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LIFECYCLES AND WORKFLOWS FOR 3D INTEGRATION STUDIES AT CERN

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Abstract

The implementation of a new Product Data Management (PDM) and Product Lifecycle Management (PLM) system at CERN has significantly improved lifecycles and workflows for 3D integration studies, thanks to the advanced features and tools of the platform. This new PDM/PLM system has provided an opportunity to reassess and optimise user methodologies, focusing on better organisation of 3D Computer-Aided Design (CAD) data, improved collaboration with mechanical and services design offices, and more effective validation processes. Additionally, enhanced traceability throughout workflows is expected to boost overall process quality. This paper examines the challenges encountered during the transition, as well as the benefits of the new PDM/PLM, highlighting its contribution to increased efficiency and quality.

INTRODUCTION

CERN's transition to a new Product Lifecycle Management (PLM) system [1] enabled the Integration Office to improve the management of its 3D integration studies. While the change introduced constraints for managing parallel spatiotemporal configurations, it also allowed the development of dedicated workflows tailored to integration needs. These workflows, defined in close collaboration with the Information Management group and design offices, improved process clarity, reinforced validation and traceability, and ensured stronger alignment between integration studies and design activities across CERN.

3D INTEGRATION STUDIES

The Integration Office dedicated to the CERN Accelerator Chain complex is responsible for 3D integration studies across accelerators and related infrastructures. Its main task is to ensure the coherent spatial arrangement of all system elements, including core equipment such as magnets, beam instrumentation and collimators, as well as technical infrastructure, like pipework and cable trays, within highly constrained environments, both in existing installations and in future upgrades [2]. A unique aspect of 3D integration at CERN is the simultaneous management of multiple configurations across different timeframes, requiring spatial layouts that remain valid for past, current and future states. To manage this complexity, the Integration Office relies on a document-centric, independently organised structure of 3D models per configuration and timeframe, maintaining clear references to each phase and ensuring full traceability between space, milestones, and installed equipment. Preserving this method was essential when moving to the new PLM system.

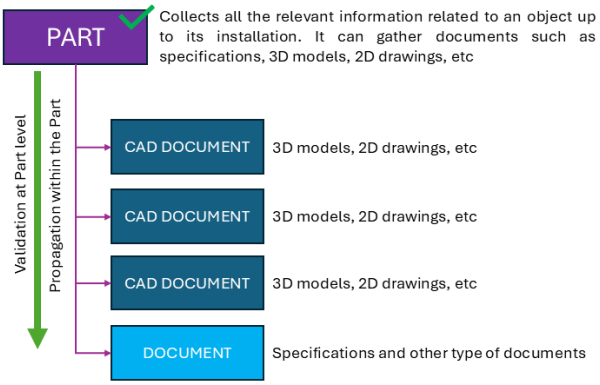

Figure 1: Part-centric process.

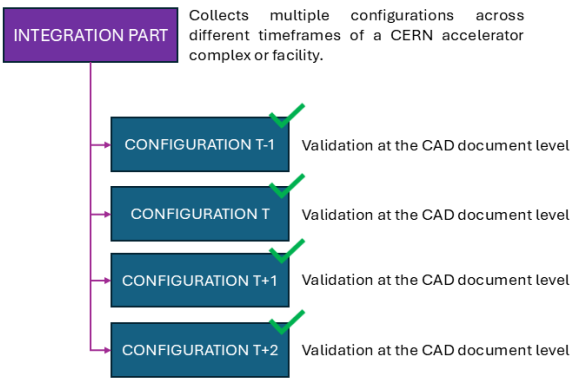

Figure 2: Document-centric process.

METHODOLOGY REVIEW TRIGGERED BY THE PLM TRANSITION

The transition to a part-centric model, as shown in Fig. 1, introduced conceptual challenges for 3D integration, particularly regarding the independence of spatial layouts across timeframes. Lifecycle states now apply globally to all Computer-Aided Design (CAD) documents attached to a part [3], risking the loss of flexibility essential for managing parallel configurations and keeping historic references across CERN databases. It became evident that this solution would not meet the unique needs of integration activities. In response, the Integration Office, in collaboration with the Information Management group responsible for the CAD/PLM service, and the Mechanical and Materials Engineering group, responsible for mechanical design at CERN, defined dedicated workflows and access control

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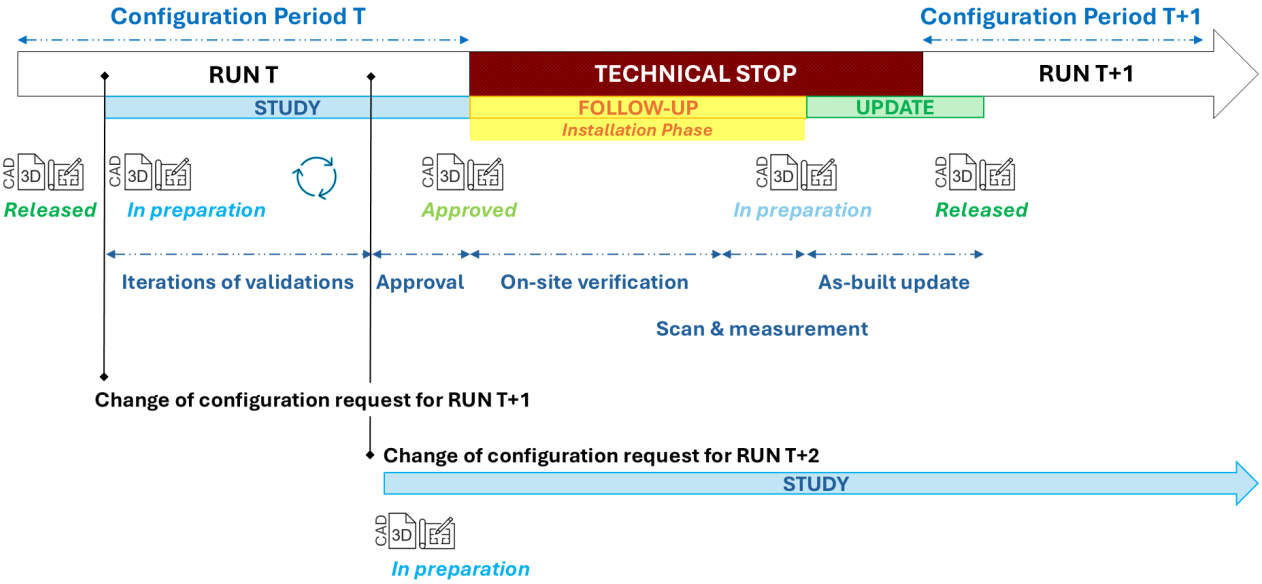

Figure 3: Integration lifecycles.

structures for document-centric processes (see Fig. 2), while launching a full review of internal methodologies to preserve flexibility and reinforce validation, traceability, and study quality. Designing these dedicated workflows required a coherent and pragmatic agreement with the CAD/PLM service and mechanical design offices. Solutions were defined after iterative prototyping phases and review cycles. The resulting system functionalities and methodology [4, 5] now represent the reference standard for integration offices at CERN.

LIFECYCLE STATES

A set of dedicated lifecycle states (see Fig. 3 and 4) has been implemented within the new CERN PLM, following ISO 11442:2006 [6] where possible:

- **In Preparation**: Default state for object development.
- **In Review**: Undergoing validation, checking, or endorsement. **Approved**: Validated and ready for final stages.
- **Released**: Final state after physical verification, authorised for operational use.
- **Replaced**: Superseded but available for reference.
- **Withdrawn**: Retired and barred from use, after formal workflow execution.

INTEGRATION WORKFLOWS

Senior Integrator Role: Securing Dedicated Integration Workflows

To safeguard the integrity of integration-specific workflows and prevent unauthorised changes, a dedicated access role was introduced: the Senior Integrator. Only users assigned to this role are authorised to initiate integration workflows focused on a CAD document level within the new PLM system at CERN. This role is managed through specific access control groups, ensuring that validations and lifecycle transitions linked to 3D integration activities are performed exclusively by trained and responsible personnel. The introduction of the Senior Integrator role strengthens process governance, improves data quality, and ensures that 3D integration studies evolve in compliance with the defined methodologies.

Valid For Integration Workflow: Improved Traceability During Early Study Phases.

The "Valid for Integration" workflow allows validation and freezing of 3D integration model versions during early study phases without altering their lifecycle state. It addresses the critical need to trace the evolution of designs when information is incomplete and multiple concepts are explored. By formally recording preliminary validations agreed upon during meetings or technical discussions, this workflow ensures that the progress of ideas is documented and preserved even before reaching formal approval stages. It improves traceability without imposing rigid lifecycle transitions, maintaining compliance with ISO standards while offering a clearer historical record of integration studies.

Approved By Integration Workflow: Strengthened Formal Approval and Collaboration Processes

The "Approved by Integration" workflow supports the formal approval of 3D configurations once validated by all relevant stakeholders, managing the transition from In Preparation through In Review to Approved, as illustrated in Fig. 4. It formalises the point at which an integration study reaches maturity, allowing the approval of 3D integration models independently of mechanical design office processes, particularly when working with simplified 3D models derived from detailed mechanical designs.

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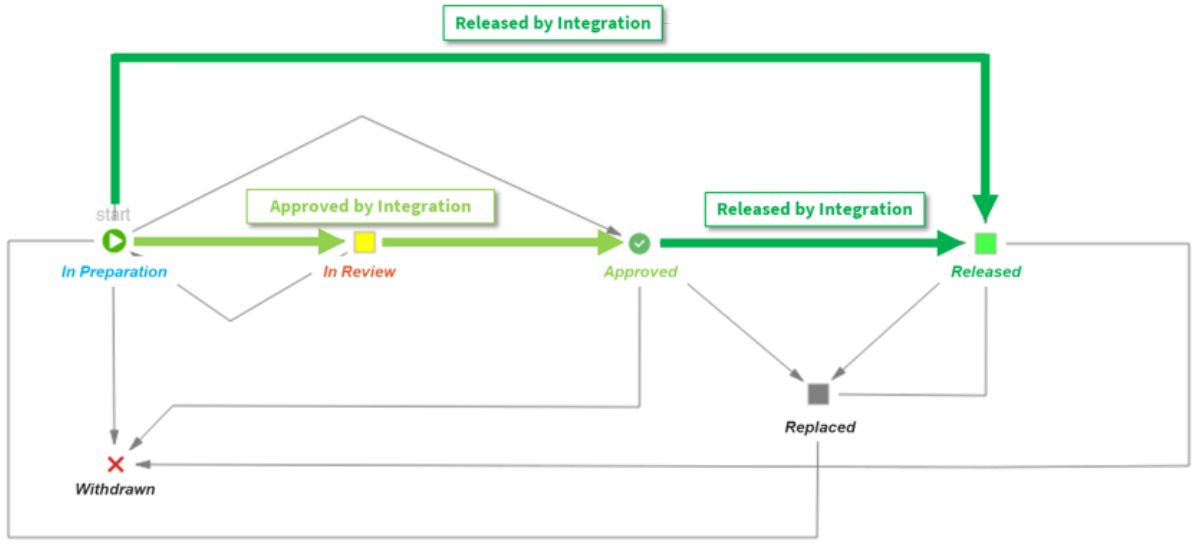

Figure 4: 3D integration workflows.

The system supports the involvement of ad hoc reviewers as needed, defined as Additional Reviewers, ensuring that integration consistency is checked during mechanical design verification, reinforcing collaboration and improving the design quality process. Controlled sharing of access rights between integration and mechanical design offices further supports this process, enabling the creation or update of simplified models while strictly limiting the scope of modifications to prevent unintended changes to mechanical CAD data.

Released By Integration Workflow: Reliable Final Documentation Through Controlled Release

The "Released by Integration" workflow applies after installation verification to transition approved integration models to the Released state (see Fig. 4). It confirms that 3D integration models accurately represent the physical reality of installed systems (i.e. "as-built"). After verifying installations, the 3D integration models are updated accordingly, and the overall integration model itself can only be released when all components within a CAD document have the Released, Approved, or Replaced status. This guarantees that final documentation fully matches the actual configuration of CERN's installations, reinforcing the quality, safety, and reliability of future projects relying on existing equipment. Together, these workflows provide a structured yet flexible framework for managing 3D integration studies under the new PLM system.

Overall, the implementation of integration-specific workflows and control mechanisms has delivered substantial benefits: Clearer and more traceable development of early-stage concepts.

- Formal approval pathways that respect the independence of integration activities.
- Strengthened collaboration between integration and mechanical design offices.
- Enhanced verification quality through mandatory involvement of Additional Reviewers.
- Safer controlled updates to shared models via access rights management.
- Reliable as-built documentation supporting future configuration management.

By addressing both the need for flexibility and the requirement for rigorous control, the new methodology significantly strengthens the management of 3D integration studies at CERN.

CONCLUSIONS

The transition to a new PLM system at CERN offered the Integration Office a unique opportunity to rethink its 3D integration methodologies from a fundamental perspective. Through early identification of operational needs, a clear strategy was established to guide the design of new workflows. Rather than adapting work practices to a predefined tool, the workflows were shaped around the real requirements of integration activities, preserving the flexibility to manage multiple space-time configurations among several CAD documents while strengthening procedural traceability and validation structures. The resulting framework combines dedicated workflows, controlled access, and structured lifecycle management. Together, these elements enable a more consistent, traceable, and quality-driven approach to 3D integration studies. As deployment progresses, further refinements will be pursued to ensure that the workflows continue to evolve alongside operational practices, fostering a continuous improvement cycle within integration activities at CERN.

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