

Material Flow System (MFS) Integration with SAP Extended Warehouse Management: Architecture, Control, and Automated Warehouse Execution

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Abstract: Automated warehouses depend on continuous coordination between warehouse management logic and the physical control equipment that moves handling units. SAP Extended Warehouse Management (EWM) Material Flow System (MFS) provides this coordination by connecting EWM directly with programmable logic controllers (PLCs), allowing warehouse tasks to be broken into smaller material-flow stages and executed through telegram-based communication. This paper examines MFS as the control interface between SAP EWM and automated warehouse equipment. It describes the MFS architecture, the roles of PLCs, communication channels, communication points, conveyor segments, and resources, and the execution logic used to control putaway, retrieval, conveyor movement, and stacker-crane activity. Particular attention is given to capacity management, malfunction handling, interleaving, case-conveyor routing, monitoring, and operational recovery. The paper positions SAP EWM MFS against the broader warehouse-automation and automated storage and retrieval system literature, which has traditionally focused on system configuration, routing, travel-time optimization, storage assignment, and sequencing. The analysis shows that MFS operationalizes many of these control concerns inside a commercial warehouse-management platform while maintaining a direct link between system decisions and physical handling-unit movement. An illustrative business case is included to demonstrate how direct EWM-to-PLC integration can be evaluated in terms of integration simplification, exception handling, operational visibility, and equipment utilization.

Keywords: SAP EWM, Material Flow System, MFS, PLC, Automated Warehouse, AS/RS, Conveyor System, Stacker Crane, Handling Unit, Telegram Communication, Warehouse Automation, Intralogistics

1. Introduction

Warehouse automation has evolved from isolated material-handling equipment into tightly integrated systems in which storage, retrieval, transport, sorting, and identification must operate as one coordinated flow. Automated storage and retrieval systems (AS/RS), conveyors, transfer cars, scanners, and stacker cranes can execute physical movement at high speed, but the warehouse-management system still has to determine which handling unit should move, where it should go, when the next movement can be released, and how exceptions should be handled.

The operations-research literature has examined automated warehousing through questions such as storage assignment, request sequencing, travel-time estimation, routing, equipment utilization, and system configuration [1]-[4]. These models provide the analytical basis for designing efficient automated systems, but commercial execution requires another layer: the decisions must be translated into real-time instructions that the physical control system can execute safely and consistently.

SAP Extended Warehouse Management (EWM) Material Flow System (MFS) addresses this execution layer. MFS enables SAP EWM to connect directly to an automated warehouse control level without requiring a separate warehouse control unit. EWM can subdivide a warehouse task into smaller execution stages and communicate these stages step by step to the responsible PLC using telegram communication [5].

This changes the role of EWM from a system that only manages warehouse business documents and tasks into a

system that can also coordinate material movement at defined control points. The physical movement between those control points remains the responsibility of the PLC, but EWM determines the logistics destination and sequence based on warehouse requirements, system status, and configured material-flow logic.

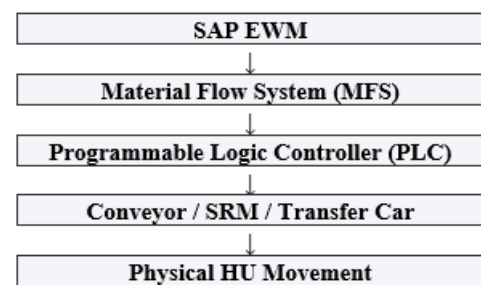


Figure 1: High-level SAP EWM MFS architecture connecting warehouse execution with PLC-controlled automated material handling

2. Literature Review

2.1 Warehouse automation and material handling

Warehouse operations research has traditionally divided warehouse activity into receiving, storage, order picking, and shipping. Gu, Goetschalckx, and McGinnis [1] show that the performance of these activities is strongly influenced by decisions about storage assignment, equipment, routing, and operating policy. As warehouse systems become more automated, these decisions are increasingly embedded in software and control logic rather than left to manual operators.

2.2 Automated storage and retrieval systems

Roodbergen and Vis [2] review automated storage and retrieval systems and identify system configuration, travel-time estimation, storage assignment, dwell-point location, and request sequencing as major research areas. These concerns are directly relevant to automated high-bay warehouses in which stacker cranes and conveyors must coordinate large numbers of storage and retrieval requests.

More recent reviews show that automated and robotized warehouses require stronger integration of subsystems and more dynamic control. Azadeh, de Koster, and Roy [3] emphasize that integrated automated warehouse systems require planning and control methods that address system interactions rather than isolated equipment decisions. Boysen and de Koster [4] similarly describe the evolution of warehouses toward technology-enriched and robotized fulfillment systems.

2.3 Conveyor and sortation control

Automated conveyor and sortation systems introduce a different control problem from single-aisle AS/RS equipment. Routing decisions must be made as handling units reach decision points, and the chosen path depends on current location, destination, equipment availability, and process context. The conveyor literature therefore emphasizes flow coordination and routing as well as the avoidance of congestion and blocking.

2.4 Positioning SAP EWM MFS in the literature

The academic literature explains the optimization problems behind automated storage and material handling, but it often does not describe how those decisions are represented and executed inside a commercial warehouse-management system. SAP EWM MFS provides a practical implementation layer: EWM maps the automated system through PLCs, communication channels, communication points, conveyor segments, and resources; it then uses warehouse tasks and telegrams to coordinate movement. In this sense, MFS connects warehouse-management decisions with the physical automation layer rather than replacing the control logic inside the PLC.

3. Scope and Method

This paper is a conceptual and implementation-oriented synthesis rather than an empirical investigation. It describes SAP EWM MFS using standard and publicly documented functionality and relates those functions to established warehouse-automation research. The paper intentionally does not describe a specific customer implementation.

The analysis treats each MFS construct as part of a three-level execution model. SAP EWM owns the logistics requirement and warehouse task. MFS translates the requirement into material-flow stages and telegram-based interaction. The PLC controls the physical equipment between communication points. This structure is used throughout the paper to explain automated putaway, retrieval, conveyor routing, capacity management, exception handling, and monitoring.

Release-specific behavior can differ across SAP EWM and SAP S/4HANA versions. Therefore, implementation teams should validate configuration details against the documentation for the target release.

4. SAP EWM MFS Architecture

MFS is not a separate warehouse-management application. It is an SAP EWM capability that extends warehouse execution into the automated control layer. The automated system is represented in EWM using several logical components that correspond to physical or communication elements of the installation [5], [6].

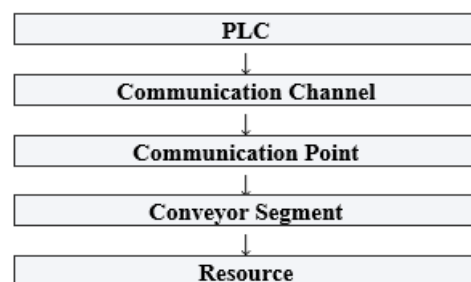


Figure 2: Core MFS components are used to map and control an automated warehouse

4.1 Programmable Logic Controller (PLC)

The PLC is the real-time control system that operates motors, sensors, readers, switches, conveyors, stacker cranes, and other automated equipment. EWM does not replace this deterministic machine-control function. Instead, each control that communicates with EWM is represented as a PLC in MFS. Larger installations can also use head controls that coordinate subordinate controls, in which case EWM communicates with the head control rather than every local control.

4.2 Communication channel

A communication channel represents the technical connection used to exchange messages between MFS and a PLC. It is defined with communication properties such as the reachable IP address and port and can be configured for telegram acknowledgments and message characteristics. Multiple channels can be used for one PLC when communication traffic is separated by purpose or port [6].

4.3 Communication point

Communication points are the locations at which SAP EWM and the PLC exchange material-flow information. A scanner, identification point, transfer position, or intermediate conveyor location can be represented as a communication point. When a handling unit arrives, the PLC reports the HU and location to EWM. EWM can then determine the next destination and return the corresponding instruction. Communication points therefore define where warehouse-management decisions enter the physical flow [6], [7].

4.4 Conveyor segment

A conveyor segment represents the physical path between communication points. EWM can maintain the readiness and capacity of a segment and can hold additional warehouse movements when that segment cannot accept more handling units. Segments can also be grouped so that a set of conveyor paths can be made inactive together during a malfunction or maintenance event.

4.5 Resource

A resource in MFS represents a vehicle such as a stacker crane or transfer car whose movement is relevant to EWM control. Resource modeling is important when the sequence of assignments affects empty travel, capacity, or equipment utilization. SAP EWM supports interleaving for applicable stacker-crane scenarios to reduce empty travel by coordinating putaway and retrieval work [5].

5. Warehouse Task Execution through MFS

The warehouse task remains the basic warehouse-execution object in SAP EWM. In an automated area, however, a single warehouse task may represent a movement that physically requires several intermediate stages. MFS can divide the end-to-end task into smaller steps between communication points.

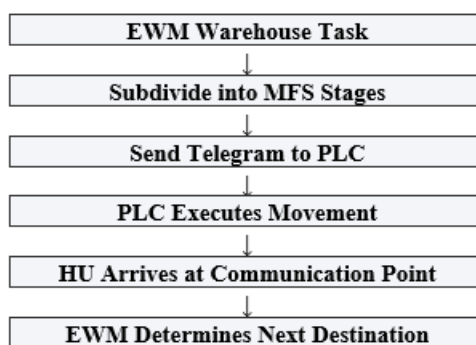


Figure 3: Warehouse-task execution through MFS stages and PLC telegram communication.

5.1 Warehouse task creation

A warehouse task is created from a source location to a destination according to EWM process logic. The source may be an identification point, staging area, conveyor location, or storage bin, and the destination may be an intermediate or final bin in the automated system.

5.2 Stage determination

MFS evaluates the path and identifies the next material-flow stage. Instead of sending the PLC the complete warehouse process, EWM provides the information required for the next controlled movement. This allows EWM to remain aware of the HU position and to make additional decisions later in the route.

5.3 Telegram to the PLC

MFS sends a telegram to the appropriate PLC. The message typically identifies the HU, its current location, and the

requested destination or action. The PLC then performs the detailed machine-level control required to move the HU.

5.4 Arrival and next-destination determination

When the HU reaches the next communication point, the PLC reports the arrival to EWM. Depending on the point type and configured logic, EWM updates the HU location, confirms or creates the relevant movement stage, and determines the next destination. The process repeats until the HU reaches the final warehouse destination.

6. Communication Points and Material-Flow Tracking

Communication points are central to MFS because they determine the granularity at which EWM observes and controls the automated flow. More communication points provide closer tracking and more opportunities for EWM to make routing decisions, but they also increase message volume and system processing.

A practical design therefore places communication points where a logistics decision is required: at identification points, routing junctions, aisle entries, transfer positions, or locations where capacity and status must influence the next movement. The PLC remains responsible for deterministic control between those points.

Every communication point is represented as a storage bin in EWM, but not every storage bin is a communication point. The distinction is important because communication points represent control-relevant locations, while ordinary storage bins may simply represent final physical stock positions.

7. Capacity, Congestion, and Malfunction Control

Automated warehouses are more sensitive to bottlenecks than manual warehouses because a blocked conveyor segment or unavailable transfer point can stop the movement of many upstream handling units. MFS therefore allows capacity and readiness to be represented for communication points, conveyor segments, and resources [5], [7].

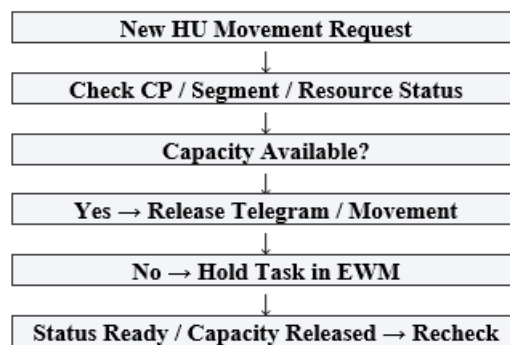


Figure 4: Capacity and malfunction control before a new automated movement is released.

7.1 Capacity management

Communication-point capacity can be expressed as the number of HUs that can be present simultaneously, including relevant inbound or outbound movements. Conveyor segments can also carry capacity limits. When the configured capacity has been reached, EWM can hold additional tasks instead of continuing to feed the blocked area.

7.2 Equipment and route status

A communication point, segment, or resource can also be placed in an unavailable or locked state. This allows MFS to stop releasing movements into an area affected by equipment failure, maintenance, or a logistics blockage. The ability to represent technical status in the warehouse-management layer helps prevent upstream movements from worsening a downstream problem.

7.3 Technical and logistical malfunctions

Automated warehouses must distinguish machine failures from logistics exceptions. A motor or sensor problem is a technical malfunction, while an occupied destination, unidentified HU, incorrect contour, excessive weight, or blocked storage location is a logistics problem. Both can interrupt material flow, but the recovery path may differ. MFS provides the warehouse-management context required to redirect, hold, or manually recover HUs when the physical flow is disrupted.

8. Resource Control and Interleaving

Stacker cranes and transfer cars create a resource-scheduling problem because the sequence of assignments affects empty travel and throughput. If a stacker crane completes a putaway deep in an aisle and the next task is a retrieval nearby, combining those tasks can reduce travel without load.

SAP EWM MFS supports interleaving for applicable stacker-crane configurations. The objective is operational rather than purely theoretical: reduce empty travel while ensuring that warehouse priorities and task sequences remain consistent with the EWM execution plan [5]. This aligns with the AS/RS literature, where dwell-point location, request sequencing, and travel-time reduction have long been core performance topics [2].

9. MFS for Case Conveyor Systems

Case conveyor systems require a different execution model from systems in which every intermediate movement is represented immediately as a warehouse task. A case can pass through many conveyor junctions, and creating a warehouse task before every short movement can be unnecessarily heavy.

SAP EWM therefore supports MFS routing decisions for case conveyor systems based on the HU current location and available process context. The system can determine a routing decision and send a telegram to the PLC even when the specific conveyor movement is not yet represented by a warehouse task [8].

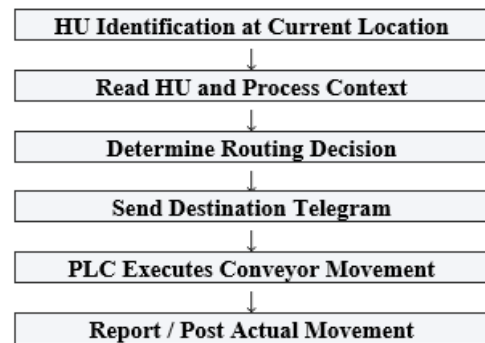


Figure 5: Context-based MFS routing for case conveyor systems.

9.1 Routing Decision

At a decision point, EWM evaluates the HU and its context. The context can include whether a final warehouse task or warehouse order exists, whether the HU is empty, whether it contains stock, whether an MFS error exists, or which activity area or destination applies. EWM then returns the appropriate direction or destination to the PLC.

9.2 Movement Posting

After the PLC executes the conveyor movement, the actual movement can be reflected in EWM. One approach is for the PLC to report the actual route so that EWM creates and immediately confirms the corresponding warehouse task. Where the PLC cannot provide the same level of detail, an asynchronous posting can be used to reflect the routing decision location.

9.3 Logical Actions

Current SAP S/4HANA EWM documentation lists logical actions for case-conveyor MFS such as HU checks, destination determination and redetermination, routing decisions, movement posting, aisle-decision functions, and resource pickup-point processing [8]. These actions show how MFS separates business-level routing decisions from low-level conveyor control.

10. Monitoring, Troubleshooting, and Recovery

Because MFS directly influences physical material flow, operational support must be able to determine both the business state in EWM and the communication state with the PLC. SAP EWM integrates MFS monitoring into the warehouse management monitor [5].

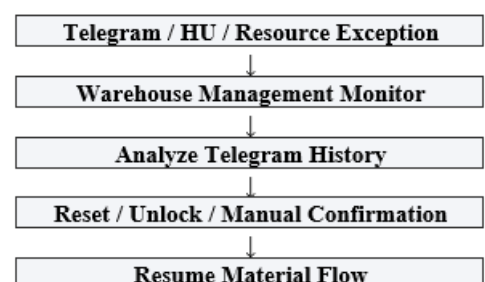


Figure 6: Monitoring and recovery process for an MFS exception.

Support personnel can use monitoring functions to review the current system state, inspect telegram traffic and response times, locate HUs, identify associated warehouse tasks, stop or restart communication, lock communication points or resources, resend telegrams, and manually confirm tasks where appropriate. These functions are important because an automated warehouse cannot rely on a simple technical “message sent” status; the actual HU position and process state must also be understood.

A disciplined recovery procedure should therefore follow four steps: identify the physical HU location, identify the current EWM task and MFS state, determine whether the PLC or logistics process is blocking the movement, and then apply the smallest safe recovery action. Resending telegrams without confirming the physical state can create duplicate or conflicting movements.

11. Implementation and Design Considerations

11.1 Decide the control boundary

The most important architectural decision is the boundary between EWM and PLC responsibility. EWM should make warehouse and routing decisions that require inventory, destination, priority, or process context. The PLC should retain deterministic control of sensors, motors, safety interlocks, and the detailed physical movement between control points.

11.2 Use communication points selectively

Too few communication points reduce material-flow visibility and limit routing control. Too many increase telegram volume and configuration complexity. Communication points should therefore correspond to real decision or control boundaries rather than every physical sensor.

11.3 Model capacity where it changes behavior

Capacity should be modeled for locations and segments where congestion can influence upstream release. In other areas, additional capacity objects may add complexity without improving control. The same principle applies to conveyor-segment status: model it where EWM needs to make decisions based on availability.

11.4 Design exception recovery before go-live

Automated systems must have explicit recovery procedures for unknown HUs, blocked destinations, scanner failures, contour errors, communication outages, and equipment malfunctions. Recovery should be tested during integration and cutover testing, not created after the first production failure.

11.5 Align throughput testing with physical constraints

MFS performance testing should include not only message volume but also equipment capacities, peak HU rates, simultaneous movements, blocked routes, and recovery scenarios. A technically fast interface cannot improve

throughput if the downstream conveyor or storage resource is the real bottleneck.

12. Business Case Benefits

The business value of EWM MFS comes primarily from tighter coordination between warehouse-management decisions and automated material handling. The benefits should be evaluated against the current architecture and operating model rather than presented as universal percentages.

Business Area	MFS Capability	Potential Operational Benefit
Architecture	Direct EWM-to-PLC communication	Can reduce dependency on a separate warehouse control layer in applicable designs.
Material-flow visibility	HU tracking through communication points	Closer alignment between EWM system state and physical movement.
Congestion control	Capacity and readiness checks	Prevents additional movements from being released into blocked areas.
Equipment utilization	Resource sequencing and interleaving	Can reduce unnecessary empty travel in applicable stacker-crane scenarios.
Exception handling	Monitor, locks, resend, manual recovery	Faster diagnosis and controlled restart after automation disruptions.
Routing	Context-based destination determination	Allows conveyor routing to use EWM warehouse and HU context.
Operational control	Warehouse tasks plus telegrams	Keeps business execution and physical automation within one coordinated model.

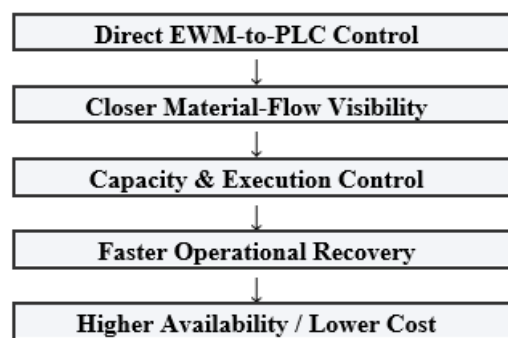


Figure 7: Illustrative business-value chain for SAP EWM MFS.

12.1 Illustrative Business Case: Automated Distribution Center

Consider a hypothetical automated distribution center operating a high-bay storage area with conveyors, scanners, three stacker cranes, and a transfer car. The facility currently uses SAP EWM for warehouse management and an additional warehouse-control layer between EWM and the PLCs. The organization is evaluating whether a direct EWM MFS design is appropriate for a future modernization program.

The business case should not assume that removing an intermediate control layer automatically produces savings. The existing control software may contain valuable custom logic, and migration and validation costs can be significant.

Instead, the analysis should evaluate recurring software, integration, specialist support, incident-resolution, downtime, and change-management costs that could potentially change after implementation.

Business Case Element	Illustrative Modeling Assumption	Illustrative Annual Value
Legacy control-layer software, maintenance, and specialized support	Enterprise automation-control support and maintenance	~\$300,000
Interface administration and integration support	50 hours/week x 52 x \$125/hour	~\$325,000
Reduced automation incident diagnosis and recovery effort	20 hours/week x 52 x \$125/hour	~\$130,000
Reduced coordination during PLC, conveyor, and control-system changes	800 hours/year x \$125/hour	~\$100,000
Reduced operational disruption and recovery effort	Illustrative reduction in support and recovery costs	~\$95,000
Illustrative recurring operational value	Combined assumptions	~\$950,000/year

The approximately \$950,000 annual value in this illustrative example should not be interpreted as an expected or guaranteed SAP EWM MFS result. It represents the output of hypothetical assumptions for a large automated distribution center. A real investment case should use actual control-system licensing and maintenance costs, specialist support rates, integration-support effort, historical automation incidents, downtime impact, change-management effort, implementation cost, validation requirements, and the expected operating life of the automation platform.

For a large automated facility, the strongest business case for MFS may extend beyond direct IT support savings. Architectural simplification can reduce the number of systems and integration points involved in determining material-flow destinations, improve visibility between warehouse-process status and physical equipment movement, accelerate exception diagnosis, and reduce coordination effort during future automation changes. These benefits should be quantified using facility-specific operating data before calculating ROI, payback period, or total cost of ownership.

13. Discussion

SAP EWM MFS provides a practical bridge between warehouse-management logic and automated warehouse control. The broader warehouse-automation literature focuses on how automated systems should be designed and optimized, while MFS focuses on how warehouse decisions are represented, communicated, and monitored during live execution.

The separation of responsibilities is central. EWM owns inventory context, warehouse tasks, destinations, priorities, and process rules. MFS converts those decisions into controlled material-flow interactions. The PLC owns real-time machine behavior and the safe physical execution between communication points. A robust automated warehouse depends on these boundaries being explicit.

MFS also demonstrates why automated warehouse performance cannot be optimized only at the equipment level. Conveyor capacity, communication-point status, resource availability, routing decisions, HU identity, warehouse-task priority, and final storage destination interact continuously. A local equipment optimization can therefore create a system-level problem if it ignores downstream capacity or warehouse priorities.

Three areas deserve particular attention in implementation. First, communication-point design determines how closely EWM tracks the physical system. Second, capacity and malfunction logic determines whether congestion is contained or propagated. Third, monitoring and recovery procedures determine how quickly the automated system can return to a consistent state after an exception.

The literature increasingly describes automated and robotized warehouses as integrated, dynamic systems rather than collections of independent machines [3], [4]. SAP EWM MFS fits this direction by connecting warehouse process context directly to automated execution. Future empirical research could measure the effect of MFS on throughput, exception-recovery time, equipment utilization, and total control-system complexity across different automated warehouse designs.

14. Conclusion

SAP EWM Material Flow System extends warehouse execution from business-level warehouse tasks into the automated control environment. It allows EWM to communicate directly with PLCs, divide warehouse tasks into execution stages, track HUs at communication points, control the release of movements according to capacity and status, and support automated putaway, retrieval, conveyor movement, and resource sequencing.

The core MFS architecture is built around five elements: PLCs, communication channels, communication points, conveyor segments, and resources. Together, these elements create the logical representation through which EWM can coordinate physical material flow while leaving deterministic machine control to the PLC.

For automated storage and retrieval systems, this structure supports stepwise movement, resource control, and interleaving. For case conveyors, it supports context-based routing decisions that do not require every short conveyor movement to be modeled in advance as a warehouse task. Across both models, capacity control, exception handling, and warehouse-monitor functions are essential because automated performance depends as much on controlled recovery as on normal movement.

The resulting operating model can be summarized as:

SAP EWM plans the warehouse movement. MFS orchestrates the material flow. PLCs execute the physical movement. Monitoring keeps the system synchronized.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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