QUALITY ASSURANCE FOR CERN ACCELERATOR BEAM-TRANSFER HL-LHC AND CONSOLIDATION DELIVERABLES

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Abstract

To assure all deliverables for the Long Shutdown 3 (LS3) will be met, the Accelerator Beam Transfer (ABT) group has launched a coordinated initiative to strengthen Quality Management (QM), Project Management (PM), and Enterprise Asset Management (EAM). A harmonized QM framework and enhanced Non-Conformity Report (NCR) process enable early anomaly detection and structured follow-up across design, manufacturing, installation, commissioning, and operation. The upgraded PM methods clarify project scope and responsibilities, enhance risk and milestone tracking, and support coordination across HL-LHC Project and Consolidation deliverables. In parallel, the unified EAM strategy enhances equipment traceability through standardized asset structures, linked documentation and NCRs, and it provides a comprehensive lifecycle overview. Additionally, logistics have been strengthened via a dedicated service supporting the group. Together, these measures establish a robust framework for planning, executing, and documenting ABT projects for LS3, but also future shutdowns, as well as interventions in the accelerators during operation.

INTRODUCTION

LS3 represents a major phase of upgrades and consolidation across the CERN accelerator complex, with extensive equipment changes linked in particular to the High Luminosity Large Hadron Collider (HL-LHC) programme. [1] Within this context, the Accelerator Beam Transfer (ABT) group is responsible for injection and extraction systems, transfer lines, and associated equipment across the LHC and injector chain, giving rise to a broad portfolio of deliverables with tight schedules and multiple technical and organizational interfaces.

Following an ABT retreat in autumn 2023, significant gaps in quality management were identified, prompting an analysis phase that produced a six-month review report [2] followed by a formal quality plan [3]. A dedicated Quality Management (QM) working group was established to define and implement a harmonized framework for QM, Project Management (PM), and Enterprise Asset Management (EAM). After two years, the effort has transitioned into the execution of this plan, marking a key milestone in project delivery. This paper describes the framework developed, with emphasis on the project management and asset management advancements achieved to date.

INITIAL SITUATION IN ABT

Prior to the QM initiative, quality management in ABT was largely informal and section dependent. Projects often started without formal roles, dedicated budgets, or minimum documentation requirements. Progress reporting was inconsistent, and documentation was scattered across personal folders, SharePoint sites, and Engineering Document Management System (EDMS) without systematic versioning or traceability. Non-conformities were tracked mainly in logbooks during operations, but shopfloor and manufacturing issues were often invisible. Previously, EAM asset structures—hierarchical trees for assemblies and sub-components—were incomplete, relying on scattered Excel tracking with poor spares visibility. Integration challenges arose with CERN tools like Layout Database (positions/3D models), GIS (spatial maps), Logbook (operations), and schedulers (PLAN/JIRA).

This created risks for LS3 deliverables, particularly around coordination across sections, integration with HL-LHC milestones, and readiness for installation and commissioning.

QUALITY PLAN AND MANAGMENT

A major step in the ABT quality initiative has been the establishment of a group-level Quality Plan that defines common principles, responsibilities, and execution rules across the full scope of ABT activities. This addresses the initial situation identified within the group, where no common quality plan or shared standards existed across sections, and expectations were often unclear.

The SY-ABT Quality Plan establishes quality as a common framework applicable to all ABT activities, including specification and design, project management, procurement and logistics, manufacturing and assembly, testing, operation, maintenance, storage, commissioning, training, and data management. Its objective is not only to ensure that technical performance requirements are met, but also to improve traceability, transparency, reliability, and long-term maintainability while giving explicit priority to safety and continuous improvement.

The plan clarifies governance. It assigns overall responsibility for quality to ABT management, defines the role of the QM steering and operational quality office, and states that quality is a shared responsibility of all group members rather than of a single specialist role. The QM working group has provided the first concrete implementation measures, including specification templates, chaired review follow-up, and the rollout of project-management guidance, thereby translating general quality principles into practical working routines.

While the initiative initially faced cultural resistance, we address this by positioning QM as a shared operational necessity, transforming individual accountability into a collective culture of reliability across all group activities.

The Quality Plan acts as the top-level reference document linking the various ABT quality developments It represents an important cultural shift for the group: from largely implicit and section-dependent practices toward a shared and visible quality framework for LS3 deliverables and future activities.

PROJECT MANAGEMENT FRAMEWORK

The most significant advancement has been in project management, where a structured process has been defined and is being rolled out.

Project Roles and Structure

Key Roles have been clarified:

- Project Sponsor: Provides mandate and oversight (Usually Group Leader)
- Project Manager: Leads execution, document and reviews.
- Project Team: Assists the Project manager in executing the project.
- Quality Officer: Ensures compliance, coordinates reviews and completion reports.

Projects follow defined pathways tailored to their origin and scope:

- Consolidation: Routine upgrades/maintenance to ensure CERN accelerator reliability (e.g., LS3 obsolescence fixes and infrastructure refresh).
- Research & Development (R&D): Exploratory work on new technologies (e.g., advanced kickers, coatings).
- External to ABT: ABT contributions to projects led by other CERN groups (e.g., Future Circular Collider (FCC) work packages, HL-LHC interfaces).

Projects are organized around four main phases: Initiation, Planning, Execution/Monitoring, and Completion. Each phase is associated with a key meeting and a minimum expected output, such as the project mandate, project-management plan, progress-review reports, and a completion or lessons-learned report as seen in Table 1.

Table 1: ABT Project Management Phases

Phase	Key Meeting	Main Outputs
Initiation	Mandate Meeting	Project Mandate
Planning	Kick-Off Meeting	Project Management Plan
Execution	Deliverables review meeting	Progress review reports
Completion	Handover / Completion meeting	Completion Report & Lessons Learnt Report

Following initial rollout and feedback—particularly positive management comments on increased initial scope/objective clarity and sponsor mandates—the framework underwent a second iteration to streamline workflows. Key refinements include online forms for project review reports (simplifying submission/standardization for faster reviews vs. documents) and iterative mandate templates, incorporating early lessons for clearer sponsor-to-manager transitions. A central Project Dashboard provides management oversight of all projects (Project ID, status, Project Manager, milestones, documentation), complemented by recommended tools like EDMS and EVM (Earned Value Management).

Early results confirm impact: 35 projects now tracked via the structure, 4 completed successfully—with tidy completion reports consolidating completed documentation. The dashboard enables project oversight, while management feedback highlighted that the structured reviews flag risks early, supporting informed decisions on project support. This approach enhances consistency and strengthens LS3 confidence, while ensuring that key deliverables are maintained.

NON-CONFORMITY REPORTING AND FOLLOW UP

ABT has established a dedicated non-conformity management procedure to harmonise NCR handling across all sections, projects, and activities, including CERN-internal work, industry contracts, and collaborations. The procedure defines NCRs as events impacting budget, production, operation, or deliverables during manufacturing, commissioning, testing, or even operation, with structured workflows to ensure detection, analysis, corrective action, and prevention of recurrence.

NCR Workflow and Criticality

Non-conformities (NCRs) either operational (causing beam downtime) or non-operational (e.g., manufacturing defects) are detected by operators via logbooks or by equipment/project responsible for other issues. A quality officer assists in entering details (title, description, disposition, criticality) into the asset management system, auto generating a document. Relevant leaders review it; critical NCRs also get management input. Criteria for NCR criticality can be seen in Table 2. Actions are then implemented, verified, and closed.

Table 2: NCR Criticality Criteria

Criteria	Non-Critical	Critical
Downtime	4-12 hours	>12 Hours
Rework Time	between 2 Days and 4 weeks	>4 Weeks
Cost	Between 0.5kCHF and 5kCHF	>5kCHF

Management Visibility and Feedback

NCRs are systematically fed back to management and stakeholders through regular updates from the QM officer in group meetings and through mandatory inter-section reviews on EDMS, ensuring that lessons learned are captured and shared across ABT. The NCR process is now in routine use across the group, improving visibility of open actions and closure status, and helping management intervene

more effectively where additional guidance, resources, or budget may be required. Since late 2024 an associated dashboard provides a consolidated view of NCR trends, criticality, ownership, status, and distribution by type, allowing the team to track 29 NCRs in total, of which 21 were critical, with categories being broken down to mechanical, electrical etc. This supports structured follow-up and reinforces cross-section learning for LS3 deliverables

ASSET MANAGEMENT

EAM forms the foundation of ABT's lifecycle tracking for high-value assets—including kicker magnets, septa, generators, and control systems—across several hundred items in operation, manufacturing, and spares. Our EAM strategy now enforces granular classification per domain, clearly distinguishing between operational equipment and spare parts. Progress toward these goals is tracked via a dedicated dashboard, serving as the primary tool for monitoring readiness. Furthermore, by linking NCRs to assets, the EAM facilitates essential safety documentation, confirming the value of the CERN-recommended tool in centralizing traceability.

EAM uses CERN-standard naming conventions to ensure compatibility without custom codes. [4]. The structure is hierarchical: main assemblies as parent assets, with subcomponents (e.g., circuits, controls) nested below. Each asset features a barcode and webpage compiling specifications, drawings, datasheets, maintenance records, and nonconformities.

EAM Benefits for ABT

EAM overcomes past limitations by providing:

- Location and status tracking: Installed assets, spares (where and how many).
- Full lifecycle view: From procurement → manufacturing → testing → operation → maintenance → NCRs.
- Tool integration: Direct links to Layout/EDMS/Logbook/PLAN/GIS/JIRA for unified data.

Once fully populated, EAM will enable real-time spares checks for LS3, access to asset history, and predictive maintenance using operational data. [5]

Implementation Status

Key efforts since 2024:

- Structure improvements: Cleaned magnets/generators/controls; approx. 500+ assets updated.
- Historical data entry: Identified key items for tracking (e.g., critical spares) and prioritized their registration, while excluding low-value consumables.
- User dashboards have been designed to facilitate efficient workflow and enhance usability for all users.
- Work orders: 3545 of Work Orders created. Tracking repairs/maintenance (underway).

Next steps: Complete critical spares (~80% goal), refine interfaces and streamline stock queries.

LOGISTICS SUPPORT

To address fragmented material handling and reception practices, ABT established the ABTeam logistics service in late 2024, which is operated by a dedicated logistics officer. ABTeam handles incoming goods reception, EAM registration, labelling, transport, and recycling, freeing project teams for design and technical work.

ABTeam services include:

- Automatic Purchase Request discovery for new purchases, followed by EDMS item/EAM part creation.
- Goods reception: counting, visual inspection, labelling (stickers or laser engraving), and documentation attachment.
- Delivery to and from operation buildings or storage kiosks.

Since its launch, ABTeam has handled over 230 individual material requests and more than 37 equipment recycling actions.

Key Achievements

- Major reorganization of the goods reception area, with added access controls, an on-site asset registration workstation, and pallet stackers.
- Audit and renaming of storage locations for clearer distinction: long-term/project stock vs. operational spares.
- Automatic registration and labelling of newly arrived assets by the ABTeam (approximately 237).

Challenges overcome: Initial resistance ("we managed fine before") and EAM learning curve, now eased via tailored workflows and training sessions.

LS3 preparations: Developing project-specific bins, optimized spares handling, and material flows aligned with HL-LHC sequences to streamline installations

CONCLUSION AND OUTLOOK

The ABT quality initiative has transitioned from gap identification to practical implementation across interconnected domains. Project management practices are operational and evolving, the quality plan provides a unified reference, NCR processes are structured, logistics services are active, and EAM rollout advances with defined ownership. The rise in EAM and NCR usage has increased workload, prompting local support enhancements—including a quality graduate since August 2024—to realize sustained benefits.

Next priorities include streamlining specification reviews, extending project management to suitable R&D/FCC work packages, enhancing EAM completeness/usability, and consolidating tools/workflows before LS3's peak demands. Amongst others, the harmonization of planning and establishment of manufacturing and inspection plans would further contribute to raise the groups quality aspects. The measures aim to enhance process repeatability, lowering the number of non-conformities while assuring documentation and guarantee an efficient knowledge transfer towards the future.

REFERENCES

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