Seamless Material Flow: From Material Handling to System Performance

A holistic approach to the strategic design of seamless material flows for the manufacturing of the future.

Graduate

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Initial Situation: Swiss and European manufacturing companies face increasing product variety, volatile demand, and growing pressure for short lead times, while still needing to operate efficiently and cost-effectively. Digitalization and automation are commonly proposed as solution approaches and often yield strong results. Nevertheless, the focus frequently remains on digital integration and information flow. Smart, lighthouse factories are envisioned as highly dynamic digital systems, yet manufacturing activities are executed in the physical, material domain. This misalignment highlights the need to rethink rigid physical linkages between operating resources in favour of flexible and seamless material flows that reflect the dynamics of digital information flow.

Objective: The objective of this work was to propose, apply, and evaluate a new methodology to improve material flow in an industrial environment. The work is structured around three main activities:
1. Analysis of the literature and derivation of potential success factors to be integrated into a framework.
2. Application of the factors to an industrial use case (shown in Figure 1).
3. Evaluation of the use case and adaptation of the framework based on the results.

Result: The result is a four domain seamless material flow (SMF) framework:
1: Suitability & Requirements Domain: Assesses if SMF fits the problem by analysing value streams, constraints, goals, and requirements. Evaluates alternatives and delivers a validated SMF use case with clear handover.
2: Change Domain:
Ensures sustainable SMF implementation by aligning planning, execution, and support processes. Uses phased transformation, addresses lot-size reduction, and builds organizational readiness.
Defines the digital representation and control of material flow, enabling system connectivity, monitoring, and synchronized, stable execution.
4: Physical Domain: Implements SMF on the shopfloor through layout, transport, and interfaces. Focuses on robust, scalable material flow aligned with digital control.

Based on the four domains, a detailed implementation case was developed and evaluated. As shown in Figure 2, SMF significantly outperformed classical value stream optimization approaches. Furthermore, a comprehensive planning scheme was proposed (Figure 3). It extends the Manufacturing Execution System layer with a Digital Twin that enables a mid-term view (days/weeks) for optimized production planning through takt balancing and resource alignment, generating load and setup plans. In the short-term view (minutes), it supports precise scheduling and intralogistics control.

Figure 1: Use case in discrete manufacturing: injection moulding to buffer to cutting and packaging.
Own presentment

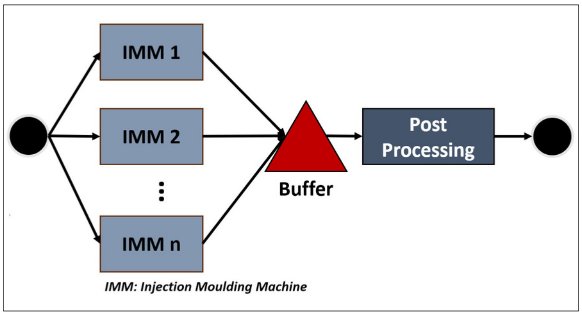
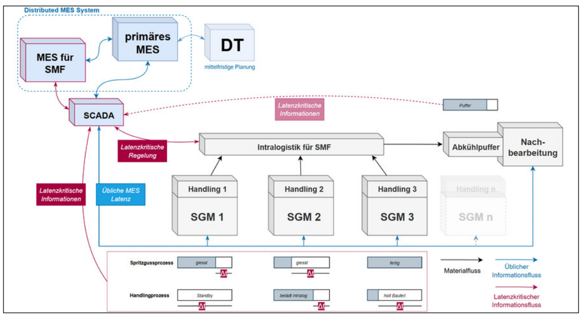


Figure 2: Comparison of current state, classic value stream optimization (based on learing to See) and SMF
Own presentment

Key Perfomance Indicators / Process Variant	Throughput Time	Buffer (units)	Space utilization (m²)	OPEX Savings (TCHF/year)	ROI (years)
Current State	up to 16 days	80'000	120	0	-
Classic Value Stream Optimization	3–5 days	40'000	80	- 6.4	>15
SMF Optimization	~10 min.	100	19	- 119.2	~4

Figure 3: Digital system architecture for application with Seamless Material Flow integration.
Own presentment



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Subject Area
Software and Systems, Innovation in Products, Processes and Materials - Business Engineering and Productions, Business Engineering

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