -51 | -64.56% |
| 39 | 2 DXF File creations (CP+DI) | 14 | 6 | -8 | -57.14% |
| 40 | Erase all from memory (MEM) | 4 | 2 | -2 | -50.00% |
| | Total | 961 | 444 | -517 | -53.80% |
| | Graphics | 298 | 116 | -182 | -61.07% |
| | CPU | 659 | 326 | -333 | -50.53% |
| | Disk | 229 | 100 | -129 | -56.33% |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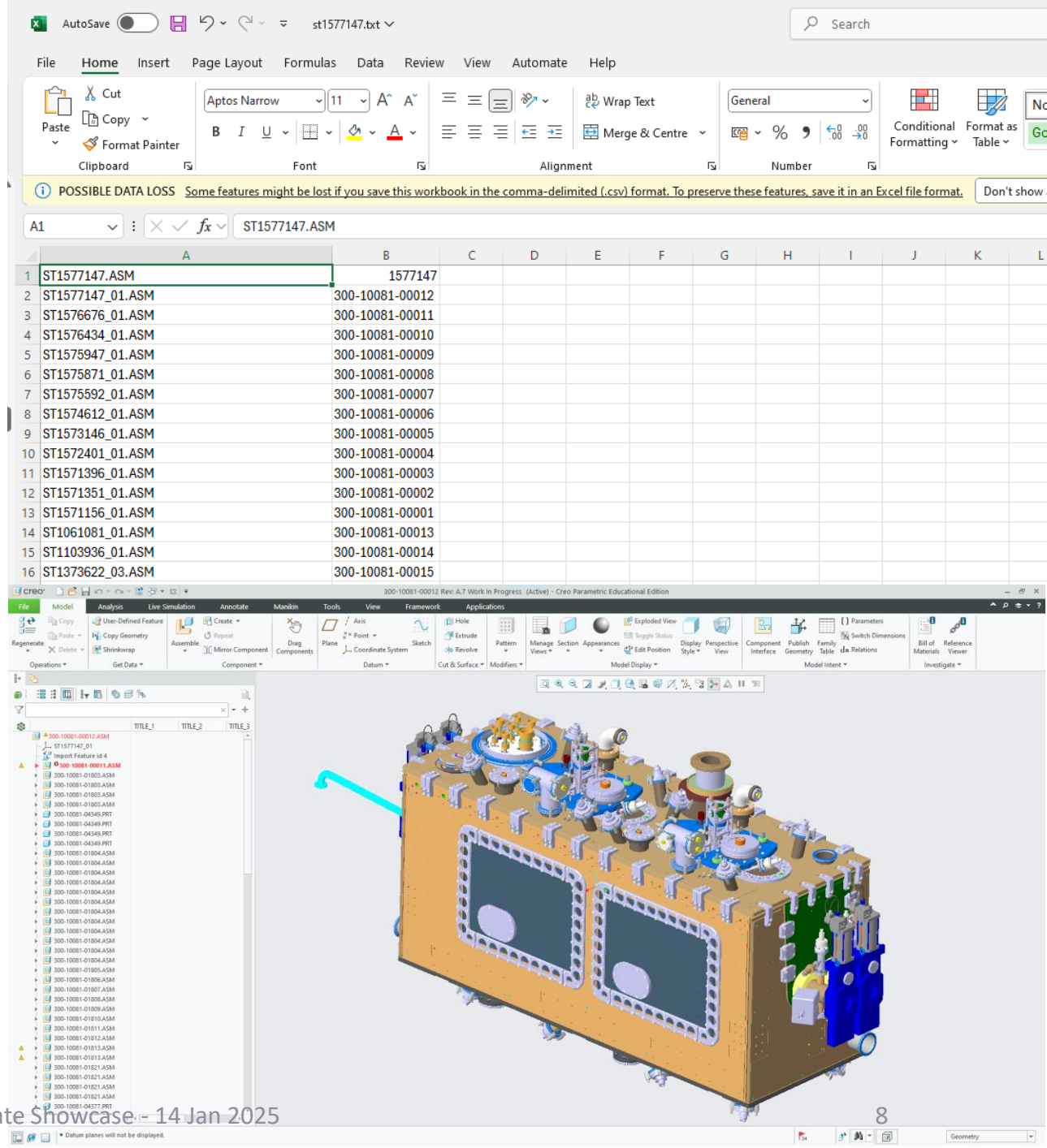
# HL-LHC-UK Involvement

## Continuous Improvement for Cryomodule DQW Series

# CAD Support

- Catia > STEP > Creo Import
  - Version Control
  - Single source of truth
  - DL PME Numbering convention

- Lightweight models
  - Shrinkwrap
  - Simplified Reps

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# RFD SPS Cryomodule

A variety of challenges:

- Procedure communication & execution error
- Supplier quality control
- NC & QA process confusion
- Procedure bottlenecks
- Damaged components
- Missing components

Timelapse can also be found on the CDS or the HL-LHC YouTube channel

For more information about challenges and lessons learned, speak to Nik Templeton and Kavi Chauhan

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# Missing Components

- 10k Components (~5k unique) + Tooling
- 2 Build Technicians + several Apprentices
- No dedicated store or store staff

- Lots of time & effort lost looking for or replacing components

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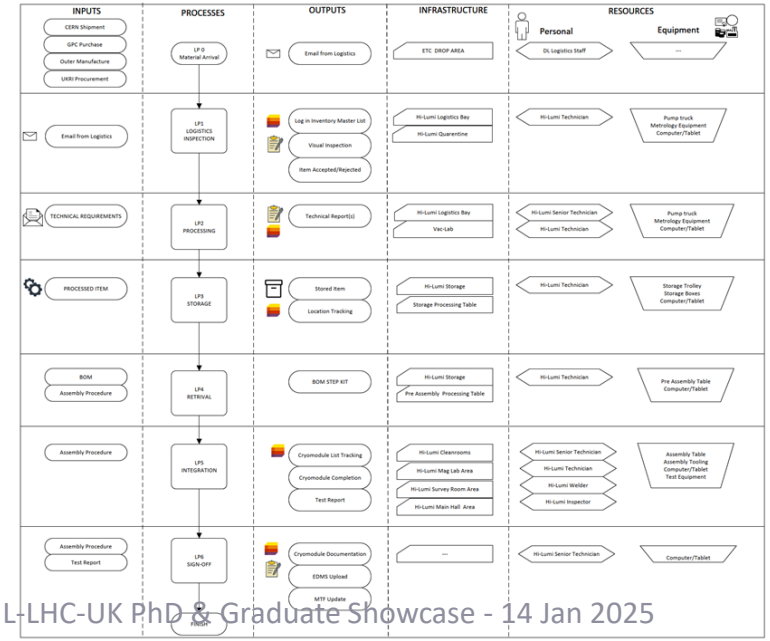
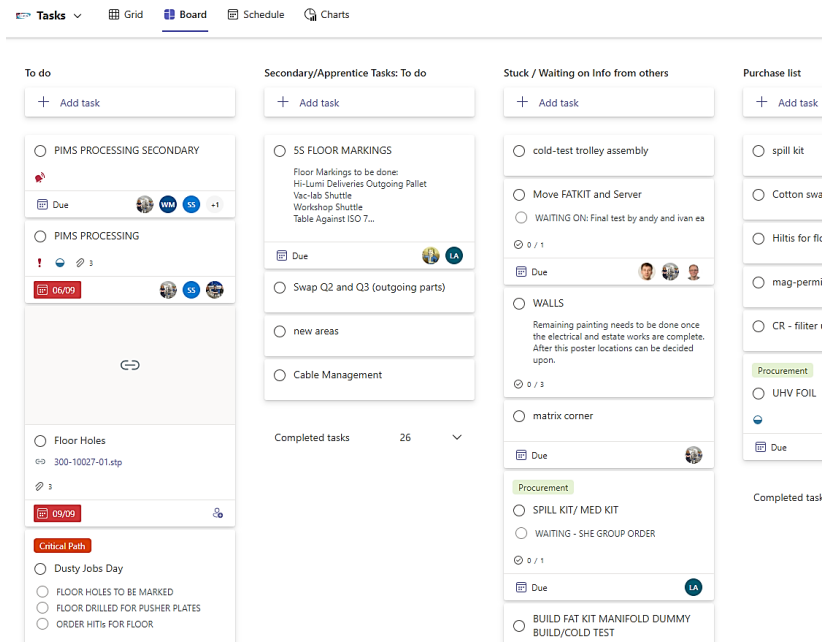
# DQW Cryomodules

## Continuous Improvement for DQW

- 5S Build Area
- Process Mapping
- Storage Locations
- Kanban Board
- Online Inventory System


For more information about 5S/Continuous Improvement changes, speak to Carlos Granjeiro and Luke Bladen

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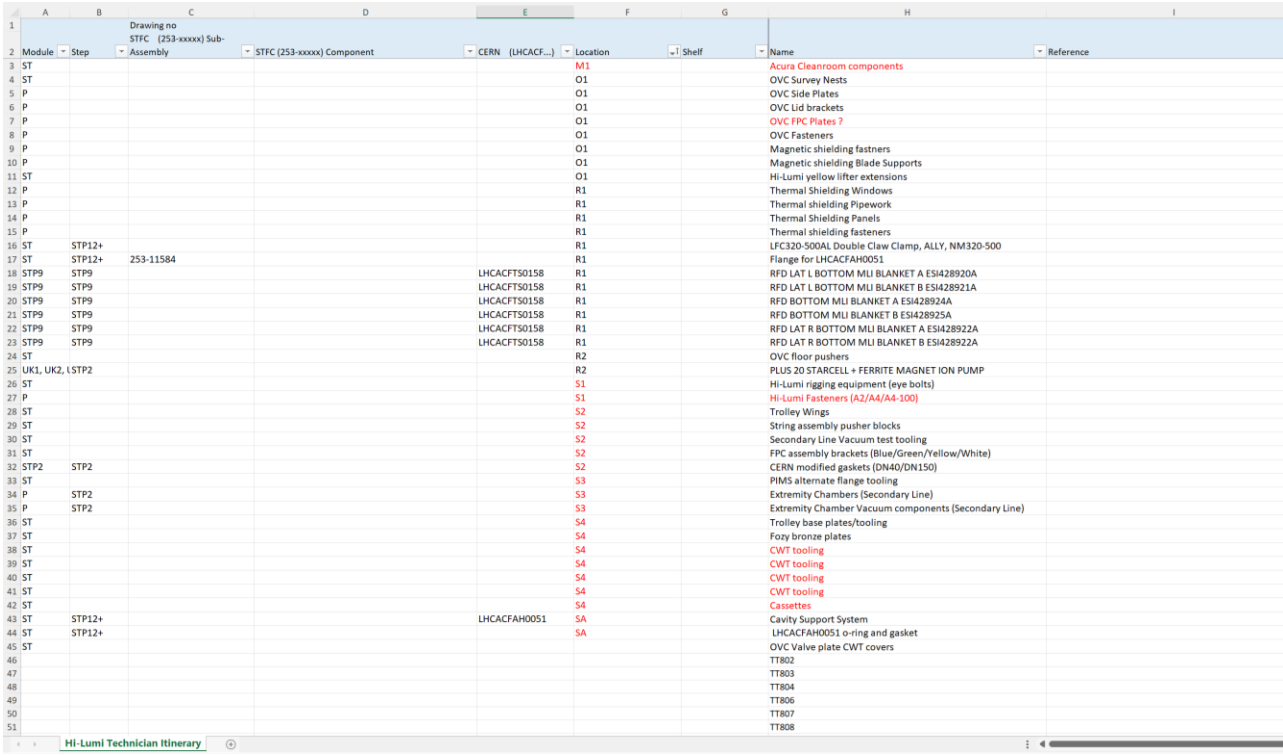
# RFD Inventory

## Excel Spreadsheet on File Share

- Locked when others are editing
- Inconsistent field entries
- People didn’t update



| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | Drawing no | | | | | | |
| 2 | Module | Step | STFC (253-xxxxx) Sub-Assembly | STFC (253-xxxxx) Component | CERN (LHCACF...) | Location | Shelf | Name | Reference |
| 3 | ST | | | | | M1 | | Acura Cleanroom components | |
| 4 | ST | | | | | O1 | | OVC Survey Nests | |
| 5 | P | | | | | O1 | | OVC Side Plates | |
| 6 | P | | | | | O1 | | OVC Lid brackets | |
| 7 | P | | | | | O1 | | OVC FPC Plates ? | |
| 8 | P | | | | | O1 | | OVC Fasteners | |
| 9 | P | | | | | O1 | | Magnetic shielding fastners | |
| 10 | P | | | | | O1 | | Magnetic shielding Blade Supports | |
| 11 | ST | | | | | O1 | | Hi-Lumi yellow lifter extensions | |
| 12 | P | | | | | R1 | | Thermal Shielding Windows | |
| 13 | P | | | | | R1 | | Thermal shielding Pipework | |
| 14 | P | | | | | R1 | | Thermal Shielding Panels | |
| 15 | P | | | | | R1 | | Thermal shielding fasteners | |
| 16 | ST | STP12+ | | | | R1 | | LFC320-500AL Double Claw Clamp, ALLY, NM320-500 | |
| 17 | ST | STP12+ | 253-11584 | | | R1 | | Flange for LHCACFAH0051 | |
| 18 | STP9 | STP9 | | | LHCACFTS0158 | R1 | | RFD LAT L BOTTOM MLI BLANKET A ESI428920A | |
| 19 | STP9 | STP9 | | | LHCACFTS0158 | R1 | | RFD LAT L BOTTOM MLI BLANKET B ESI428921A | |
| 20 | STP9 | STP9 | | | LHCACFTS0158 | R1 | | RFD BOTTOM MLI BLANKET A ESI428924A | |
| 21 | STP9 | STP9 | | | LHCACFTS0158 | R1 | | RFD BOTTOM MLI BLANKET B ESI428925A | |
| 22 | STP9 | STP9 | | | LHCACFTS0158 | R1 | | RFD LAT R BOTTOM MLI BLANKET A ESI428922A | |
| 23 | STP9 | STP9 | | | LHCACFTS0158 | R1 | | RFD LAT R BOTTOM MLI BLANKET B ESI428922A | |
| 24 | ST | | | | | R2 | | OVC floor pushers | |
| 25 | UK1, UK2, L | STP2 | | | | R2 | | PLUS 20 STARCELL + FERRITE MAGNET ION PUMP | |
| 26 | ST | | | | | S1 | | Hi-Lumi rigging equipment (eye bolts) | |
| 27 | P | | | | | S1 | | Hi-Lumi Fasteners (A2/A4/A4-100) | |
| 28 | ST | | | | | S2 | | Trolley Wings | |
| 29 | ST | | | | | S2 | | String assembly pusher blocks | |
| 30 | ST | | | | | S2 | | Secondary Line Vacuum test tooling | |
| 31 | ST | | | | | S2 | | FPC assembly brackets (Blue/Green/Yellow/White) | |
| 32 | STP2 | STP2 | | | | S2 | | CERN modified gaskets (DN40/DN150) | |
| 33 | ST | | | | | S3 | | PIMS alternate flange tooling | |
| 34 | P | STP2 | | | | S3 | | Extremity Chambers (Secondary Line) | |
| 35 | P | STP2 | | | | S3 | | Extremity Chamber Vacuum components (Secondary Line) | |
| 36 | ST | | | | | S4 | | Trolley base plates/tooling | |
| 37 | ST | | | | | S4 | | Fozy bronze plates | |
| 38 | ST | | | | | S4 | | CWT tooling | |
| 39 | ST | | | | | S4 | | CWT tooling | |
| 40 | ST | | | | | S4 | | CWT tooling | |
| 41 | ST | | | | | S4 | | CWT tooling | |
| 42 | ST | | | | | S4 | | Cassettes | |
| 43 | ST | STP12+ | | | LHCACFAH0051 | SA | | Cavity Support System | |
| 44 | ST | STP12+ | | | | SA | | LHCACFAH0051 o-ring and gasket | |
| 45 | ST | | | | | | | OVC Valve plate CWT covers | |
| 46 | | | | | | | | TT802 | |
| 47 | | | | | | | | TT803 | |
| 48 | | | | | | | | TT804 | |
| 49 | | | | | | | | TT806 | |
| 50 | | | | | | | | TT807 | |
| 51 | | | | | | | | TT808 | |

Hi-Lumi Technician Itinerary

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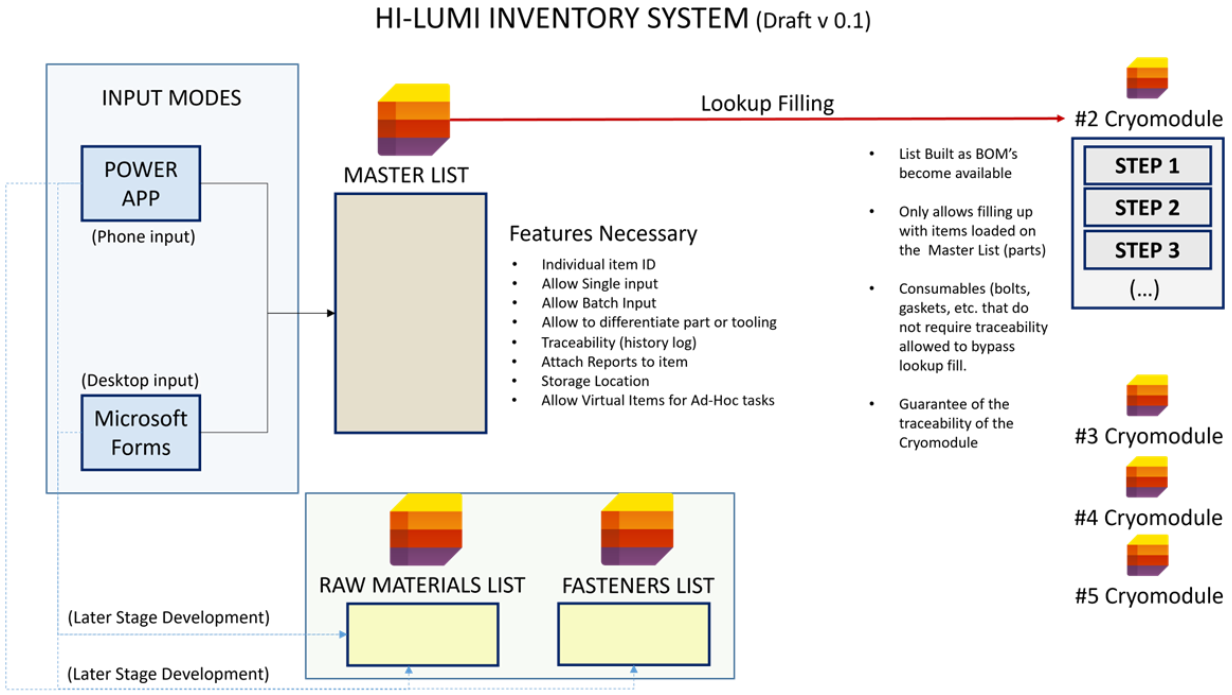
# DQW Inventory

- Simple to use
- Available on mobile
- Simultaneous access
- Specify processing per component
- Change history/Traceability

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# SharePoint Backend

- Parts Lookup
  - ID
  - Processing requirements
- Inventory
  - Part ID
  - Location
  - Processing status

Parts Lookup

| | PartID | ST Num... | CERN Nu... | DL Number | ISO Num... | Description | Cleanlines... | Magnetic ... | Metrolo... |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | ST1571156 | LHCACF_A0043 | 300-10081-00001 | | DQW cryomodule assembly - STEP 1 | UHV | | |
| | 2 | ST1571351 | LHCACF_A0046 | 300-10081-00002 | | DQW cryomodule assembly - STEP 2 | IV | | |
| | 3 | ST1571396 | LHCACF_A0047 | 300-10081-00003 | | DQW cryomodule assembly - STEP 3 | IV | | |
| | 4 | ST1572401 | LHCACF_A0049 | 300-10081-00004 | | DQW cryomodule assembly - STEP 4 | IV | | |
| | 5 | ST1573146 | | 300-10081-00005 | | | N/A | | |
| | 6 | ST1574612 | | 300-10081-00006 | | | N/A | | |
| | 7 | ST1575592 | | 300-10081-00007 | | | N/A | | |
| | 8 | ST1575871 | | 300-10081-00008 | | | N/A | | |
| | 9 | ST1575947 | | 300-10081-00009 | | | N/A | | |
| | 10 | ST1576434 | | 300-10081-00010 | | | N/A | | |
| | 11 | ST1576676 | | 300-10081-00011 | | | N/A | | |
| | 12 | ST1577147 | | 300-10081-00012 | | | N/A | | |
| | 13 | ST1061081 | LHCACFDC0008 | 300-10081-00013 | | DQW/LHC - DRESSED CAVITY + BEAM SCREEN | UHV | | |

Inventory

| Part Lookup | Part Lookup:DL Number | Part Lookup:CERN Number | Part L... | Part Lookup:Description | Location | BOX NUM.. |
|---|---|---|---|---|---|---|
| 4583 | 253-11449 | | | LONG CWT CL IN TOOLING ASSEMBLY | Outerwork space | |
| 4586 | 253-11473 | | | BOTTOM CLAMP SUPPORT PEICE 2 | MAGLAB | 38 |
| 4587 | 253-11479 | | | CLAMP SUPPORT PIECE 2 | MAGLAB | 38 |
| 4588 | 253-11415 | | | SHORT CWT CANTILEVER SUPPORT ASSEMBLY | Outerwork space | |
| 4589 | 253-11445 | | | CWT FLANGE HANDING ASSEMBLY | Outerwork space | |
| 4590 | 253-11481 | | | CLAMP SUPPORT PIECE 2 | T1 | 79 |
| 4591 | 253-11482 | | | CLAMP SUPPORT PIECE 2 | T1 | 79 |
| 4593 | 253-11412 | | | SHORT BOTTOM SUPPORT A | | 121 |
| 4595 | 253-11908 | | | ALTERNATE UPPER CENTERING COLLAR | CLEANROOM | |
| 4596 | 253-11909 | | | ALTERNATE LOWER CENTERING COLLAR | CLEANROOM | |
| 4601 | 253-12220 | | | | CLEANROOM | 10 |
| 4605 | 253-11379 | | | SHORT SL SPACER | Outerwork space | |
| 4606 | 253-11462 | | | VALVE PLATE LIFTING PIECE | T1 | 32 |
| 4615 | 253-12224 | | | VALVE PLATE ATTACHMENT FOR CWT | Installed On Cryo 2 CR | |
| 4620 | 253-12436 | | | VAC CHECK TOOL 2 | T2 | 74 |

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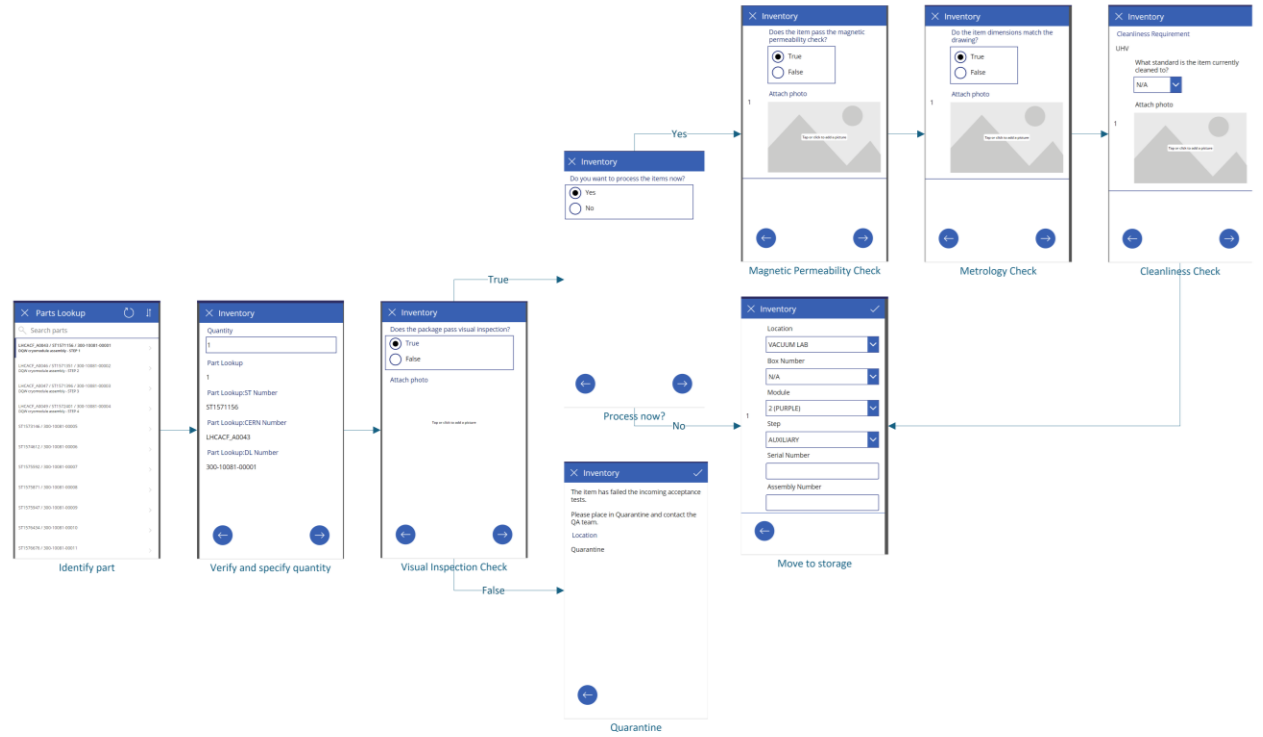
# PowerApps Frontend

- Mobile-first experience
- Defined input flow
- Ensures consistent fields
- Bulk input

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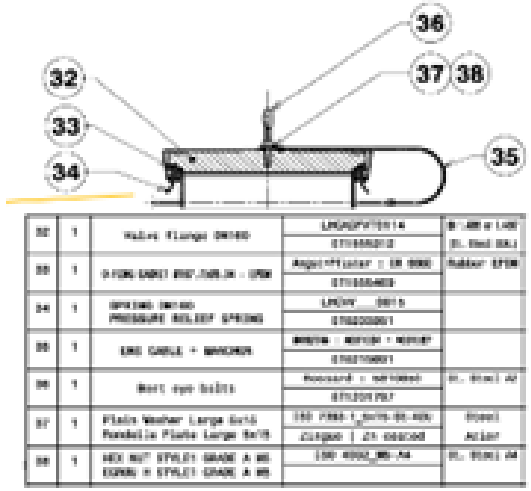
# The Story So Far

- System has been used for several months to great success
- Adjustments made to the columns and fields
- Missing features:
  - BOM Kitting
  - Automatic notifications
  - Updating multiple entries simultaneously



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# Future Plans

## Further Continuous Improvement

# SharePoint/PowerApps Disadvantages

- Low-code Programming Language with limited functionality (Power Fx)
- SaaS and occasional breaking changes with no clear changelog
- Poor documentation, especially hidden object attributes

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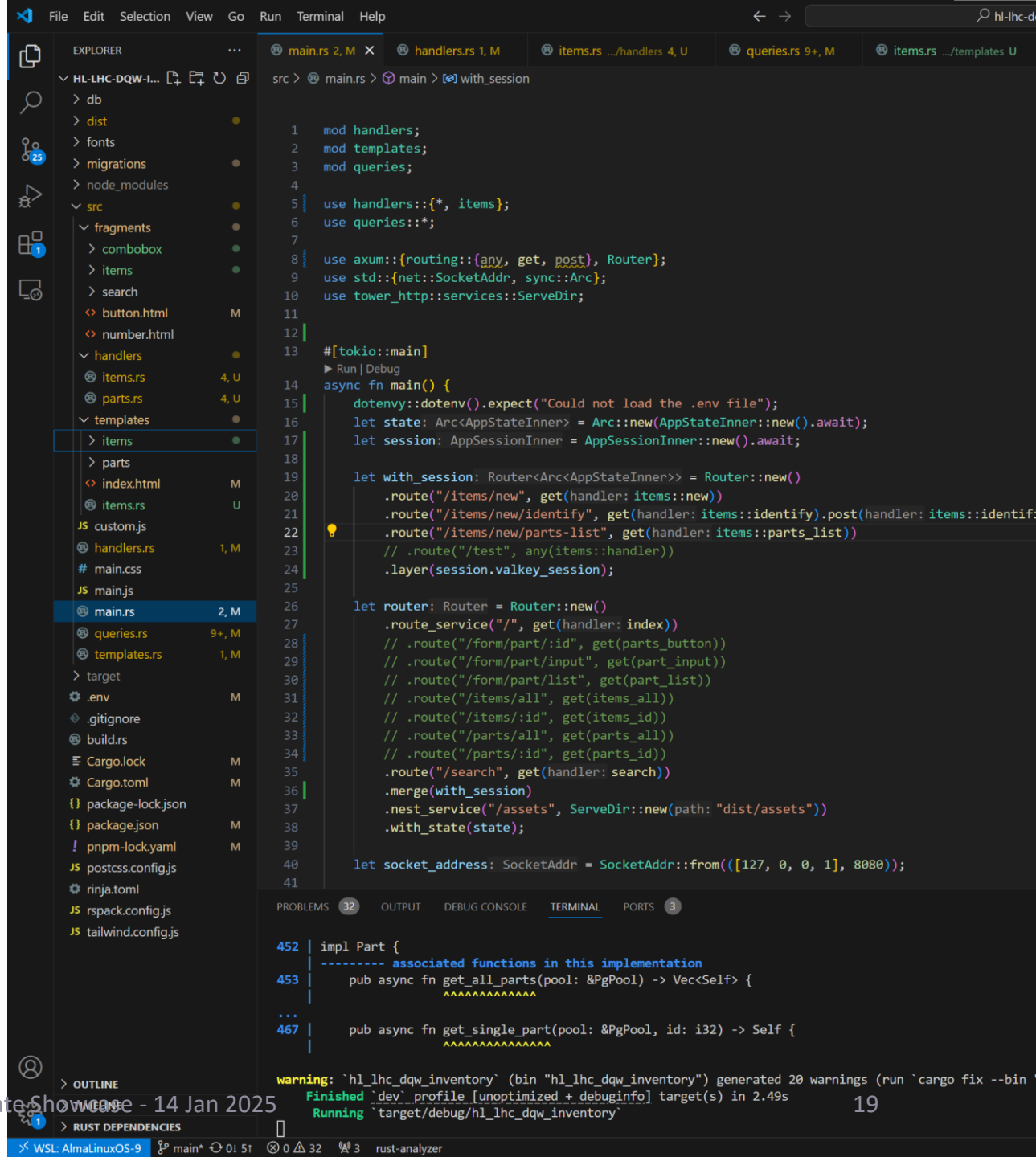
# Custom Web App

- Tech Stack:
  - Frontend: HTMX, Tailwind CSS
  - Backend: Rust (Axum)
  - Database: PostgreSQL
  - Session: Valkey

- More easily implement missing and nice-to-have features (QR code lookup, 3D preview,)
- Fully customised to need of Hi-Lumi
- Can deploy to other teams/projects
- Use same tech stack to improve other internal web applications

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# Summary

- Digital tools are used in a variety of ways to support engineering, from CAD to asset management

- They can be extremely powerful if used effectively, or a source of frustration if poorly implemented

- It’s important to consider the needs of users and how they work to ensure the tool is right for the job

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# Thank you

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