WHITE PAPER

MES Integration Architecture for S/4HANA Manufacturing

Lessons from Complex Manufacturing Organisations

Automotive · Pharmaceuticals · Chemicals · Oil & Gas

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April 2026

Executive Summary

The integration of Manufacturing Execution Systems (MES) with SAP S/4HANA represents one of the most technically demanding and strategically consequential challenges in modern industrial digitalisation. Organisations across automotive, pharmaceutical, chemicals and oil & gas sectors are discovering that while S/4HANA provides a powerful enterprise backbone, the real transformation value is only realised when shop-floor execution data flows seamlessly to and from the ERP layer.

This white paper draws on direct programme experience across seven full end-to-end S/4HANA implementations — including one of the UK's largest automotive S/4HANA transformations, the world's first global ICSM and BRH implementation at a Top 5 pharmaceutical company, a commercial Cell and Gene Therapy CDMO programme, and multiple global pharmaceutical and industrial clients — to share the architectural patterns, integration decisions, and hard-won lessons that determine whether an MES-S/4HANA integration succeeds or fails.

> *The central thesis: MES integration is not a bolt-on after the S/4HANA core goes live. It must be designed as an architectural first principle from the blueprint phase, or organisations pay a significant cost in rework, data reconciliation, and lost operational value.*

1. The MES Integration Imperative

1.1 Why MES Integration Has Become Critical

Three converging pressures are making real-time MES-ERP integration a business necessity rather than a technical nicety:

- Regulatory compliance demands — GxP in pharmaceuticals, IATF 16949 in automotive, and ISO standards across industry require digital, auditable manufacturing records that cannot be produced from a paper-based shop floor.
- Operational efficiency requirements — advanced planning tools such as SAP IBP and PP/DS can only optimise production schedules when they receive real-time feedback on actual production progress, machine states, and quality outcomes.
- Industry 4.0 and digital twin ambitions — the vision of a digital twin that mirrors the physical plant in real time is entirely dependent on bidirectional data flows between the shop floor and the enterprise layer.

1.2 The Scope of the Integration Challenge

'MES integration' encompasses several distinct integration domains, each with its own technical patterns, data models, and governance requirements:

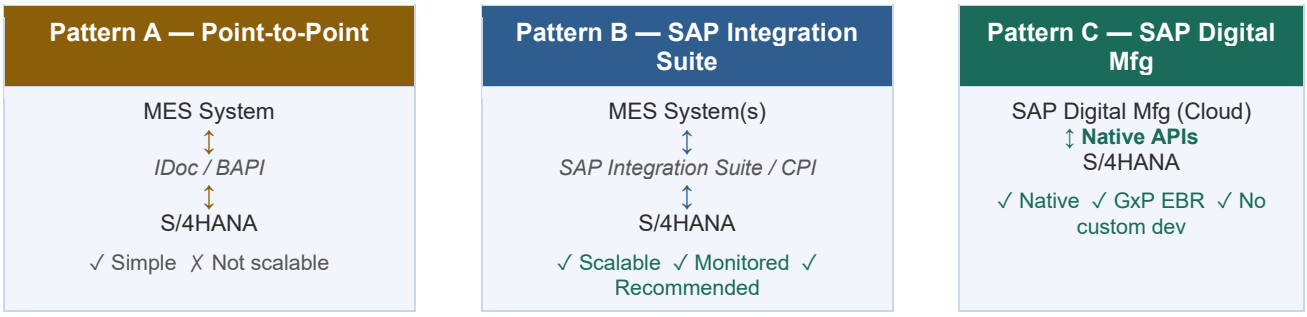
Integration Domain	What Flows	Key SAP Objects
Production Order Execution	Order confirmations, operation completions, scrap and yield	PP orders, Plant Maintenance, QM inspection lots
Goods Movements	Goods issue to order, goods receipt from order, storage unit transfers	MM movements, EWM transfer orders, HUM
Quality Management	In-process inspection results, usage decisions, non-conformances	QM inspection lots, quality notifications
Equipment & OEE	Machine states, downtime events, OEE calculations	PM functional locations, measurement documents
Batch & Genealogy	Batch classifications, parent-child relationships, component traceability	MM batch management, classification, WM
Serialisation & Track/Trace	Serial number creation, pack-level aggregation, SSCC assignments	ATTP, HUM, SD delivery items

2. Architectural Patterns — What Works and Why

2.1 The Three Integration Architectures

MES-S/4HANA integration is delivered through one of three primary architectural patterns. Choosing the wrong one for the organisational context is one of the most common and costly mistakes.

Figure 1 — The Three Integration Patterns Compared



Pattern B (SAP Integration Suite) is the recommended architecture for programmes with multiple MES systems or future expansion plans.

Pattern A — Point-to-Point (IDoc / BAPI)

The legacy approach. Direct BAPI calls or IDoc messages pass between MES and SAP without a middleware layer. Simple to implement for a single MES, fragile at scale.

- Appropriate for: Single MES system, stable interface, low transaction volume, no plans to add further shop-floor systems.
- Avoid when: Multiple MES systems, high volumes, or architecture needs to evolve. Creates a web of dependencies that becomes unmaintainable.

> *Lesson from a major automotive programme: Point-to-point integration that worked for legacy WM became technically unmanageable when extended to embedded EWM and MFS. The architectural cost of retrofitting a middleware layer mid-programme was significantly higher than designing it in from the start.*

Pattern B — SAP Integration Suite / CPI (Recommended)

The strategic pattern for S/4HANA programmes. SAP Integration Suite acts as the central hub. Standard adapters handle IDoc, ODATA, REST, and SOAP. Event-driven patterns via SAP Event Mesh enable real-time shop-floor data without polling.

- Single integration layer to monitor and maintain. New MES systems connect to CPI, not directly to S/4HANA.
- SAP Event Mesh enables the event-driven Warehouse Order Business Event integration available from S/4HANA 2025 FPS0 — the strategic direction for automation integration.

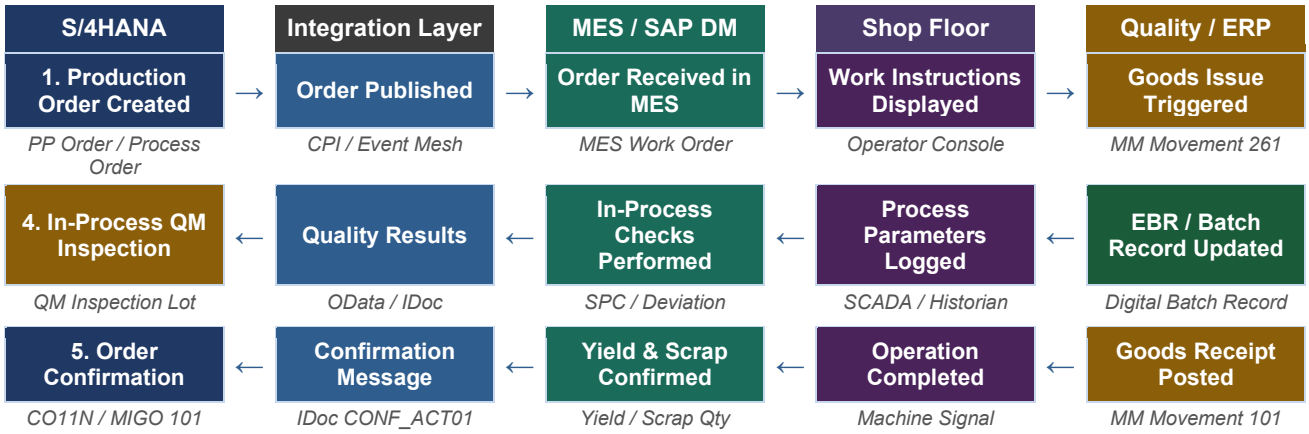
Pattern C — SAP Digital Manufacturing (Cloud)

Where the MES layer itself is SAP Digital Manufacturing Cloud, integration is native. Production orders, confirmations, and quality results flow through standard S/4HANA APIs without custom development. Increasingly adopted in pharmaceutical manufacturing for GxP electronic batch record capability.

2.2 Production Order Execution — End-to-End Flow

The production order execution cycle illustrates the full scope of bidirectional data flows required between S/4HANA, the integration layer, MES, and the physical shop floor.

Figure 2 — Production Order Execution Flow: S/4HANA ↔ MES ↔ Shop Floor

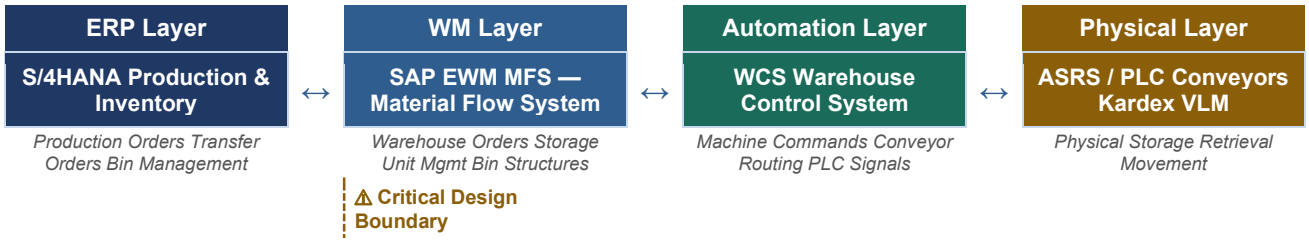


Each message flow requires explicit design, error handling, and performance benchmarks. The integration is only as strong as its weakest message type.

2.3 ASRS and MFS Integration — The Hidden Complexity

Automated Storage and Retrieval Systems (ASRS) and Material Flow Systems (MFS) represent a distinct and frequently underestimated integration challenge. The ASRS operates at millisecond response times — a world apart from the transactional SAP layer.

Figure 3 — ASRS/MFS Architecture: Four-Layer Integration Stack



The EWM/WCS boundary is the highest-risk design decision in any warehouse automation programme. Document it explicitly in an Architecture Decision Record before configuration begins.

> *Lesson from a UK automotive programme: The bin management boundary between EWM and automated vertical storage units required three architecture iterations before reaching a design that satisfied both operational and technical requirements. Defining this boundary explicitly in the blueprint phase would have saved six weeks of rework.*

The key architectural principle: EWM owns the logistics logic — what to move, from where, to where, in what sequence. The WCS owns the physical execution — how to move it, machine commands, conveyor routing. This boundary must be documented explicitly in an Architecture Decision Record before configuration begins.

3. Cross-Industry Patterns — What Transfers and What Does Not

3.1 Automotive — Cell Design and JIT Sequencing

In automotive manufacturing, the production cell is the fundamental unit of planning and execution. S/4HANA's integration with MES centres on cell-level production orders, JIT sequencing from the OEM demand signal, and real-time feedback on cycle times and quality.

- Cell design in S/4HANA maps to work centres and production resources/tools (PRTs). Each cell has a capacity profile that PP/DS uses for scheduling. Accurate cell design data in SAP is a prerequisite for any meaningful planning optimisation.
- JIT delivery integration requires S/4HANA to receive sequence numbers from the OEM and convert them into production orders with the correct variant configuration and delivery timing.
- The MES provides real-time cycle time data back to S/4HANA, enabling dynamic rescheduling when a cell falls behind the production plan.

3.2 Pharmaceuticals — GxP, Batch Genealogy, and Electronic Batch Records

Pharmaceutical MES integration carries a layer of regulatory complexity absent in most other industries. Every data point that flows between MES and S/4HANA is potentially subject to GxP audit requirements.

- Electronic Batch Records (EBR) in SAP Digital Manufacturing must capture every process parameter, operator action, equipment ID, and material lot used during manufacturing — a primary regulatory document, not a reporting function.
- Batch genealogy in S/4HANA tracks parent-child relationships between input batches and output batches. When integrated with MES, this extends to component-level traceability.
- In-process quality data flows from MES to SAP QM inspection lots in real time. Usage decisions can be automated based on specification limits, or routed for manual review via workflow.

> *Lesson from a global Top 5 pharmaceutical programme: The integration between ICSM and the manufacturing execution layer required explicit design of the batch status handoff — when does a batch move from 'in production' in MES to 'awaiting release' in ICSM? This transition point carries significant regulatory weight and must be defined precisely in the solution blueprint.*

3.3 Oil & Gas — Real-Time Process Data and Tank Management

In oil and gas and bulk chemicals manufacturing, the process historian captures thousands of process variables per second from the distributed control system (DCS). Integrating this data with S/4HANA IS-Oil and bulk scheduling requires significant data reduction and business rules.

- Tank management in IS-Oil requires accurate, real-time inventory at each tank — originating in the DCS historian and reconciled with the SAP balance.
- The integration architecture must address the impedance mismatch between historian data (continuous, time-series) and SAP data (transactional, event-driven). Intermediate aggregation rules define how process averages become SAP measurement documents.

4. The Five Most Common Mistakes

4.1 Designing MES Integration as a Phase 2 Activity

The single most damaging decision on any S/4HANA programme that includes MES integration. Core S/4HANA design decisions made in phase 1 — production order structure, batch classification schemas, quality inspection plan design — have direct consequences for MES integration. Retrofitting MES connectivity to a live system is significantly more expensive than including it from the start.

> *Recommendation: Conduct an MES integration architecture workshop in the blueprint phase, even if MES go-live is planned for a later phase. Document interface requirements, data ownership boundaries, and message schemas before S/4HANA core configuration begins.*

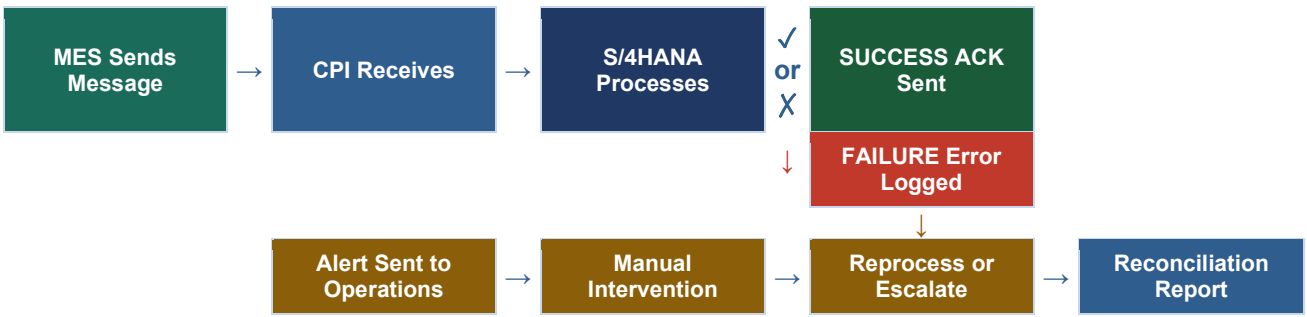
4.2 Underestimating the Data Governance Challenge

MES integration surfaces data quality issues that were invisible when the shop floor operated independently. Bill of material accuracy, work centre routing consistency, and unit of measure alignment all require a higher standard of data precision than manual production reporting demands.

4.3 Neglecting the Error Handling Architecture

In a live MES-S/4HANA integration, things go wrong. The question is not whether errors occur — they always do — but whether the architecture handles them gracefully or creates a production crisis.

Figure 4 — Error Handling Flow: From Failure to Resolution



Every message flow requires an explicit error handling design. Discovering error scenarios in a live production environment is significantly more costly than designing for them upfront.

- Message queuing and guaranteed delivery — in high-volume automotive environments, thousands of confirmations per shift must be posted without loss.
- Reconciliation reports — daily or shift-level reconciliation between MES totals and SAP confirmed quantities catches integration gaps before they become audit findings.

4.4 Ignoring the Network and Latency Architecture

Shop-floor systems have different network requirements than office systems. A confirmation that takes 3 seconds to post in SAP is invisible to a finance user. It may be unacceptable on a production line running at 60 units per minute. Latency requirements must be defined per interface and tested under load.

4.5 Treating the MES as a Black Box

A common failure mode is for the SAP team to treat the MES as something that 'just needs to send us the data.' In reality, MES configuration must be aligned with the S/4HANA design, requiring active collaboration between both teams from blueprint day one.

5. The Integration Blueprint — A Practical Framework

5.1 The Eight Deliverables Every Programme Needs

Deliverable	Why It Matters
1. Interface Catalogue — every message flow documented with source, target, trigger, frequency, and volume	Provides the baseline for design, testing, and monitoring. Without it, interfaces are discovered in testing rather than designed upfront.
2. Data Ownership Matrix — who owns each data element, who can update it, and where is the master record	Prevents the most common integration failure: two systems updating the same field with conflicting values.
3. Architecture Decision Records (ADRs) — documented decisions on pattern, middleware, error handling, and boundary ownership	Creates an auditable record of why design decisions were made, reducing rework when team members change.
4. Integration Test Scenarios — end-to-end from shop floor event to ERP posting, with expected results	Integration testing is where most failures are discovered. Comprehensive scenarios accelerate resolution.
5. Error Handling Design — per interface: what happens on failure, retry logic, alerting, and reprocessing	Go-live without error handling design means the first production error creates a crisis rather than a managed exception.
6. Performance Benchmarks — latency and throughput targets per interface, tested under production volumes	Functional correctness is necessary but not sufficient. An interface that works at low volumes may fail at production rates.
7. Cutover Integration Plan — how live MES and SAP data are synchronised at go-live	The cutover is the highest-risk moment. Without a specific integration cutover plan, data gaps occur.
8. Hypercare Monitoring Dashboard — real-time visibility of interface health in the weeks after go-live	Most production integration failures occur in the first 4 weeks. A monitoring dashboard enables rapid detection.

6. Emerging Patterns — What Is Changing in 2026

6.1 Event-Driven Architecture and SAP Event Mesh

The traditional request-response model of MES-SAP integration is being displaced by event-driven architecture. SAP Event Mesh enables MES systems to publish events — a machine stops, a batch completes, a quality hold is applied — that S/4HANA and other systems subscribe to in real time. The Warehouse Order Business Event integration available from S/4HANA 2025 FPS0 is the most visible example of this shift in the EWM space.

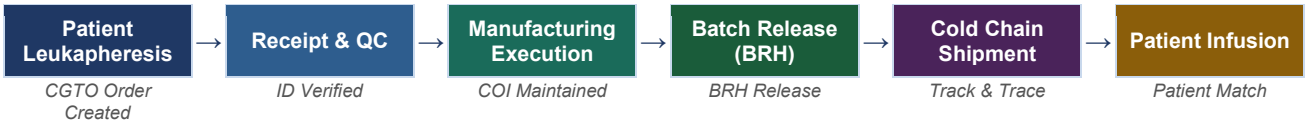
6.2 AI-Assisted Anomaly Detection

The availability of real-time MES data flowing into S/4HANA or SAP Analytics Cloud enables a new class of manufacturing intelligence. Machine learning models trained on historical production and quality data can identify anomaly patterns — a gradual drift in a process parameter that precedes a batch failure — that were previously invisible. The integration architecture must be designed to support this: structured data, consistent timestamps, and complete genealogy.

6.3 Cell and Gene Therapy — A New Integration Frontier

The cell and gene therapy (CGT) industry creates an entirely new MES integration challenge. Unlike conventional pharmaceutical manufacturing where thousands of identical doses are produced in a batch, CGT manufacturing is inherently personalised — each patient's cells are collected, processed, and returned to that specific patient.

Figure 5 — CGT Chain of Identity (COI) Flow: CGTO + MES Integration



⚠ **Chain of Identity (COI) maintained at every step — a break is a patient safety event, not a data quality issue. CGTO + MES integration governs this boundary.**

SAP CGTO (Cell and Gene Therapy Orchestration) manages the chain of identity and chain of custody across the manufacturing journey. The integration between CGTO and the shop-floor MES must maintain patient identity integrity at every step — from leukapheresis receipt through manufacturing, release, and delivery. This is arguably the most demanding MES integration challenge in any manufacturing sector.

About the Author

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Ram is a Senior SAP Solution Architect with 28 years of end-to-end programme delivery across S/4HANA, EWM, TM, PP/DS and MES integration. He has delivered seven full S/4HANA implementations and supported over twelve clients across manufacturing, automotive, life sciences, chemicals and oil & gas.

Current and recent engagements include: leading MES integration and ASRS architecture on a major UK automotive OEM's S/4HANA programme; Senior CGTO Solution Architect for a global biopharmaceutical CDMO; and previous roles on the world's first global ICSM/BRH implementation at a Top 5 pharma company, and major programmes at global specialty chemicals and biopharma organisations.

Certifications: TOGAF · GxP Computer Validation (FDA/EMA) · S/4HANA EWM · IATF 16949 aware

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