Summary: MBD, Digital Thread and Digital Product Passport

Benefits, barriers — and my view of how they should fit together

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MBD
Engineering truth

MBE
Enterprise use

Digital Thread
Lifecycle flow

DPP
External access

Perspective synthesis based on Hedberg et al. (2016), Uski et al. (2020), Goher et al. (2020, 2023), and EU ESPR/DPP requirements.

What's needed **is a governed transformation** that clearly defines:

How EBOM structures become MBOM structures
Which objects remain connected
Who owns each decision and attribute
How engineering changes affect manufacturing
How plant-specific variations are managed
How feedback returns to engineering

Without that connection, every engineering change triggers another courtroom drama:

"Was manufacturing notified?"

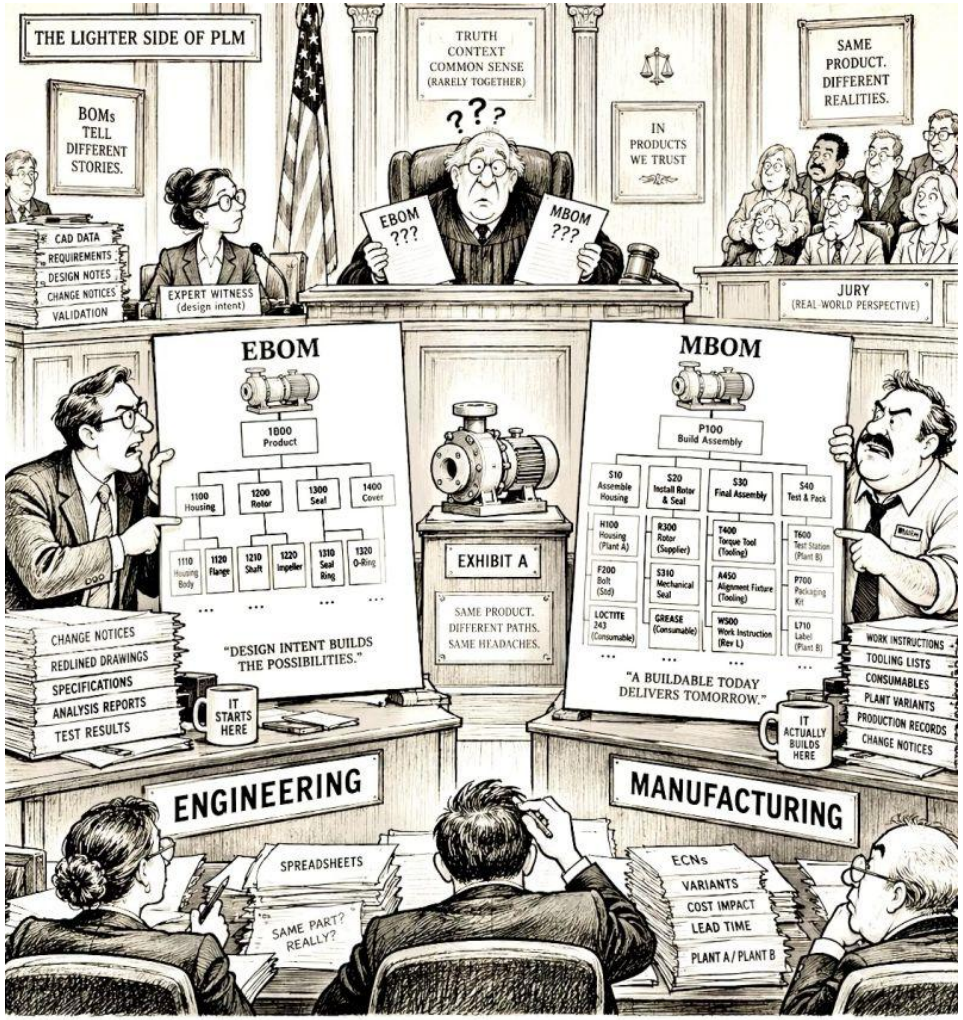
"Which plants are affected?"

"Why does the work instruction show the old revision?"

"Who added this component?"

The **digital thread must preserve the relationship** between the two parties without pretending they serve the same purpose.

Source: Brion Carroll (II)



They agree it's the same product.
That's where the agreement ends.

BC II

My core opinion

DPP should not become another isolated reporting database.

1 Build the product definition once

MBD should provide the authoritative engineering definition: geometry, PMI, requirements and other structured product information.

2 Reuse it across the enterprise

MBE is the organisational capability to use model-based information in engineering, manufacturing, inspection, service and change management.

3 Extend the thread to the lifecycle

Digital Thread should connect authoritative information and events over time. DPP can expose a governed subset to customers, authorities and circular-economy actors.

The strategic opportunity is not “compliance data” — it is controlled reuse of trusted product data.

Conceptual interpretation grounded in the supplied MBD/MBE/Digital Thread literature and ESPR Articles 9–11.

The overall architecture I would aim for

One information backbone, different views for different users.

MBE = internal capability

Processes, people, tools, governance and model-based reuse across functions.

DPP = controlled external window

Product-specific information made accessible according to rules, identifiers and access rights.

Requirements | **MBSE** | **CAD, CAM, MBD** | **Manufacturing Supply** | **Inspection** | **Service / reuse**

Digital Thread = continuity

Links product definition, derived information, lifecycle events and evidence without repeatedly recreating data.

Hedberg et al. define the digital thread through reuse of MBD in manufacturing and inspection; ESPR requires interoperable, structured and machine-readable DPP data.

Why this is worth doing

The strongest benefits come from reuse, automation and traceability.

Less manual translation

Fewer drawings, re-keying steps and document conversions between engineering, manufacturing and inspection.

Faster flow

Hedberg et al. reported a 74.8% average cycle-time reduction in their model-based test cases versus drawing-based processes.

Better quality & consistency

A common authoritative source reduces ambiguity and supports automated use of PMI and inspection information.

Traceability & change impact

A digital thread can connect requirements, definition, production evidence, inspection and lifecycle changes.

Circularity & compliance

DPP can make relevant sustainability, repairability, material and compliance information accessible throughout the value chain.

New analytics potential

Structured lifecycle data can support feedback loops, product improvement, service, portfolio decisions and evidence-based sustainability.

Evidence: Hedberg et al. (2016); Uski et al. (2020); Goher et al. (2020, 2023); European Commission / Regulation (EU) 2024/1781.

The barriers are not mainly about 3D CAD

The difficult part is ecosystem-wide transformation.

Business case

Benefits and investments are distributed unevenly across OEMs, suppliers and lifecycle actors.

Maturity mismatch

Partners may have different software, skills, data practices and MBE maturity.

Legacy & coexistence

Old product definitions, 2D drawings and long-lived products cannot simply be converted overnight.

Interoperability

Semantic meaning, standards, software exchange and preservation must survive system boundaries and time.

Governance & authority

Who owns, validates, updates and is legally responsible for each piece of information?

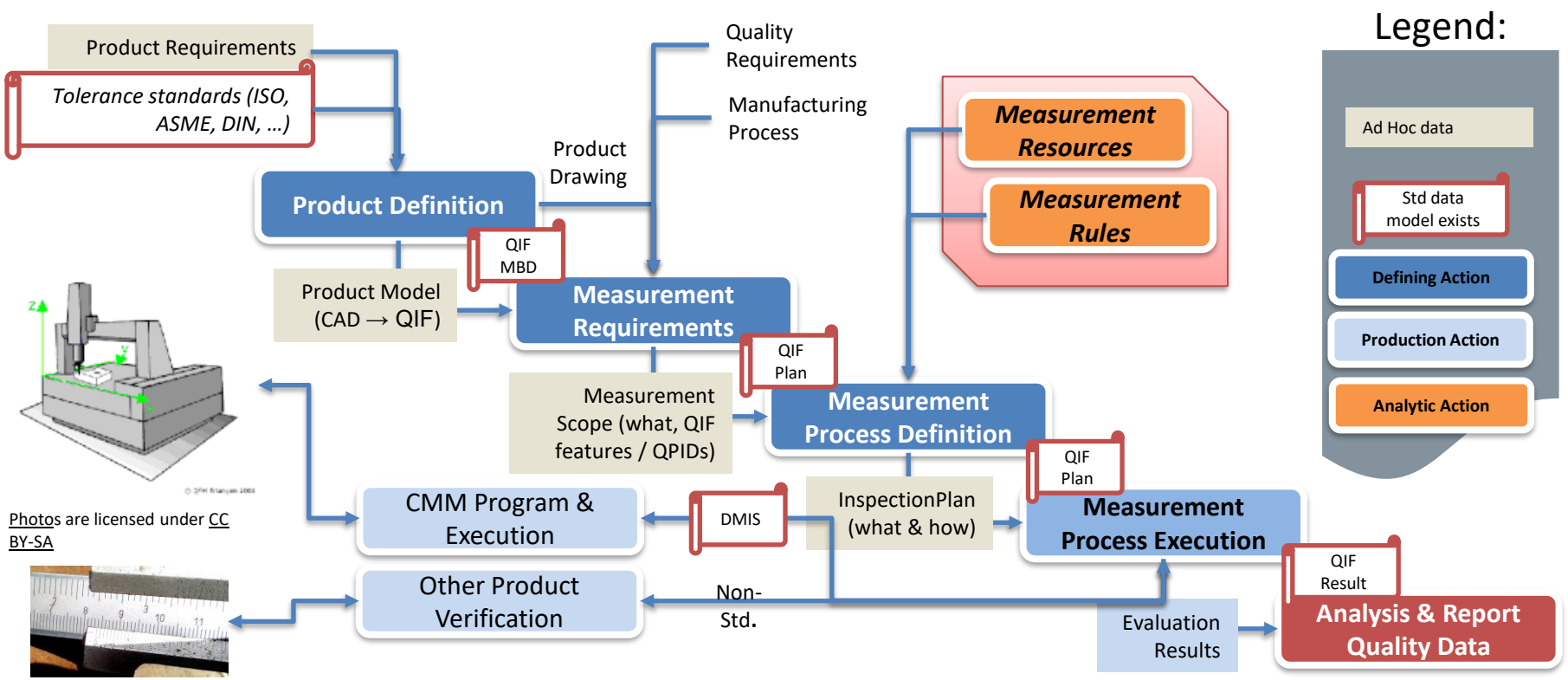
Change & competence

Processes, roles, training, incentives and contractual practices must change together with technology.

Uski et al. (2020) emphasize ecosystem maturity, investment, legacy data, software/process harmonisation and actor-specific business cases; Goher et al. classify technical, management and certification uncertainties.

Example: Potential in QC – digital compliance

It is possible to create formal (automated) digital loop for Quality Control



Compliance

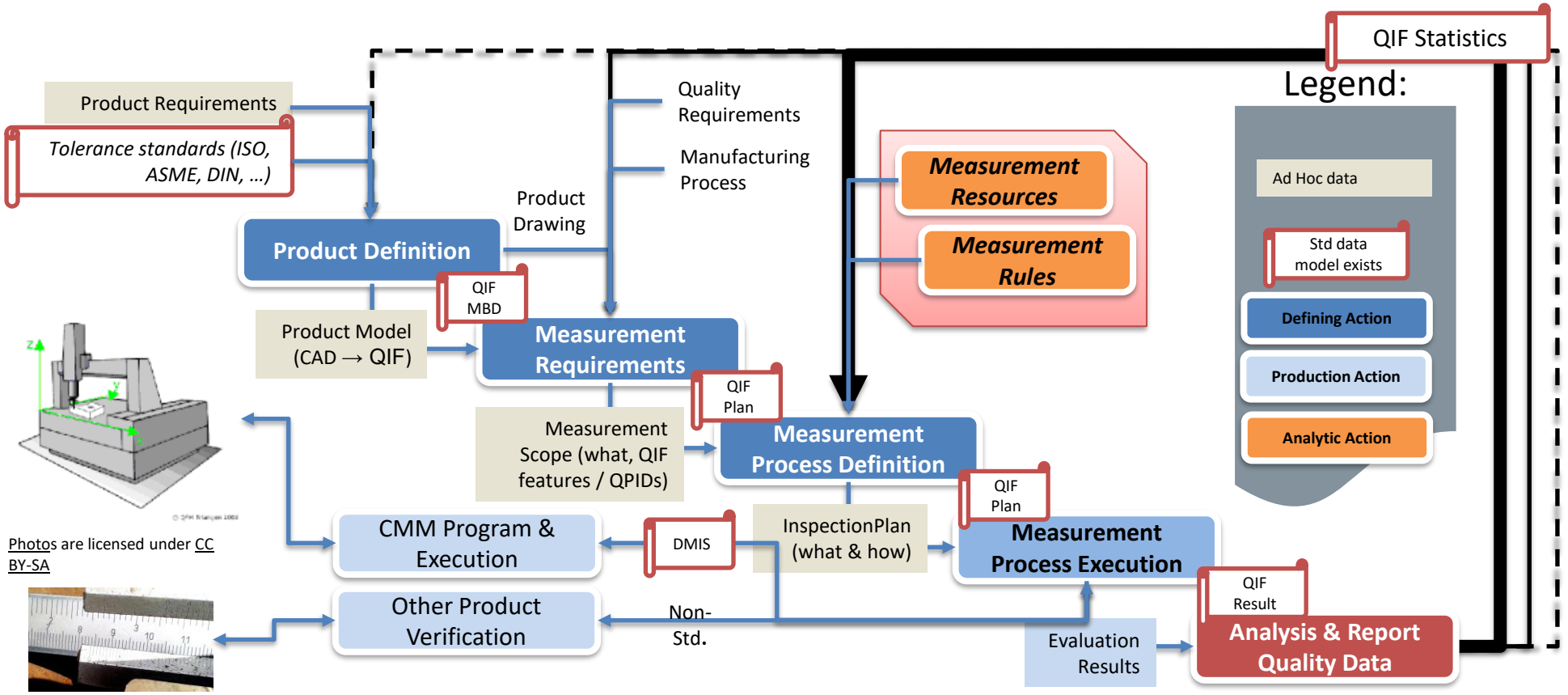
Output Control

https://www.iso.org/standard/77461.html

qifstandards.org/wp-content/uploads/2014/08/QIF-101-What-is-QIF-Curtis-Brown-20220419cwb.pptx.pdf

Potential in QC – learning and improving

It is possible to create formal (automated) digital loop for Quality Control



SPC (feedback) | AI (feedforward)

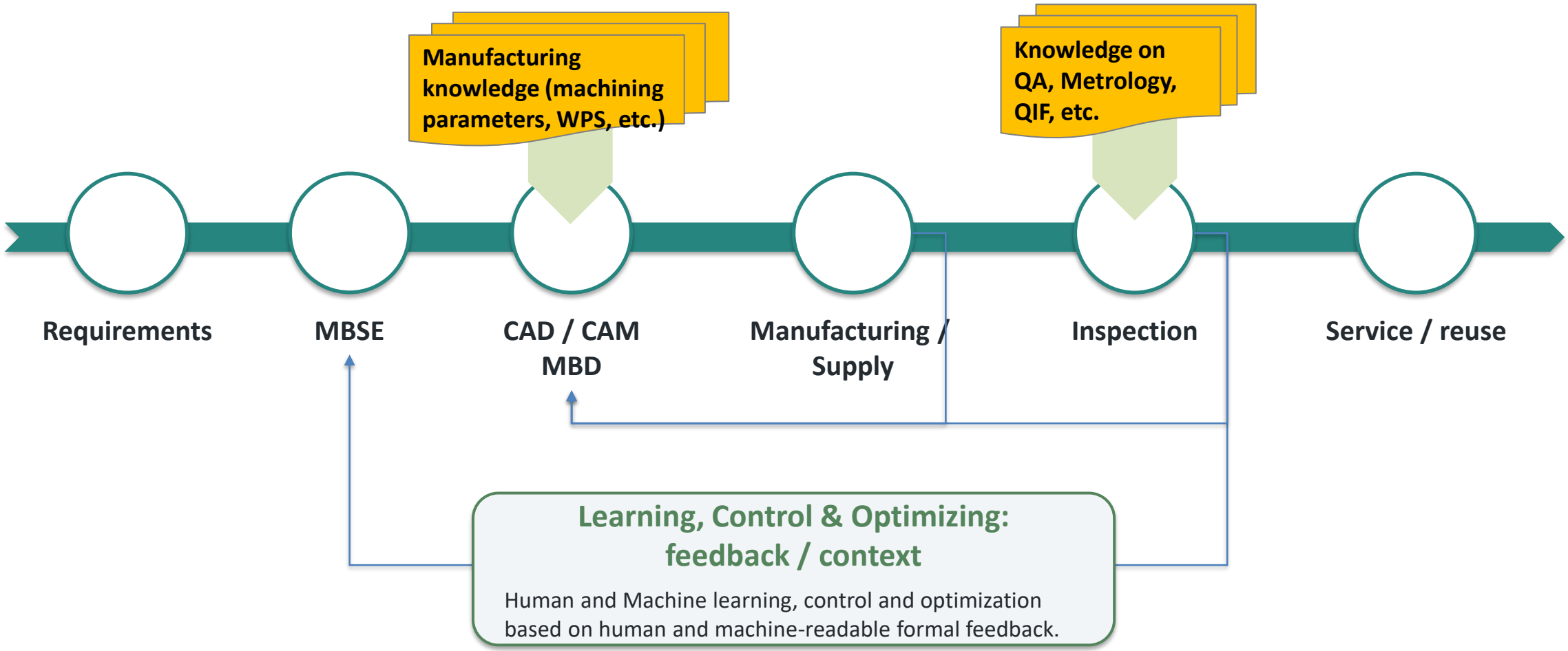
Process Control

https://www.iso.org/standard/77461.html

qifstandards.org/wp-content/uploads/2014/08/QIF-101-What-is-QIF-Curtis-Brown-20220419cwb.pptx.pdf

Digitalization challenge –MBD vs. Domain Specific Knowledge

Beyond integrating workflows



Sirén, et al. Tools for adaptive and intelligent control of discrete manufacturing processes TANDEM - Final Project Report see: https://cris.vtt.fi/ws/portalfiles/portal/120765825/S0410_TANDEM_Final_Project_Report_v3.5_annexes_250725.pdf
Kokkonen P, et al. Robust lightweight design and digital twins considering manufacturing quality variation and sustainability requirements. RakMek [Internet]. 2022 Dec. 23 See: https://rakenteidenmekaniikka.journal.fi/article/view/120693

DPP adds value — but also a new risk

If implemented separately, it may create another information silo.

Potential value

- A persistent product identity
- Easier access to sustainability and compliance information
- Support for repair, reuse, remanufacturing and recycling
- Better traceability across the value chain
- A regulatory push toward interoperable, machine-readable product information

Potential failure mode

- Manual DPP reporting detached from engineering truth
- Duplicate master data and conflicting versions
- High maintenance cost over long product lifetimes
- Sensitive IP exposed too broadly
- Suppliers repeatedly entering the same information into different customer systems

My view: generate and maintain DPP information from governed lifecycle sources wherever possible.

ESPR Articles 9–11 require accurate, up-to-date DPP data, persistent identifiers, access control, open standards, interoperability and machine readability.

A practical adoption path

Start with high-value information flows — not with a company-wide ‘big bang’.

1	**Select a use case**	Choose a painful handover: e.g. PMI → manufacturing/inspection, change propagation, service or DPP data.
2	**Define authoritative sources**	Agree which system/model is authoritative for each information object and identifier.
3	**Make semantics explicit**	Standardie structures, meaning, metadata, versioning and validation — not only file formats.
4	**Prove reuse**	Measure lead time, errors, manual work, traceability and downstream value.
5	**Scale across partners**	Build actor-specific business cases and support different maturity levels in the ecosystem.
6	**Expose DPP views**	Publish only the required/valuable subset with appropriate access rights and lifecycle maintenance.

Adoption logic synthesised from the supplied research, especially Uski et al. (2020) and Goher et al. (2023).

What I would prioritise in research and industry

The unresolved question is how to turn product data into sustainable enterprise value.

Quantify the business value of information reuse across the full lifecycle — not only within engineering

Develop methods for ecosystem-level value sharing: who invests, who benefits, and how incentives can be aligned.

Connect MBD/MBE and Digital Thread architectures with DPP rather than treating DPP as a separate compliance layer.

Improve semantic interoperability, long-term preservation, configuration/change management and trustworthy provenance.

Use lifecycle data analytically: assess cost, value, quality, sustainability and change consequences across large product portfolios.

Support gradual transition: hybrid 2D/3D environments and heterogeneous supplier maturity will remain reality for years.

The goal is not a digital model. The goal is a trustworthy, reusable information continuum.

Perspective slide: synthesis and interpretation of the cited literature.

Questions, Comments & Contacts

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Sources

Hedberg, T. et al. (2016). Testing the Digital Thread in Support of Model-Based Manufacturing and Inspection. Journal of Computing and Information Science in Engineering, 16(2). DOI: 10.1115/1.4032697

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Brown. C. The Quality Information Framework for the World See: https://qifstandards.org/wp-content/uploads/2014/08/QIF-101-What-is-QIF-Curtis-Brown-20220419cwb.pptx.pdf

Regulation (EU) 2024/1781 — Ecodesign for Sustainable Products Regulation (ESPR), especially Articles 9–11 on the Digital Product Passport.

European Commission (2026). ESPR implementation information and Digital Product Passport rollout.

Note: Slides distinguish source-backed findings from the presenter's synthesis/opinion.