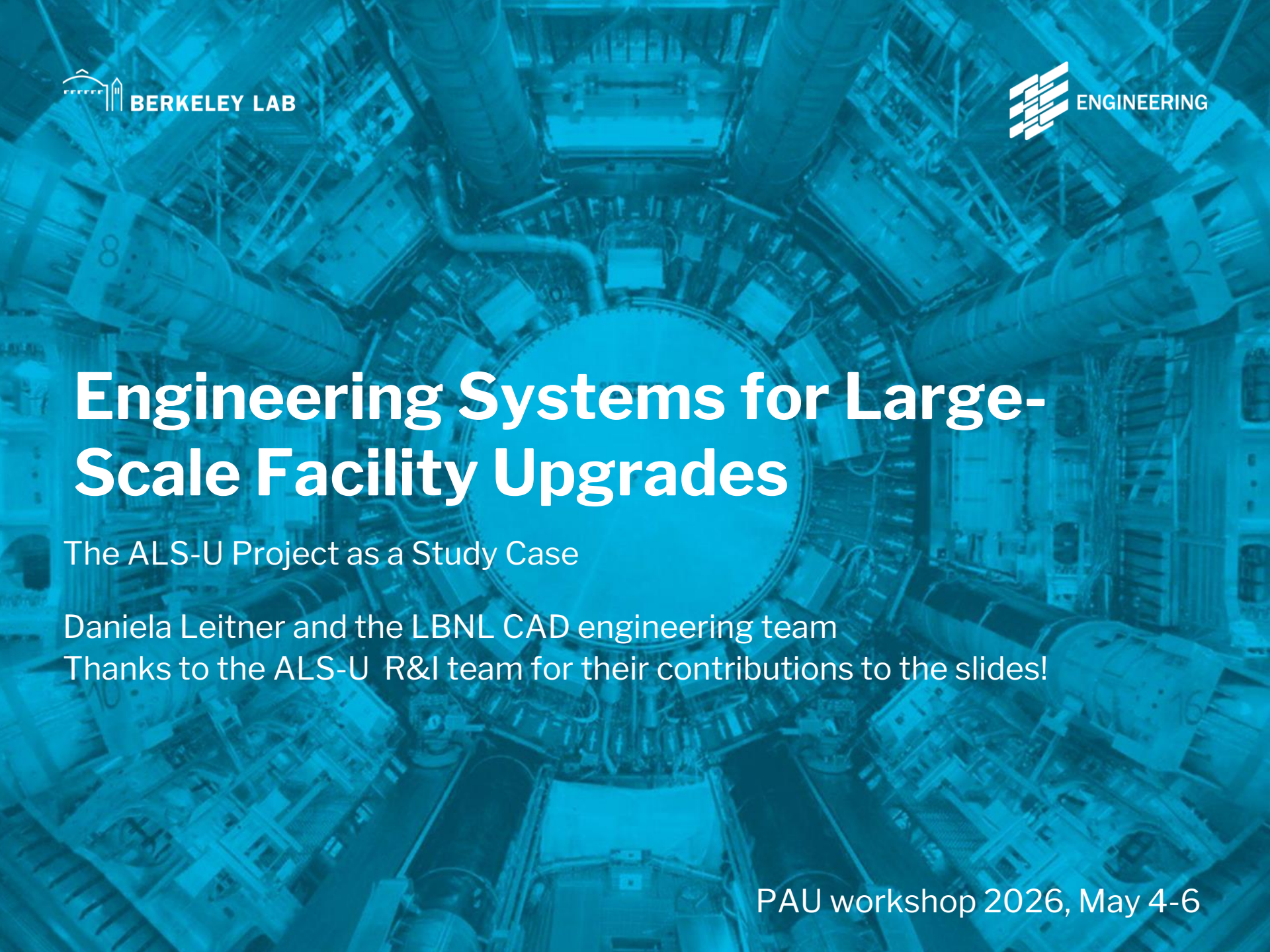

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ENGINEERING

Engineering Systems for Large-Scale Facility Upgrades

The ALS-U Project as a Study Case

Daniela Leitner and the LBNL CAD engineering team

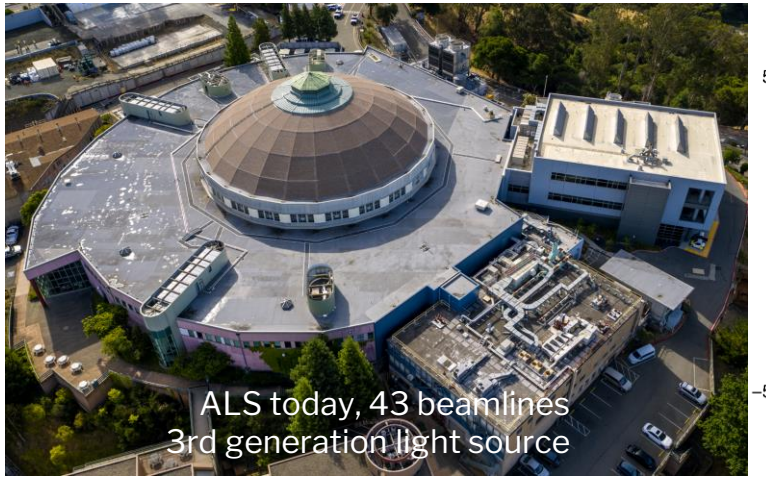
Thanks to the ALS-U R&I team for their contributions to the slides!

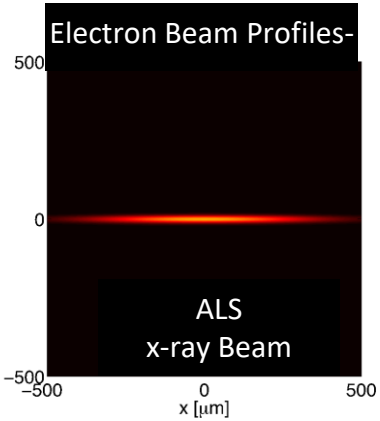
PAU workshop 2026, May 4-6

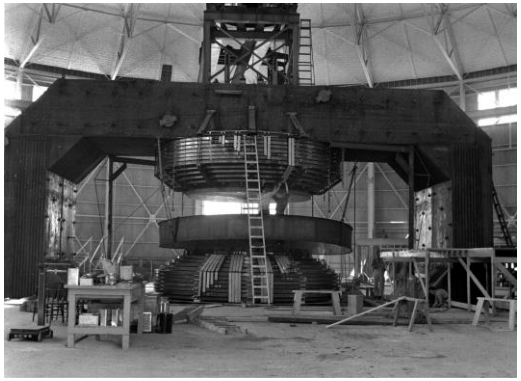
Content

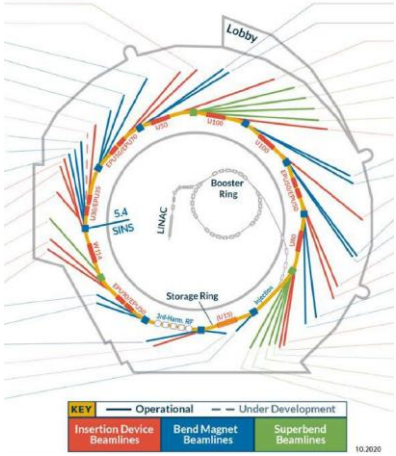
- Introduction to the ALS-U project and its challenges
- Configuration management strategy for large-scale projects
  - Documentation
  - Mechanical Design Configuration Management
  - Electrical Design Configuration Management
  - Quality Assurance
- As-built configuration and CAD integration using BIM
  - Integration with other CAD systems and construction vendors

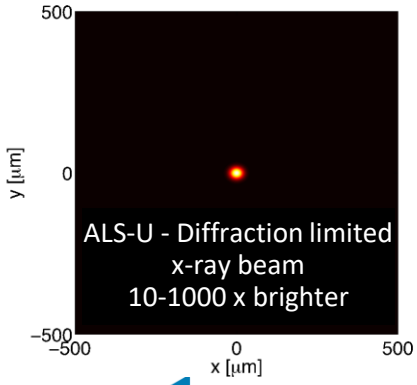
Transforming a historic site into a 4th Generation Lightsource











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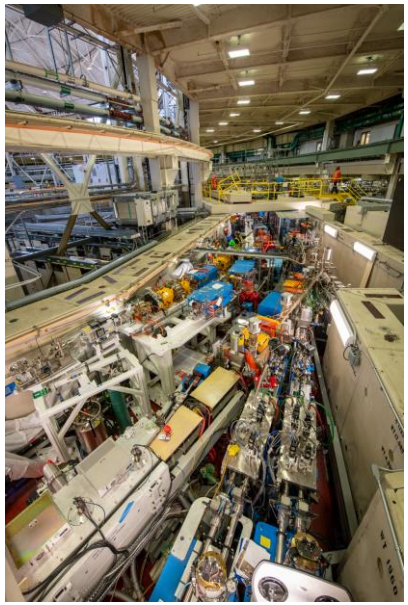
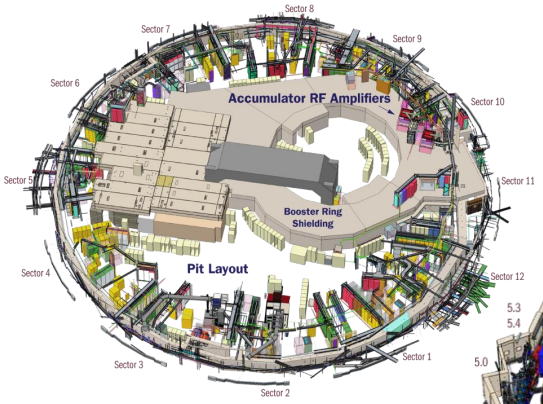
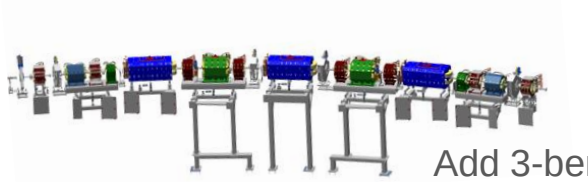
The challenge: Fit two accelerators into the space of one and modernize the 30 year old facility

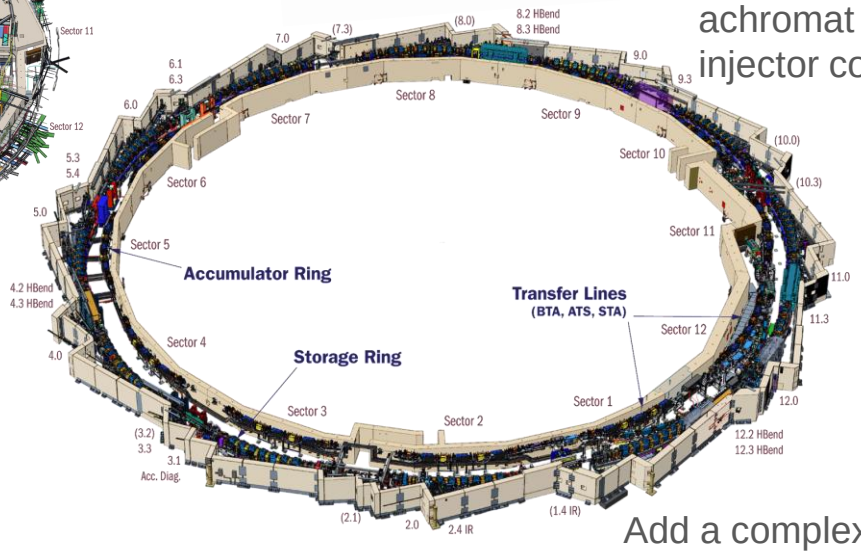


Renew and upgrade infrastructure and strengthen seismic integrity



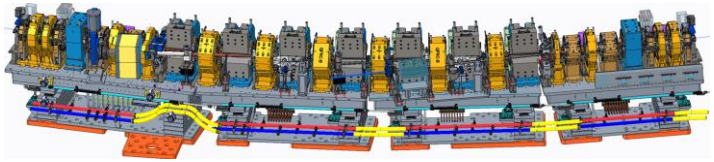


Add 3-bend achromat to the injector complex



Add a complex transfer line region

Replace the existing storage ring with a multibend achromat
36 bends -> 108 bends



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Configuration Management Strategies

Utilize a centralized database and interconnect auxiliary systems

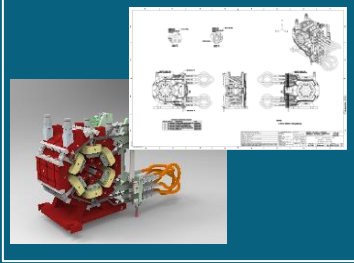
- At Berkeley Lab, Windchill PLM is implemented as the central project repository for all engineering supported projects and facilities
- Supports multiple CAD (electrical and mechanical) formats, project documentation and Change Management, as well as Quality Assurance & Control files
- Provides interconnectivity and traceability between elements
- Revision, History and Approval Workflows are implemented through Windchill and connected into the LBNL Document Control Center

Configuration Management Strategy

Utilize a centralized database and interconnect auxiliary systems

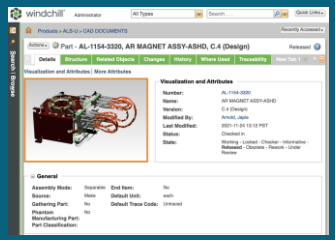
example workflow

create



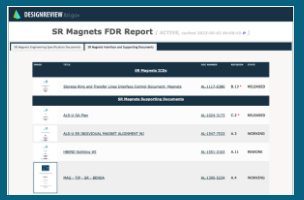
concept
modeled
drawn
finalized

manage



saved
controlled
approved
released

design review



config spec
shared
accessible

dcc

archived
neutral file
watermarked
controlled

fabricate
assemble

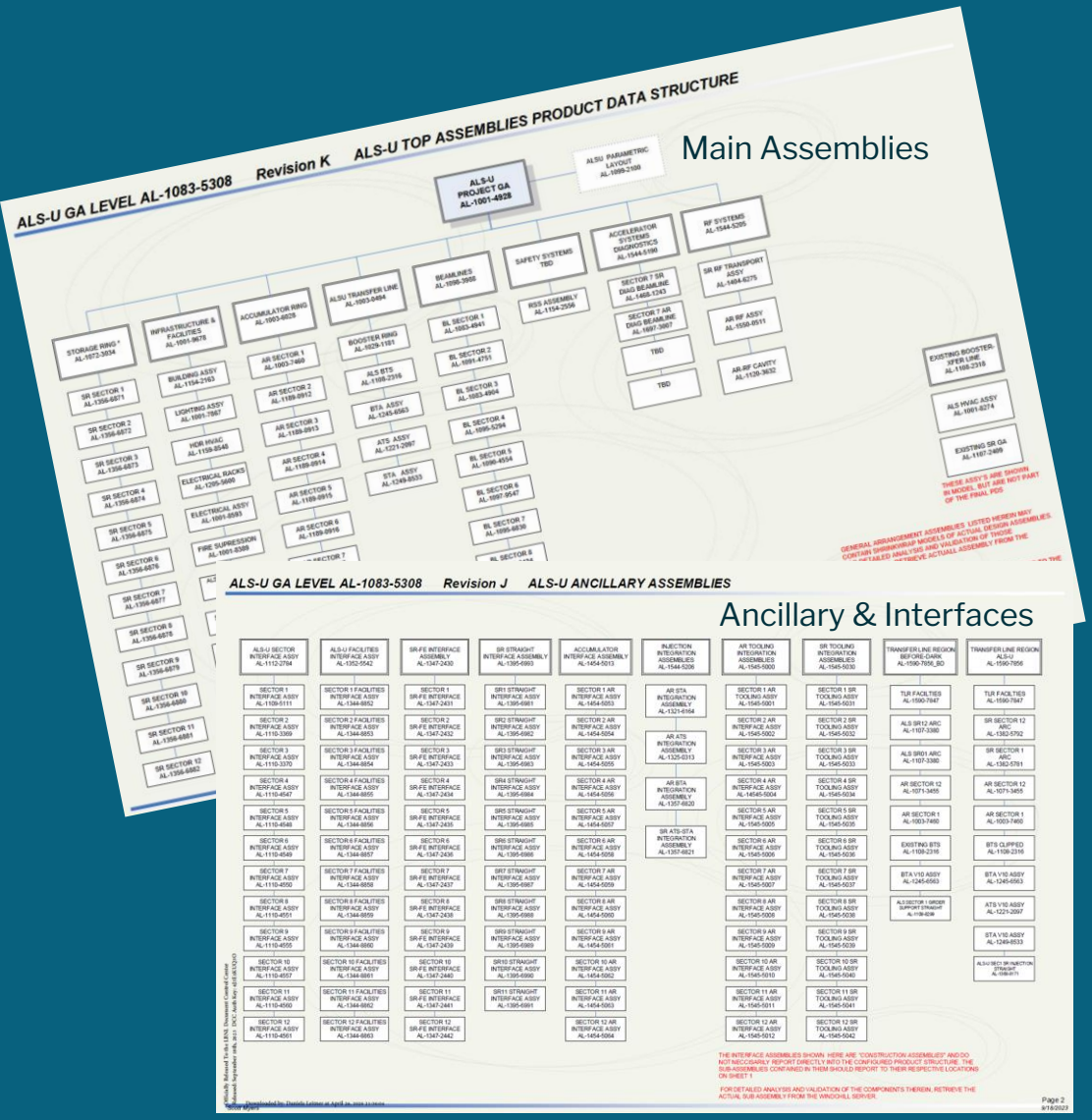
job created
charge #
sent to fab
… or …
requisition
placed

operations

serialization
QA docs attach
QRcode applied
Visualize in
Navigate.lbl.gov

Slide courtesy of Samantha Gholba

For large projects the top-level assembly provides the roadmap to the technical assemblies (mechanical and electrical)



Includes

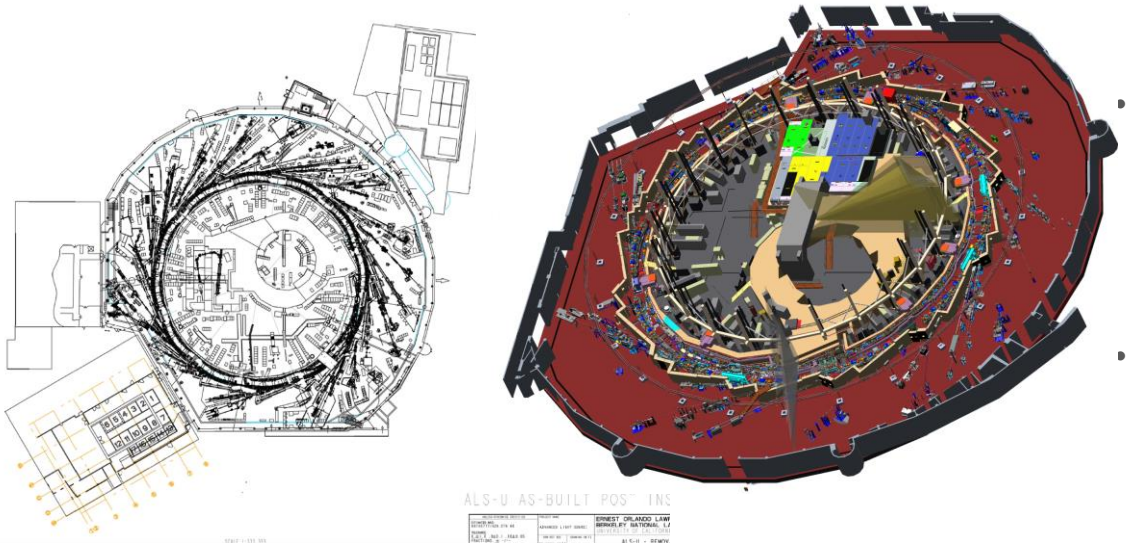
- Mechanical assemblies
- Electrical assembly (in progress)
- Infrastructure
- Ancillary and interface assemblies

Challenges

- Overall complexity of the full model makes it impossible to open with full details
- Utility and contractor model implementation

1) Modeling discipline is key for managing these assemblies
2) ALS-U makes extensive use of
   a) Shrink wraps (automated updates)
   b) Vendor models and views
   c) Envelopes (in progress)
   d) Training for modeling & drawing techniques
3) BIM modeling used for infrastructure integration

Managing large CAD assemblies



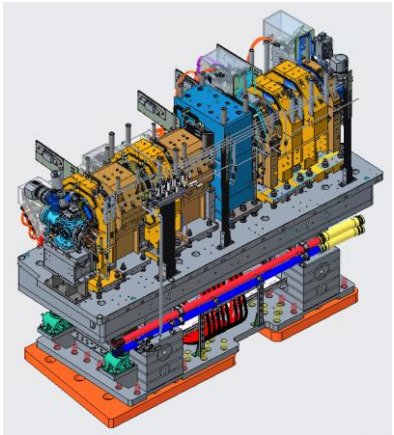
opening time <2 min (CreoView)

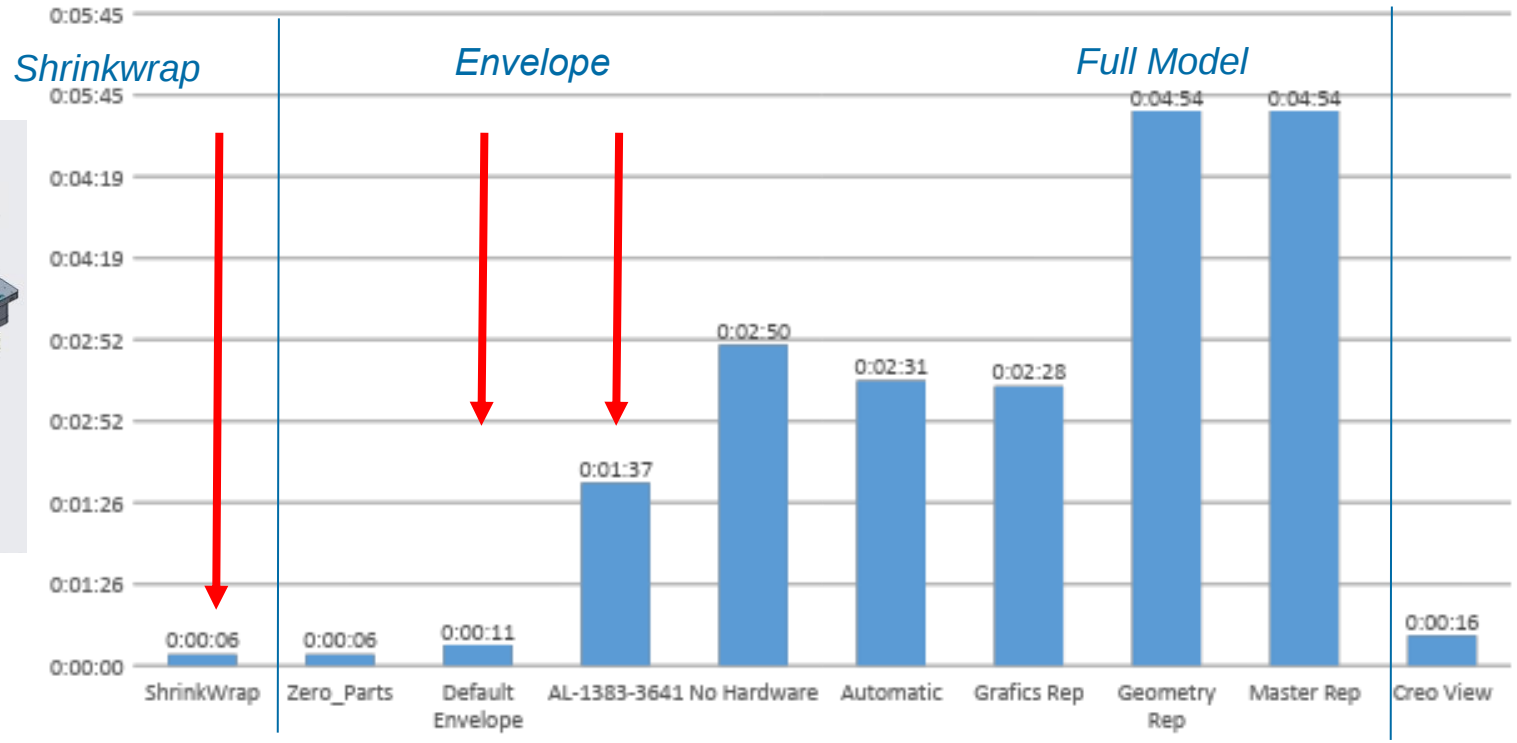
The top assembly for ALS-U AL-1001-4928 has~180,000 unique objects in it - it is not a model that is routinely opened and is very cumbersome to maintain and keep clean

- Shrinkwraps (SW) create a simplified, "wrapped" version of an assembly or parts.
- Extensively used in assemblies to develop interface assembly and viewables for vendors, etc..
- A process for the automation of Shrinkwraps for ALS-U has been developed and are updated from the assemblies at different granularity

CAD performance example for a smaller assembly

ALS-U SR Raft 1 assembly ~ 2175 unique parts





AL-1383-3641_sw.prt

AL-1383-3641.asm

Slide courtesy of Jacob Arnold

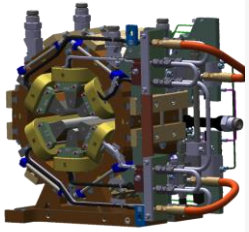
Windchill is implemented as the central project repository for all engineering projects and engineering supported facilities

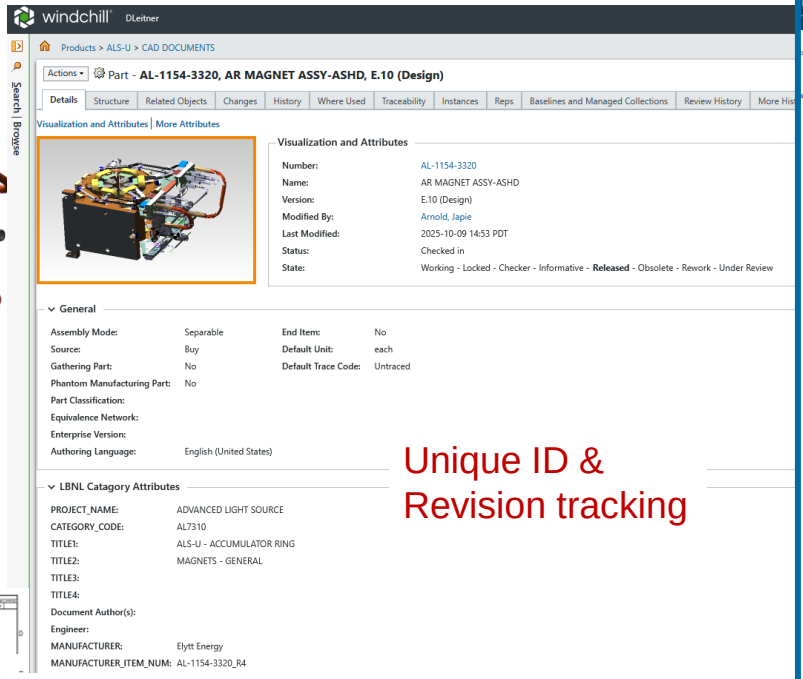
Mechanical Modeling
&
Drawings

creo parametric

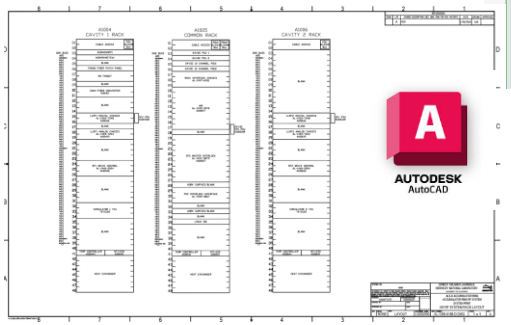
creo elements/direct

SW

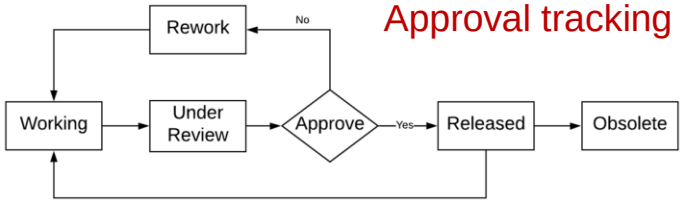




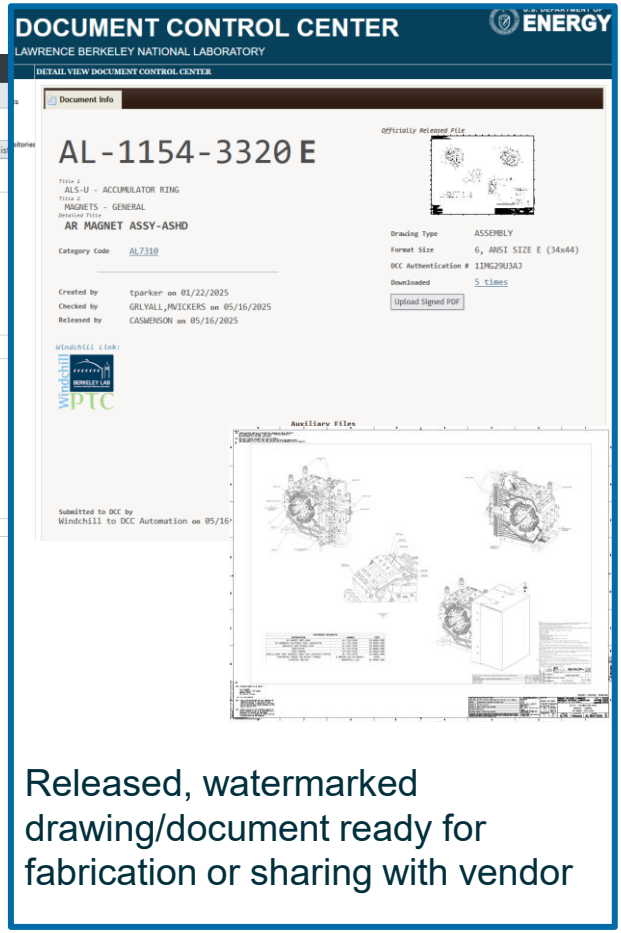
Unique ID &
Revision tracking



AUTODESK
AutoCAD



Approval tracking



Released, watermarked drawing/document ready for fabrication or sharing with vendor

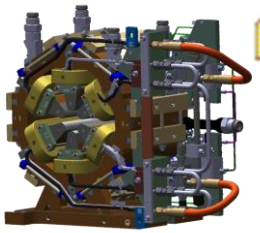
Electrical Schematics and Layouts

Design workflow is similar to other engineering configuration management systems

WTParts are utilized in LBNL creating Digital Twins

Windchill Technology Part: Digital representations of design/physical objects in Windchill

Digital container that contains: Design documentation, Certifications, Work instructions, Checklists, Calibration data, link to auxiliary documents, redlines, serial information, ….



Assembly

Part

AL-1154-3320

WTParts are utilized in LBNL creating Digital Twins

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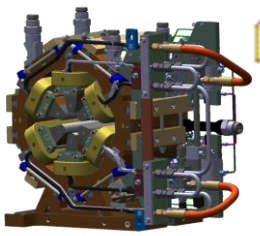

Assembly

Part

AL-1154-3320

Serial Number	Lc
AL-1154-3320-0001	
AL-1154-3320-0002	
AL-1154-3320-0003	
AL-1154-3320-0004	
AL-1154-3320-0005	
AL-1154-3320-0006	
AL-1154-3320-0007	
AL-1154-3320-0008	
AL-1154-3320-0009	
AL-1154-3320-0010	

Serialization

WTParts are utilized in LBNL creating Digital Twins

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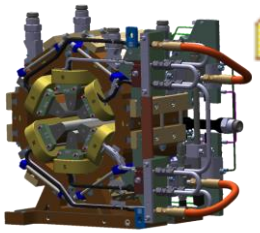

Assembly

Part

AL-1154-3320

Serial Number	Lc
AL-1154-3320-0001	
AL-1154-3320-0002	
AL-1154-3320-0003	
AL-1154-3320-0004	
AL-1154-3320-0005	
AL-1154-3320-0006	
AL-1154-3320-0007	
AL-1154-3320-0008	
AL-1154-3320-0009	
AL-1154-3320-0010	

Serialization

- Calypso PiWeb Report - ASHD_0005 AL-1154-3320-0005 (Pre Split)
- Calypso PiWeb Report - ASHD_0005 AL-1154-3320-0005 (Post Split 1)
- Calypso PiWeb Report - ASHD_0005 AL-1154-3320-0005 (Post Split 2)
- Calypso PiWeb Report - ASHD_05 AL-1154-3320-0005 (Post Re Torque Split1)
- Rotating Coil Measurement Report - ASHD-05 AL-1154-3320-0005
- Stretched Wire Measurement Report - ASHD-05 AL-1154-3320-0005
- Magnetic Measurement ACL Record - ASHD-05
- Elytt Quality Control Record ASHD-05 AL-1154-3320-0005
- Results_ASHD05
- E-BERKAR-100-RP-000079 126-ASHD-05 AL-1154-3320-0005 DIMENSIONAL CONTROL
- E-BERKAR-100-RP-000070 ASHD MAGNETS MATERIAL TRACEABILITY
- Receiving ACL Record - ASHD-05

Reports & Documentation

WTParts are utilized in LBNL creating Digital Twins

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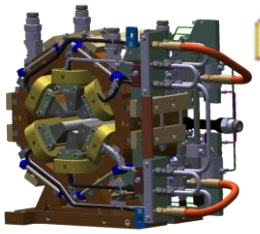
Digital container that contains: Design documentation, Certifications, Work instructions, Checklists, Calibration data, link to auxiliary documents, redlines, serial information, ….



Assembly

Part

AL-1154-3320

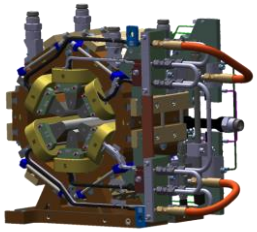
	Serial Number	Lc
	AL-1154-3320-0001	
	AL-1154-3320-0002	
	AL-1154-3320-0003	
	AL-1154-3320-0004	
	AL-1154-3320-0005	
	AL-1154-3320-0006	
	AL-1154-3320-0007	
	AL-1154-3320-0008	
	AL-1154-3320-0009	
	AL-1154-3320-0010	

Serialization

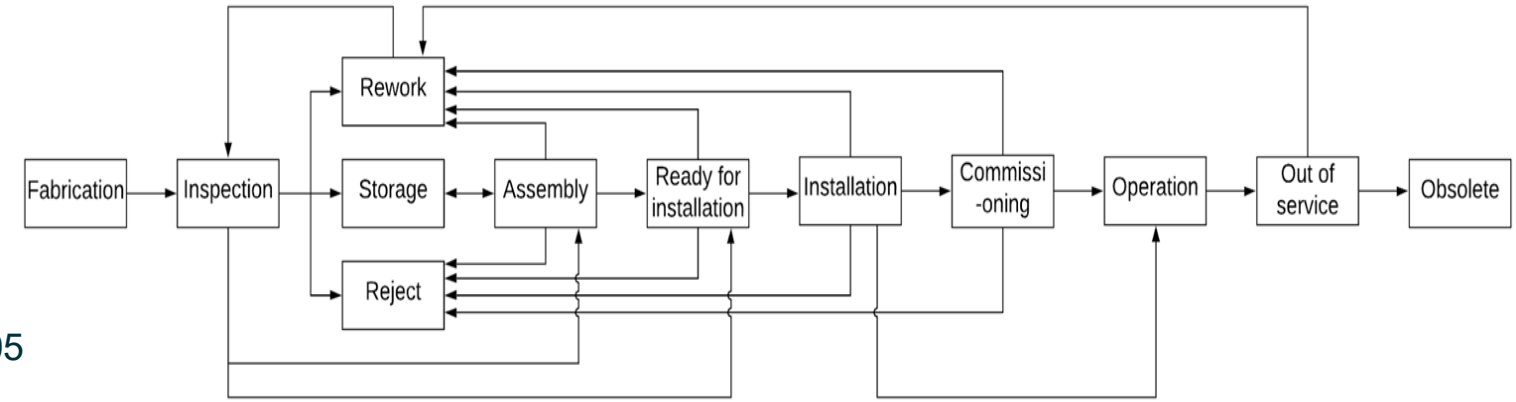
Reports & Documentation

WTPart lifecycle follows an object from design and build through operation in a facility

Status of the object and hand-offs are recorded as it moves through its' lifecycle



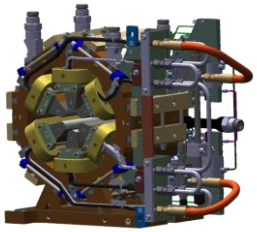
AL-1154-3320-005



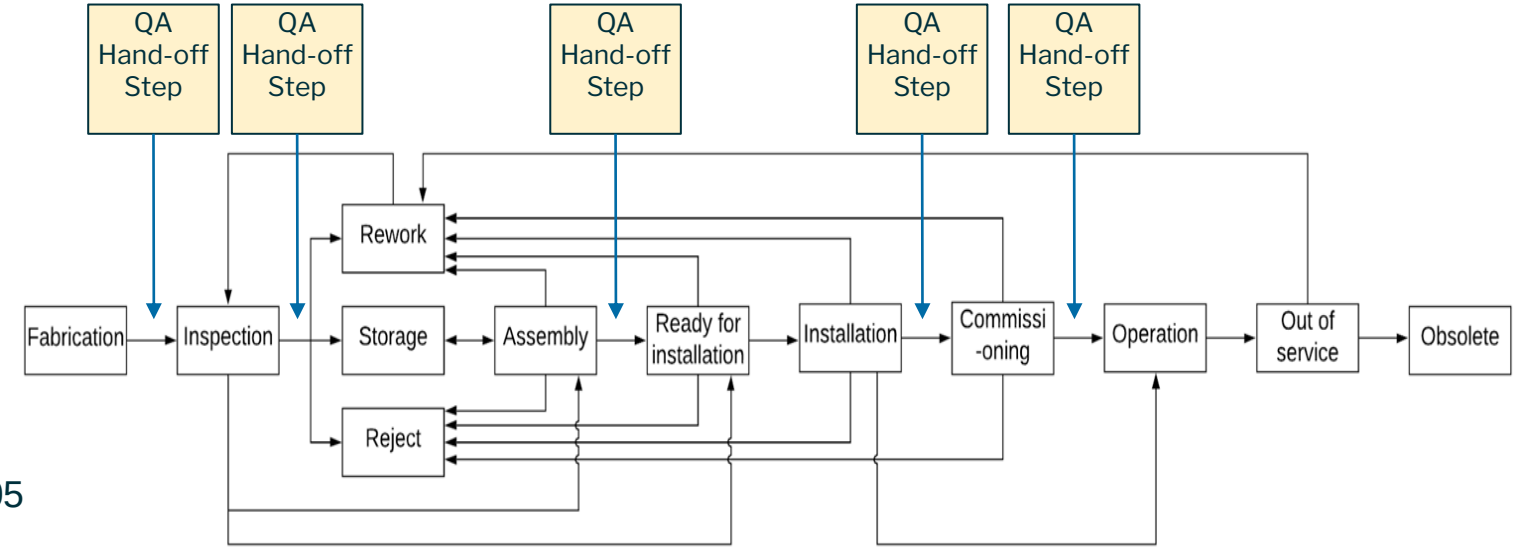
As-built manufacturing data, calibration and measurement, QA data, NCRs, location, installation, commissioning, and repair data are added throughout the lifecycle.

WTPart lifecycle follows an object from design and build through operation in a facility

Status of the object and hand-offs are recorded as it moves through its' lifecycle

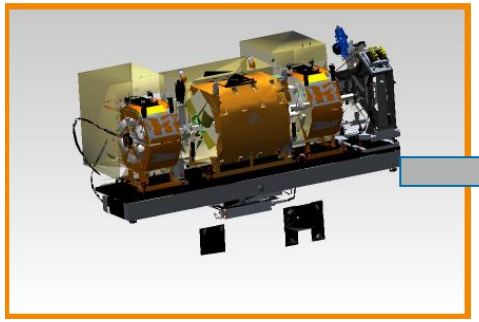


AL-1154-3320-005



As-built manufacturing data, calibration and measurement, QA data, NCRs, location, installation, commissioning, and repair data are added throughout the lifecycle.

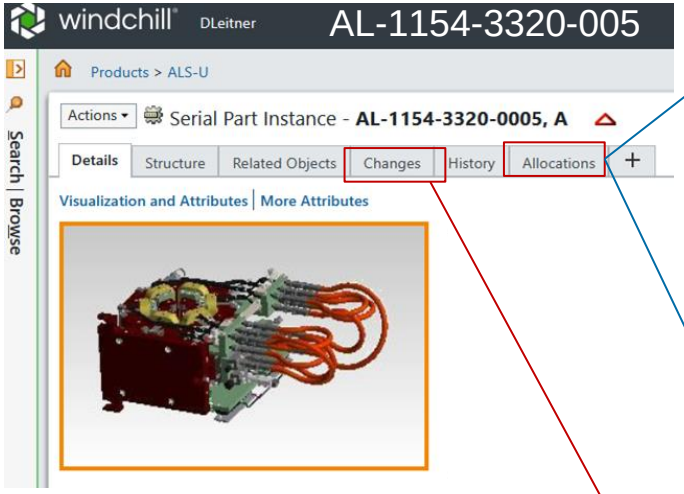
Serialization enables traceability for as-built information

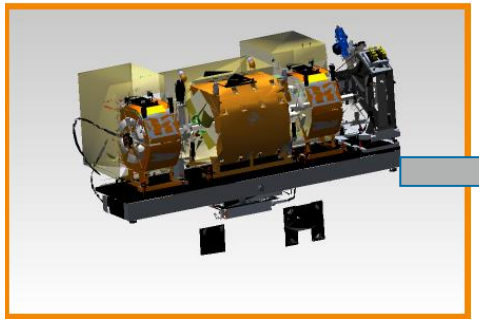


AL-1030-8792-000, Raft 4

AL-1189-0919-0001, AR Sector 9

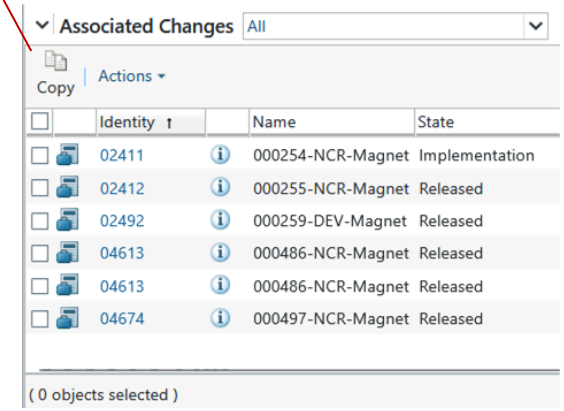
Serialization enables traceability for as-built information





AL-1030-8792-000, Raft 4

AL-1189-0919-0001, AR Sector 9

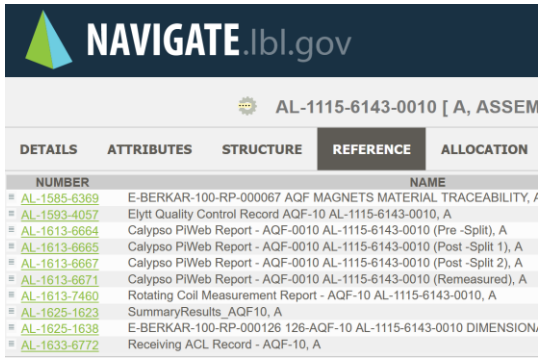


- 5 NCRs
- 1 DEV
- NCR implementation
  (waiting for safety covers)

How does it work in the field

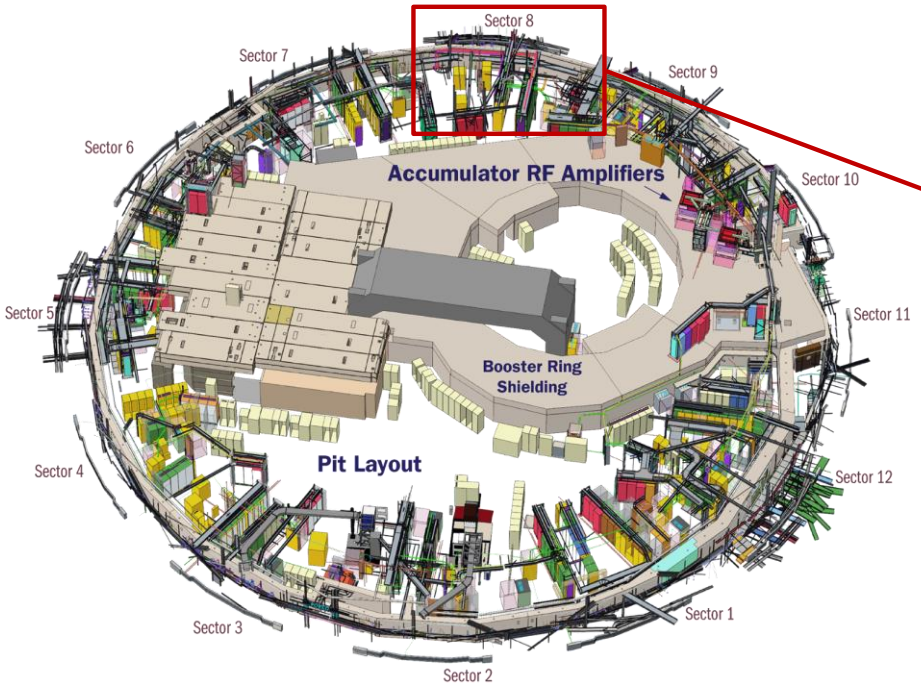
Access information via browser based interfaces to quickly access and enter information in the field

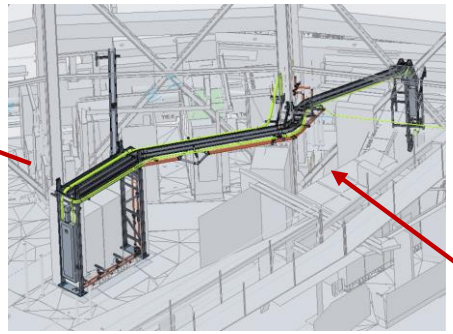
Related and linked objects, CAD, documents (QA, procurements, EG notes, measurements…)



QR codes are applied to assemblies in the field, tie available data together and allow drill down through a browser based interface with the windchill database

Cable plant and infrastructure systems

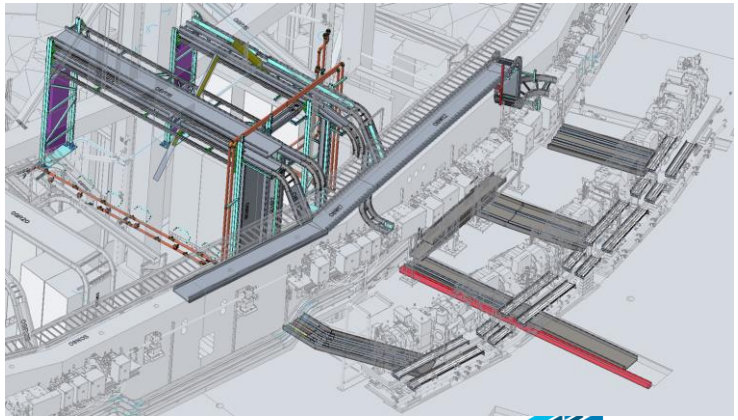




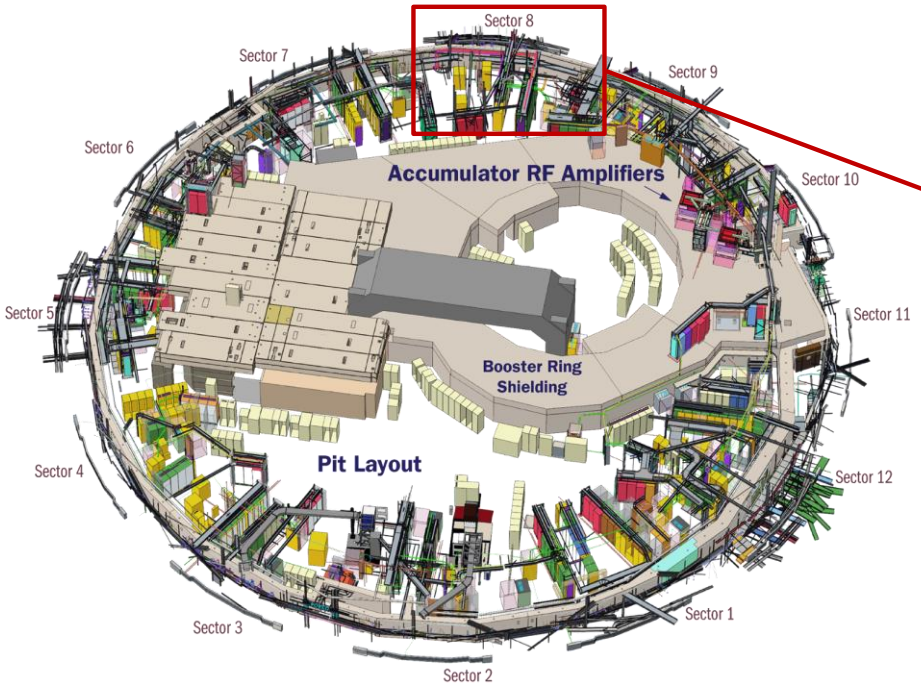
complex
as- builts

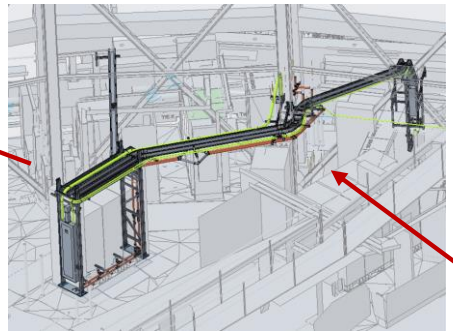
Unique and complex design to accommodate existing equipment of the before and after Dark Time

The AR was designed with extensive engineering effort using the Creo Parametric CAD system, with many field changes required due to as-builts not present in the model.



Cable plant and infrastructure systems



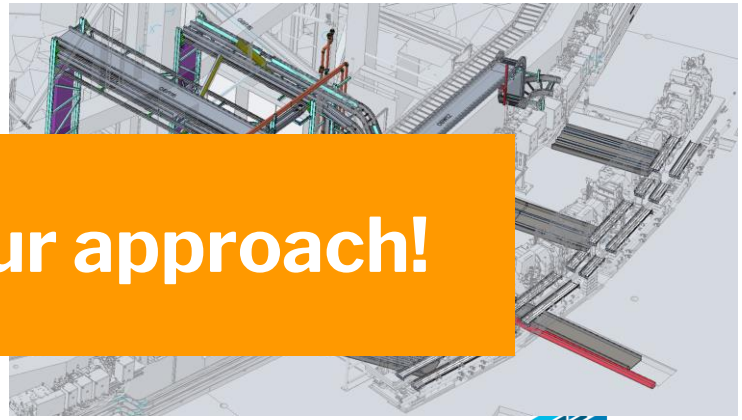


complex
as- builts

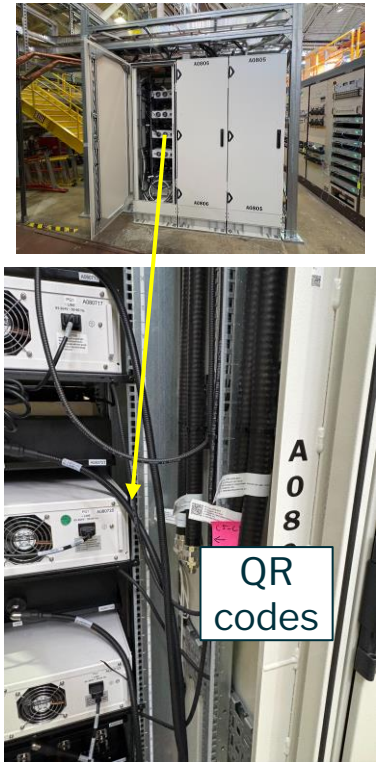
Unique and complex design to accommodate existing equipment of the before and after Dark Time

The AR was designed with extensive engineering effort using the Creo Parametric changes present in the model.

We need to change our approach!



Windchill is used as overall cable management database leveraging WtParts and Serialization capabilities



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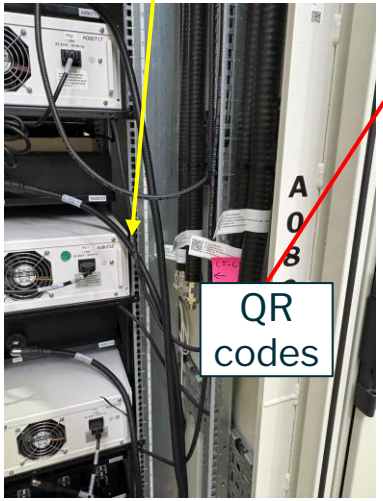
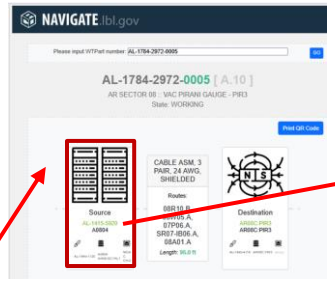
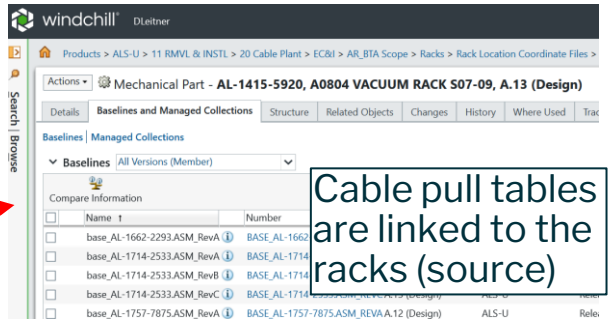


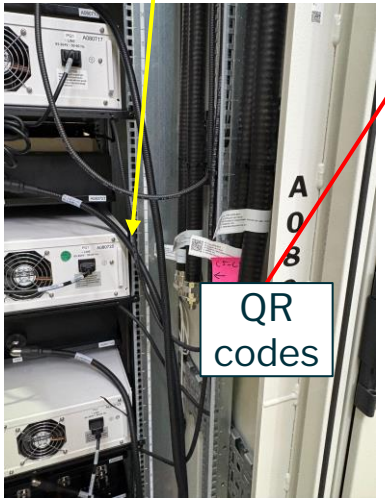


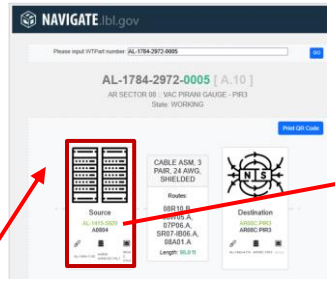


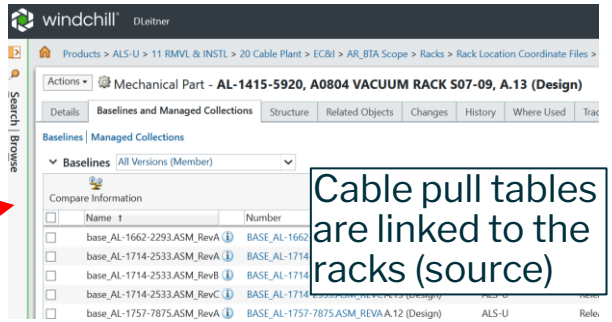
Cable pull tables are linked to the racks (source)

Cable instance with source, destination and cable status with link to rack information

Windchill is used as overall cable management database leveraging WtParts and Serialization capabilities







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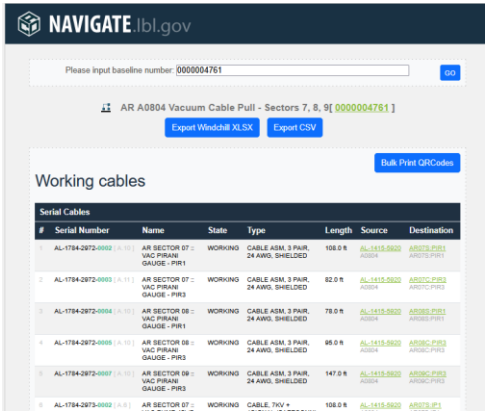

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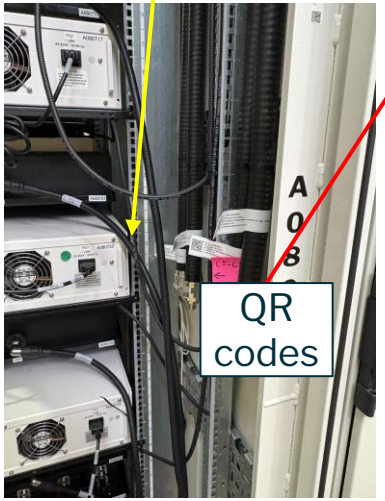

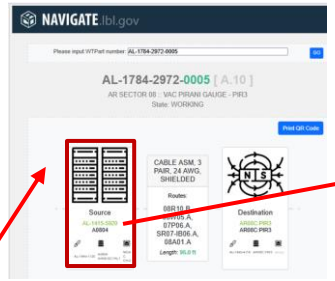

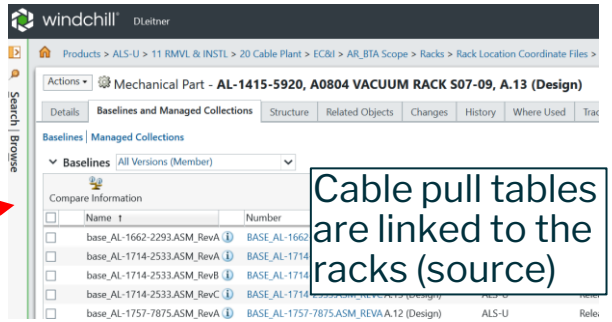

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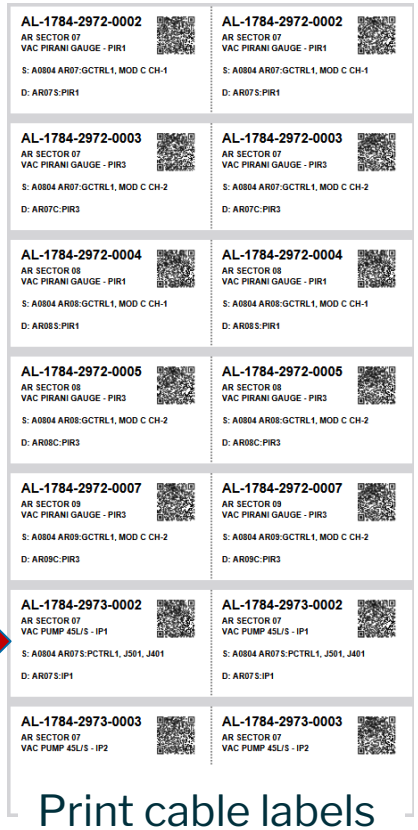
Extract cable pull sheets and workinstructions

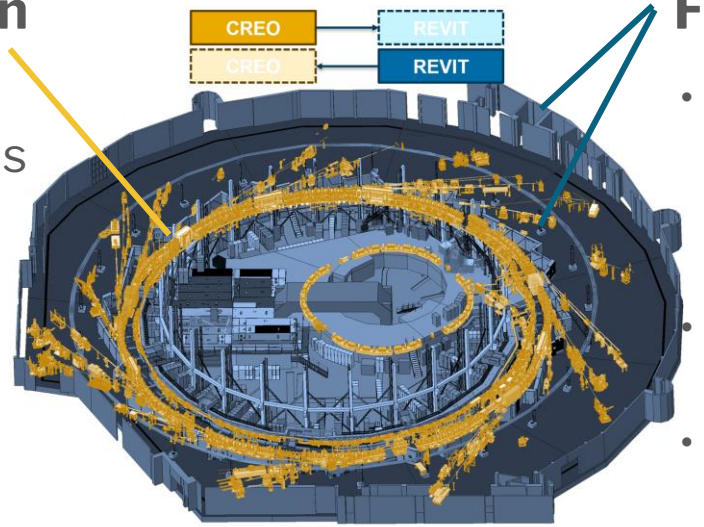


Print cable labels

Focus a dedicated engineering team on the integration of utilities and cable distribution into the facility

Accelerator Integration

- Top Assembly & Accelerator CAD models
- Link physics lattice with the CAD data
- Interface models and ancillary models



Facility Integration

- Mechanical/Electrical infrastructure systems (incl. conduits and cable routing)
- Overall Facilities CAD & BIM Models
- Integration of external contractor models

BIM Model Usage

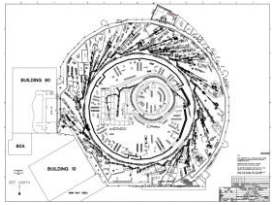
- Shared spatial model of accelerator, building, and infrastructure
- Visibility into As-Built, installation phases, construction phases
- Clash detection
- Subcontractor interface
- Utility interfaces with accelerator equipment

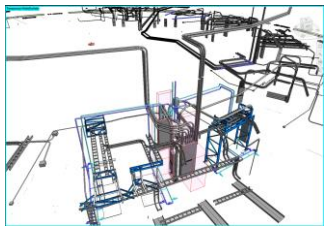
creo parametric

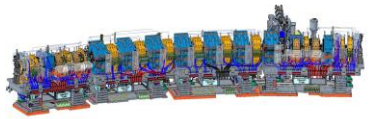
RVT

BIM capabilities provide

- Ability to integrate systems across disciplines
- Ability to integrate data sources at the accelerator, building, and infrastructure level







Historical Data

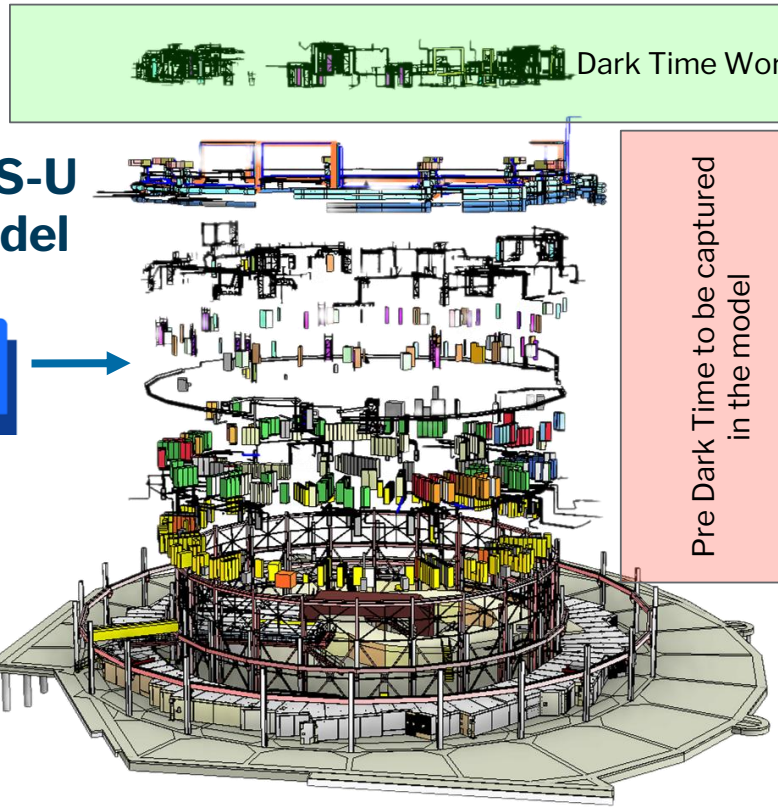
Survey Data

Point Cloud Scans

External Revit

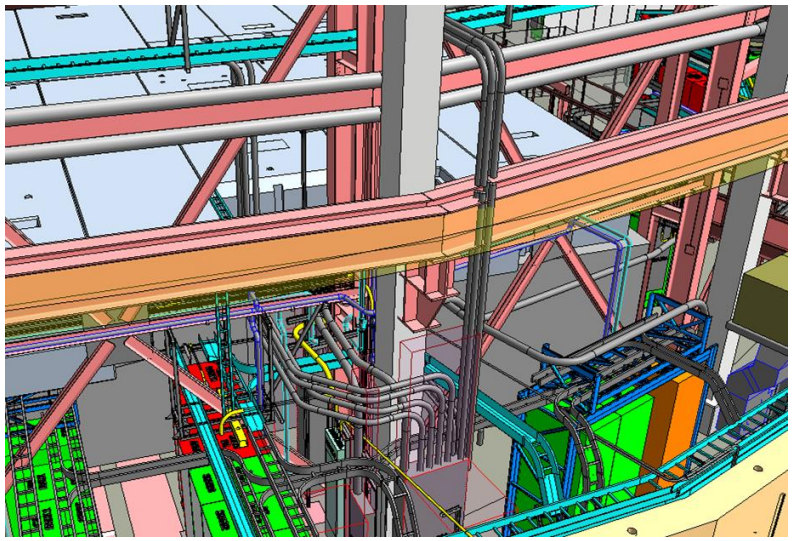
Creo Model Data

ALS-U Model



Slide courtesy of James Haliburton and Andrew Lodge

Empty space in model ≠ Empty space in facility



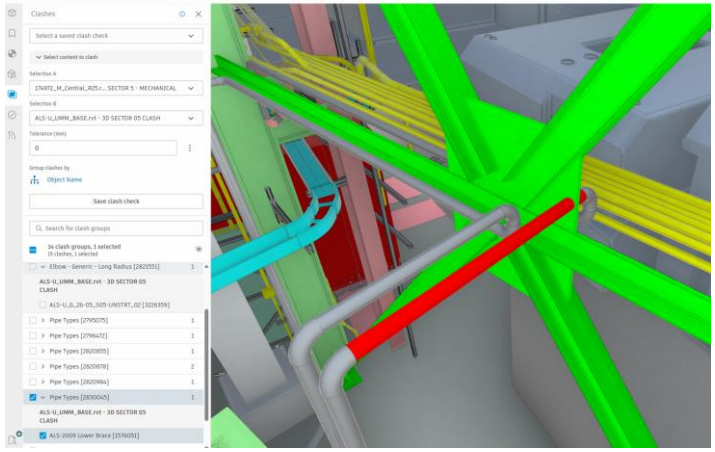
Clash Detection Tool depends on model completeness and structure

- Identifies spatial conflicts between systems
- Reveals misaligned assumptions across disciplines

Clash detection Implementation (cloud based)

- Chosen views from vendor and LBNL models form Clash Matrix
- Clashes are grouped by category
- Overlapping objects are identified by name and object ID

Conflicts are flagged in the model and can be reviewed and assessed



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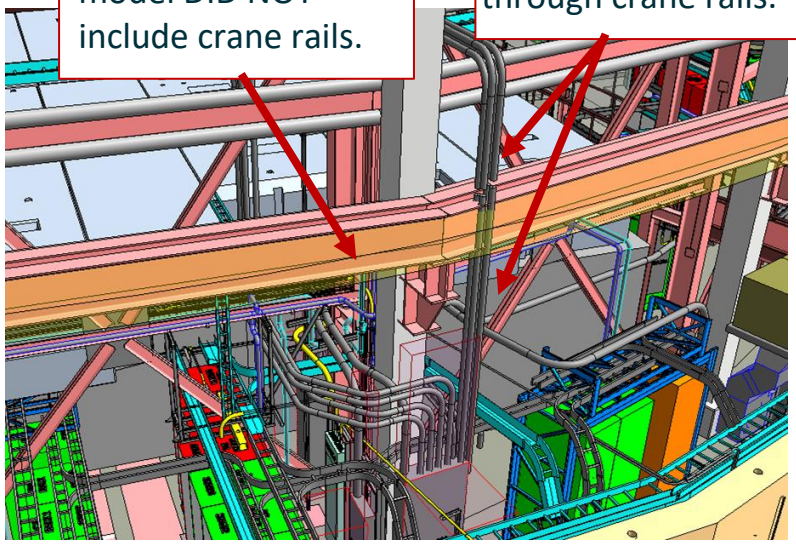

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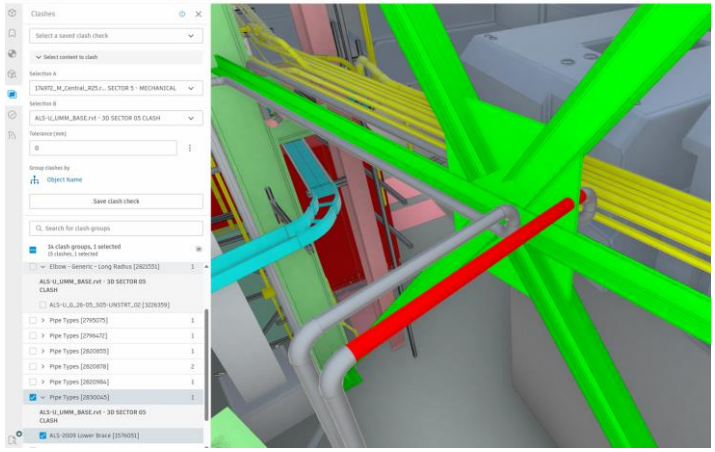

Slide courtesy of James Haliburton and Andrew Lodge

Summary

- LBNL has developed the Project Lifecycle Management Tool Windchill to serve as the main repository for all project documentation, engineering documentation, change management and quality assurance documents.
- WtPart capability is used to link hardware assemblies to reference documents and serves as a Digital Twin of the physical objects.
- Serialization is used to track individual instances of assemblies and their history.
- A cable database is embedded in the PLM Windchill framework.
- Field access to the DB is enabled through a lightweight browser based user interface via QR codes
- BIM capability is utilized to bind as-builts, building information, infrastructure design, construction documentation, and CAD hardware data together

Next steps and discussion

Next steps

- Consistently link cable plant elements, electrical data and mechanical information.
- Programmatic cabling and controls with mechanical hardware
- Integration of BIM data with LBNL configuration management system.
- Human interface and training of diverse users - managers, scientists, engineers and facility operators.

Discussion Points

- What is the right level of configuration management?
- Change management is important to track completion of engineering work and design- but of course needs effort
- Tension between schedule pressure, costs and adherence to standard process
- Team discipline - Systems are only effective if there is wide adaptation and discipline to input the data and keep them up to date

ENGINEERING

Thank you

Questions? Contact dleitner@lbl.gov