Integrating Workflows with Project-Based CAE Environments into Simulation Data Management

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1 Summary

Simulation Data Management (SDM) is commonly used for solver-centric workflows in which an editable ASCII input deck serves as the source of truth. For project-based CAE environments such as ANSYS Workbench which bundle geometry, meshing, physics setup, parameter management and post-processing into a proprietary project structure consisting of many interdependent files and large binary databases, this model breaks down. Such projects are fragile under manual file operations, frequently exceed gigabytes per iteration, and rely on tool-managed references that are not visible at the file-system level.

This contribution presents an SDM integration concept intended to be transferable across workbench-style CAE tools. Its core elements are an immutable project snapshot that preserves all internal references, and externally managed inputs like CAD geometry, materials, parameter sets captured as versioned objects. A reference implementation based on SCALE.sdm demonstrates CAD integration, a configurable Python-based tool connector, automated result capture and end-to-end traceability from upstream baselines to solver outputs.

2 Introduction

SDM has matured in solver-centric workflows such as LS-DYNA, PAM-CRASH, NASTRAN and Abaqus, where the simulation input is an editable ASCII deck and outputs follow stable conventions. Versioning and change tracking in these cases are straight forward and rely on textual differences and well-defined artifact boundaries.

In many engineering departments, however, an increasing share of simulations is authored in project-based CAE environments such as ANSYS Workbench, COMSOL, Moldex3D, STAR-CCM+, and others. These environments bundle geometry handling, meshing, physics setup, parameter management and post-processing into a proprietary project structure that consists of many interdependent files, large binary databases, and tool-managed references. The resulting projects are fragile under manual file operations, frequently exceed gigabytes per iteration, and cannot be reliably moved, merged or archived with conventional file-based methods.

Using ANSYS Workbench as a representative example of a project-based CAE environment, this paper identifies the recurring practical challenges observed in such workflows, proposes an SDM integration concept that addresses them, and illustrates the approach with a reference implementation.

3 Challenges in Project-Based CAE Workflows

Even in the simplest setting — a single engineer building geometry, mesh, boundary conditions and running a simulation inside one Workbench project file — version management becomes non-trivial. Engineers commonly resort to manual duplication of project folders, producing directories such as Project_v1, Project_v2, Project_final and Project_final_final. This constitutes manual copying, not version control, and becomes unsustainable as soon as multiple engineers collaborate on geometry, mesh, materials or boundary conditions simultaneously.

Four recurring problems are observed in practice:

- ***Risky manual copying.*** Entire project directories are duplicated for small changes. The current or authoritative version is often unclear, and internal tool references are easily invalidated by file-system operations.
- ***Untraceable parameter drift.*** No systematic record captures who modified which parameter, when and why. Troubleshooting, auditing, and regulatory documentation are difficult.
- ***Loss of reproducibility.*** Without the exact input configuration that produced a given result, runs cannot be reliably reconstructed — a critical gap for quality assurance.

- ***Inefficient sharing.*** Large project files are transferred via email, shared drives or spreadsheets; collaboration slows down and engineers end up working in isolation.

These problems are amplified in project-based environments by limited scripting access to internal tool state, opaque internal dependencies and the need to preserve tool-specific link structures that are not visible at the file-system level.

4 Proposed Integration Concept

The concept is framed to be transferable across workbench-style CAE tools rather than specific to ANSYS Workbench. It rests on three elements.

4.1 Immutable project snapshots

A project snapshot captures a consistent, re-openable state of the tool-native project and preserves all internal references that must remain intact. Snapshots are immutable and versioned inside the SDM repository, which allows any previous state to be retrieved and reopened without manual file operations.

4.2 Library "Pools" for externally managed inputs

A project typically consumes upstream artifacts that are owned outside the CAE tool: CAD geometries from PDM systems, material definitions from validated libraries, parameter baselines and boundary-condition templates. These are managed in SDM as versioned entities inside Pools which are strictly versioned and injected into the project as references. This reflects the practical split between tool-native artifacts that must remain fixed inside the project structure and upstream data that must be synchronized reproducibly.

4.3 Traceability

Each simulation run is associated with the exact Pool-Versions of its geometry, materials and parameter sets, together with the outputs produced from that configuration. Any past run can therefore be reconstructed unambiguously, and iterations can be compared on a consistent set of inputs rather than on loosely labelled file copies.

5 Reference Implementation

The concept, although generic in principle, is realized as a reference implementation in the SCALE.sdm platform. The complete workflow is shown in Fig. 1.

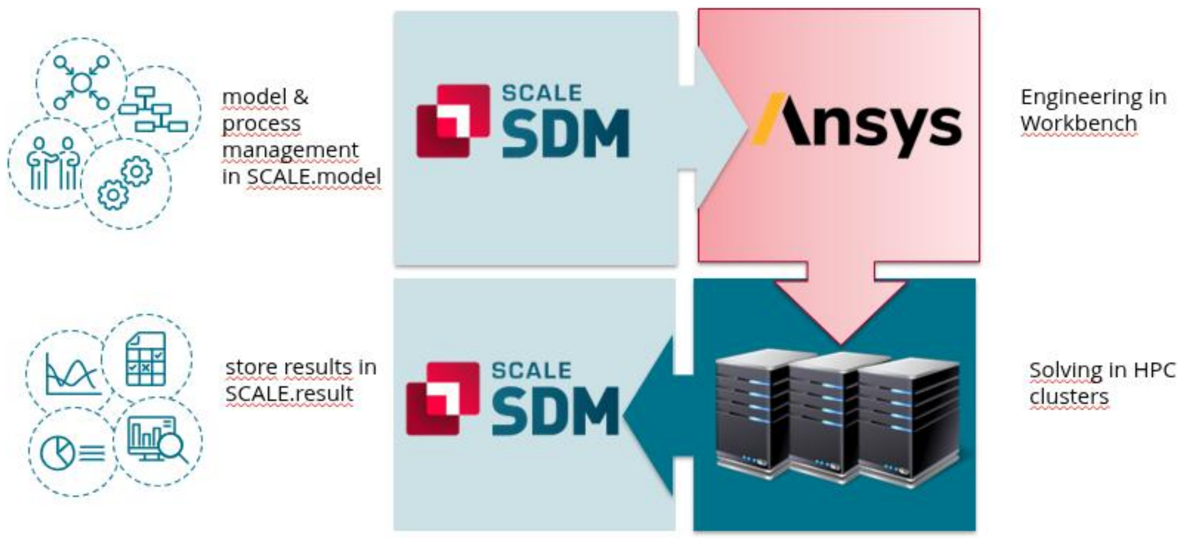

Fig. 1: End-to-end workflow.

The Model module manages input artifacts (geometry, mesh, materials, boundary conditions, solver settings) with version control and parameter management. The input data can be opened in Ansys Workbench from within the SDM system and can be further edited as per user requirements. The simulations can be solved locally or on a HPC System. Using post-processing scripts, KPIs are automatically extracted to be stored in Result module. The Result module stores and evaluates simulation outputs, links them to the producing model and solver setup, and also provides integrated post-processing, KPI extraction and comparison.

5.1 Upstream CAD integration

SCALE.sdm connects to CAD systems including CATIA, NX, SolidWorks and Creo. Geometry and design data flow into the simulation environment as versioned objects, so every design update is automatically linked to the dependent simulation models and results. This removes the manual export and file-exchange step between design and simulation teams that is a frequent source of version mismatches.

5.2 CAE tool integration via External Applications

The integration with ANSYS Workbench is implemented through a configurable mechanism called External Applications. Each External Application is a Python script that uses the Python API of the SDM System to access SDM-managed data and to launch the target CAE tool with the correct files and settings. Engineers launch Workbench directly from the context menu of a project in the SDM client; no manual downloads, folder management or ad-hoc file copying is required. Beyond launching the tool, an External Application can automate setup steps for example, loading the correct geometry into the Geometry system and activating task-specific extensions. Because these scripts are stored centrally in SDM, they can be distributed across teams as reusable, governed standards.

5.3 Shared libraries

SDM Systems support shared libraries for example, material libraries and common CAD components — that are referenced by multiple projects. When a library item is updated, the change becomes available to every referencing project, enabling CAE experts to propagate validated data and best practices across the organisation without ad-hoc distribution.

5.4 Solver execution and automated result capture

In the demonstrated workflow, solver runs are executed from the Workbench environment, either locally or through an HPC system. Upon solver completion, a Python routine embedded inside Mechanical automatically pushes the result files, solver logs and metadata to the SDM Result module. The full Workbench project including models, parameters and solver settings can additionally be saved back to SDM as a versioned snapshot. Every result remains explicitly traceable to its originating project snapshot and the referenced upstream Pool-Versions (geometry, materials, parameters). In the Result module, multiple results can be selected interactively and the associated report with attached KPIs, images and curves updates dynamically, enabling side-by-side comparison of design variants without manual replotting. Because result attachments, solver logs and the full project snapshot are captured in a single governed transaction, each simulation run carries an audit-ready record of what was computed, with which inputs and on which compute target. Combined with the SDM client's rail-graph and history view of iterations, this supports rapid navigation between versions and makes variant comparison and regulatory documentation first-class outputs of the workflow rather than manual afterthoughts.

5.5 Day-to-day interaction

Engineers interact with the integrated environment through a rich desktop client that exposes version history as a rail graph, which makes the otherwise complex web of snapshot dependencies navigable at a glance. Selecting an artifact shows its version history, metadata and, where applicable, an inline 3D preview without the need to launch the CAE tool (Fig. 2). Folder structures inside a project are customizable per use case rather than fixed by the SDM schema, which allows teams to organize data along their existing engineering conventions while still benefiting from the underlying version control. Every simulation result is stored in result databank, and KPIs are extracted using custom post processing scripts. On the result side, multiple simulations can be selected simultaneously in a tabular view; the attached solver outputs, logs, images and KPI curves appear in a dynamically updated report so that interactive comparison across variants becomes the default mode of evaluation rather than a separate manual step (Fig. 3). A user has access to thousands of simulation results in the databank which have accumulated over time from all other colleagues for a quick comparison. A complementary web interface provides lightweight read access for stakeholders who do not require the full desktop client.

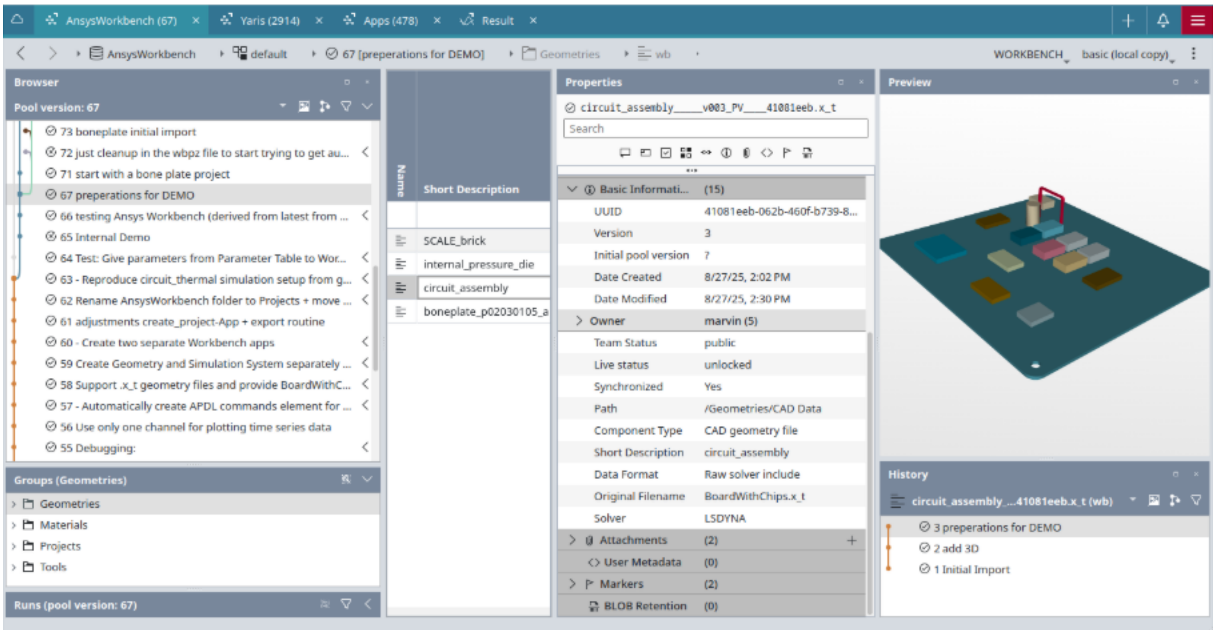

Fig. 2: SCALE.sdm UI for model management.

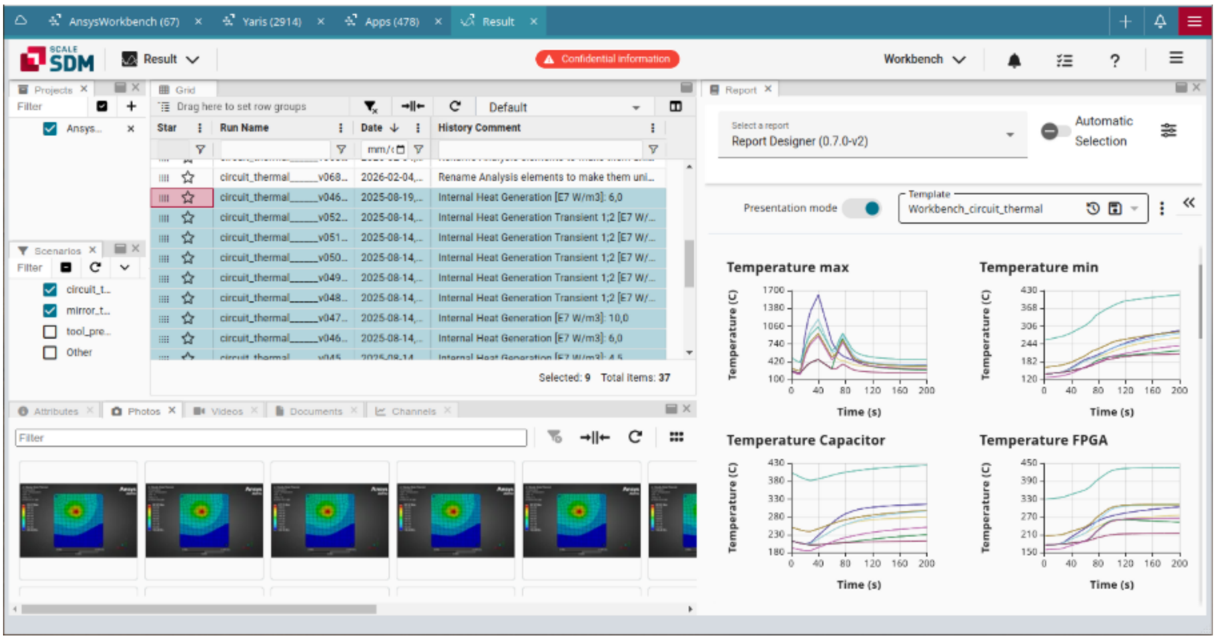

Fig. 3: SCALE.sdm UI für result management.

6 Conclusions

Project-based CAE environments require an SDM approach that goes beyond ASCII-deck versioning. By combining immutable project snapshots with versioned Pool-Versions for externally managed inputs, and by embedding lightweight actions directly into the CAE tool, file-based fragility can be replaced with reproducible, traceable configurations. The approach is transferable across workbench-style tools; the implementation in SCALE.sdm demonstrates its feasibility in practice.
The expected outcomes are:

- A centralised source of truth for models, parameters, results and reports, replacing scattered folders and version confusion.
- Reduced reruns, as past configurations can be reproduced without guesswork.
- Faster onboarding through reusable templates, shared libraries and predefined workflows.

- Better engineering decisions, supported by traceable and comparable results across design variants.