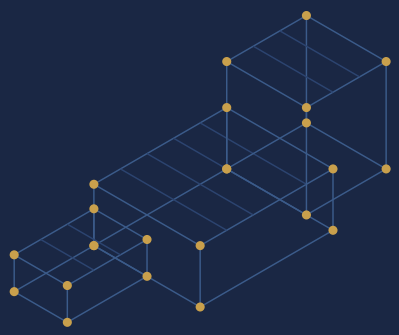


The Digital Thread

Why AI in manufacturing fails at the seams, not at the algorithm

In an Aras survey, 89% of industrial executives polled call the digital thread critical to success with AI. Yet Tech-Clarity finds that only about one in five large manufacturers has truly mature PLM–MES integration, and more than three-quarters still assess the impact of engineering changes by hand. Lay AI over that, and you automate the gaps.

SUMMARY

PLM, MES, and manufacturing IT programs rarely fail on the software. They fail at the seams: between requirement and solution, engineering and production, system of record and downstream system, legacy data and target system. The same holds for AI. It delivers value where a continuous data thread runs from engineering to the shop floor, and does little where changes still travel by hand between systems.

This paper maps the situation in four chapters:

1. **Break points:** six typical places where the thread breaks.
2. **Target picture:** what a continuous digital thread looks like.
3. **AI:** what it can and can't do on that thread.
4. **Approach:** four steps to close the thread: Understand, Plan, Execute, Hand over.

It is for heads of engineering, operations, and IT, and for program leaders who must decide where to start.



1. Where the thread breaks: six break points

The numbers are clear, but they come from vendors. In a survey by PLM vendor Aras of 656 executives in automotive, aerospace, and machinery (Europe, US, Japan; January 2025), 89% call the digital thread critical to success with AI, automation, and robotics.[1] The top obstacles are product complexity (46%), tracking changes (36%), configuration variety (35%), and disconnected supply chains (33%). A Tech-Clarity study of more than 200 large discrete manufacturers, sponsored by the consultancy Kalypso, paints the same picture: only about one in five has truly mature PLM–MES integration, and more than three-quarters still assess the impact of engineering changes manually or with reports.[2]

Both studies come from interested parties, but they match what programs show again and again. Six break points keep recurring:

#	Break point	How you spot it	Consequence
1	**Requirement ↔ solution**	The requirements spec describes product features, not needs.	Customizations that put every upgrade at risk
2	**No clear system of record per object**	Two systems maintain the same material or bill of materials (BOM).	Conflicting versions, manual work
3	**Engineering BOM → manufacturing BOM**	Structure and effectivity are rebuilt by hand.	Faulty manufacturing BOMs, late changes
4	**Changes across system boundaries**	CAD, PLM, and ERP changes run separately.	Production builds to an outdated revision
5	**Legacy data**	Mapping, revision history, and validation are planned late or not at all.	Delays just before go-live; in regulated environments, an evidence gap
6	**Engineering ↔ production ↔ IT**	Three organizations, three goals, no shared accountability.	The program fails on ownership, not technology

The first break point often causes the others. Programs start with a preferred solution (“we need module X”) instead of the need. Better: capture each requirement as a specific role's need, phrased so it can't be split further, separating what the system must do, how well, and under what constraints. When in doubt, ask “What for?” several times. Requirements change, so they are managed as a living object. That keeps changes negotiable instead of quietly shifting scope.

FIELD PATTERN (ANONYMIZED): SELECTION BY DEMO EFFECT

A mid-sized manufacturer wants to introduce a PLM system. It has an old functional specification but no shared view across engineering, production, and purchasing. If the overall impression of vendor materials decides, one vendor wins the demo but doesn't fit the company's size and direction. It works better when a few workshops first produce a prioritized requirements catalog, each item with a priority and benefit. Proposals are then scored against fixed criteria: completeness, plausibility, modularity, future viability, service, risks, and cost. Shortlisted vendors must demo the key requirements live, using the customer's script, not their standard slides. The decision then rests on the company's own criteria and is defensible to executive management.

2. Target picture: the digital thread

A digital thread isn't a product you buy. It's a state in which four things hold true.

One system of record per object. Material, BOM, routing, and document each have a defined lead system. All others receive only released data and change nothing on their own. That sounds trivial, yet most system landscapes haven't done it.

One change process, one object model. Design, manufacturing, and quality use the same flow from change request to executed change, with clear roles and unambiguous object states (in work, in review, released, frozen). Between request and execution sits the engineering change order, which bundles the individual actions. Originator, reviewer, approver, and configuration management each have a fixed role, for engineering and manufacturing parts alike. So a change has an owner and status, and the ERP doesn't find out weeks later. Downstream systems receive only released revisions. The standard process changes only where an audit or business process requires it.

A feedback loop from production. Production and quality data flow back into engineering: a closed loop. It's a vendor concept with no independent metric; whether it pays off depends on the case. The ISA-95 standard series (IEC 62264) provides the common language for this seam: it describes Level 3, manufacturing operations management (MES), and Level 4, business planning (ERP), and defines what information flows between them.[3]

Shared accountability. Where engineering, production, and IT report separately, you need a person or body that can decide for all three. Without one, every technical interface remains a stopgap.

FIELD PATTERN (ANONYMIZED): MIGRATION AS THE LAST STEP

A manufacturer connects its PDM system to the ERP and migrates legacy CAD data. Schedule and effort are too tight because migration is treated as the last step before go-live. The reverse order is more robust, and a PDM vendor's rollout plan prescribes it too: the migration specification comes early, after the configuration workshops. Next come ERP integration and configuration release. A test migration runs before key-user testing. The whole system of configuration, interfaces, and data migration is released first; only then do training and production release follow. Production migration waits for that release. Additional modules such as document management come in a second wave. Migration thus becomes its own workstream, with its own specification, testing, and release.

3. The role of AI

Bitkom reports that 42% of German industrial companies use AI in production and another 35% plan to (552 companies with 100+ employees, surveyed January–February 2025).[4] Switzerland is more cautious: a 2024 ETH Zurich study with Swissmem found pilots at 10% of companies and planned tests at another 12%. Two-thirds cited too little in-house AI know-how, and a quarter had an AI strategy.[5] The Swiss figures are more than two years old and show a direction, not a current state. The bottleneck isn't the technology: in Germany, 42% of companies cite missing expertise in integrating AI into existing processes.[4]

First the thread, then the AI.

That points to a simple order: **first the thread, then the AI.** Where the impact of a change can only be determined by hand, AI has nothing to build on. Where objects, states, and releases are managed cleanly, it can lighten the load:

- **Change impact analysis:** Which parts, BOMs, and routings does a change affect? Major PLM platforms are adding AI features for this in 2026: Siemens Teamcenter with a BOM agent (June 2026), Dassault ENOVIA with AI in change management (October 2026).[6]
- **Documents:** summarize, compare, check for consistency.
- **Research and documentation:** prepare decisions, draft meeting minutes, search your own records.

What AI doesn't do: decide which system leads, or replace a change process. If two systems maintain the same BOM, even the best analysis returns two answers. Decisions at the seams remain a leadership task.

Three rules have proven their worth. First, test on the platform's standard before deciding on customizations; each one is a future upgrade burden. Second, in regulated environments (medical devices, aerospace, defense), keep results traceable and plan validation from the start, following the V-model with traceability from requirement to production. Third, watch the regulatory framework. Under the EU AI Omnibus (Regulation (EU) 2026/1744, in force since July 27, 2026), obligations for Annex III high-risk systems now apply from December 2, 2027, and for AI embedded in regulated products from August 2, 2028.[7] This can also affect Swiss exporters. This note is not legal advice.

A PLAUSIBLE SCENARIO: AI IN A VALIDATED ENVIRONMENT

In medical devices, every change to a validated system needs evidence. Adding an AI assistant for change impact analysis outside the validation plan creates an evidence gap. Treating it as a prep aid, with a person reviewing and releasing its output, saves time without risking the evidence. The usual rules for validated systems help here: as little custom development as possible, keeping validation effort small, and traceability from requirement to production.

4. Approach in four steps

The thread can't be closed in one go; it takes four steps that build on each other.



1 UNDERSTAND
Clarify



2 PLAN
Define



3 EXECUTE
Lead



4 HAND OVER
Secure

1. Understand. Clarify the starting point, goals, and constraints with the people who carry the work. Result: problem space described, system of record per object named, break points from Chapter 1 assessed. Requirements are captured as needs, not as a preferred solution (“we need module X”).

2. Plan. Set goals, milestones, responsibilities, and risks. Migration, interfaces, and validation are separate workstreams with their own milestones. Validation is planned from the start, not bolted on at the end. Result: a roadmap with decision points.

3. Execute. Lead, steer, decide. Regular reporting to executive management, early rather than late escalation, standard before customization. Result: a thread that holds up in operations.

4. Hand over. Documentation, a trained successor, an organization that carries on without outside leadership. A program is done only when it runs without consultants.

Unsure where to start? A two- to four-week assessment. It independently reviews a current or planned program and reports findings and prioritized actions. It's the smallest effort that shows where the thread breaks.

Five questions for your own assessment

1. Is the lead system defined for material, BOM, and routing?
2. Is a change managed from design to production by one process with clear roles?
3. Can you determine the impact of a change without manual work?
4. Does feedback from production reach engineering without detours via email and spreadsheets?
5. Is there a person or body authorized to decide across engineering, production, and IT?

Rule of thumb (not a study): if you answer No to more than one question, work on the thread before your next AI initiative.

Conclusion and contact

The technology for the digital thread is available. What's usually missing is clarity at the seams: who leads, who decides, how changes travel, and how legacy data reaches the target system. Settle that early and firmly, and you'll need fewer customizations later, can apply upgrades, pass audits, and lay the foundation for AI to lighten the load.

About Lux IT Consulting. Tobias Lux comes from aerospace engineering, has built and run two companies, and has worked as an interim manager and program leader since 2012. His focus is where engineering, production, and IT meet. He has experience in PLM, MES, and manufacturing IT, including regulated environments with computer system validation under the V-model and FDA 21 CFR Part 11, across aerospace, industry, and medical devices. He also builds and runs his own AI agents for research, documentation, and workflows. Engagements are possible worldwide, on site or remote: as an interim assignment (typically 3 to 12 months), program management, or an assessment.

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Where engineering, IT, and production have to come together.

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