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Original Article

The Digital Cockpit: Empowering Warehouse Operations Through Real-Time Visibility and Intelligent Staging

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Abstract - *The logistics world is looking for Speed, Accuracy, and Flexibility, but many warehouses fall short due to poor data integration and visibility in real time. The shipping monitor and shipment stage lane monitor are a unified diaper and human cockpit that digitizes the shipping process in SAP EWM. The paper discusses the design, development, and implementation of this cockpit. The answer solves critical pain points such as unreliable stock availability indicators, complex coordination of the automated Material Flow System (MFS), and inefficient staging lane management. In a Fiori app, we consolidate vital data that enables warehouse operators to progress into a more proactive role. As a result of this earlier detection, they can prevent delays and errors from occurring in the workflow, optimize resource streams, and prevent errors in shipment. This template provides a model for digital transformation, showing how system adaptations can enhance the human role in highly automated logistics.*

Keywords *- Digital Cockpit, Real-Time Visibility, Material Flow System, Returnable Containers, EWM.*

1. Introduction

The warehouse floor is the heart of the supply chain. The shipping process needs to become efficient due to the rise in customer expectations and complexity in product offerings. As MFS (Material Flow System) in the warehousing space is being automated, the interface between man and machine often becomes the bottleneck. Operators often have to work with different systems, Decipher Unclear Data, and manually intervene in automated processes.

The project was a result of realizing that technology must assist the operator, not make their job harder. We aimed to turn away from a strictly transaction-oriented model and build a “Digital Cockpit”, a single intuitive source of truth that provides visibility for all outbound logistics. The Shipping Monitor and the Shipment Stage Lane Monitor were built through a fabulous journey.

The paper shows that through digital transformation, the operator is now at the center of an intelligent and efficient shipping system. This system guides the operators and managers to get the complete picture of what is currently being shipped out and what is going to be shipped out.

The subsequent sections will explain the technical details of problems faced, the architectural design of the provided solution, the stepwise implementation, and the impact on operational efficiency.

2. Problem Statement: The Fog of Fragmented Shipping

Prior to the Digital Cockpit’s introduction, three main friction points existed that caused the Warehouse to work less efficiently. All of them had their roots in a disconnect between the technical data structure of the system and the actionable information required.

2.1. The Stock Availability Dilemma: Technical Noise vs. Operational Reality

The Shipping Monitor primarily informs the warehouse team about when to begin picking the items for shipment. This decision relies on a traffic light system called the Stock Availability Indicator. The indicator, prior to improvement, was flawed because of a bug within the EWM delivery document structure.

The problem was stated: this is what the system considered when calculating stock availability: Text Line Items. The unintended unlocking of these line items, which are purely informational and not pertinent for physical picking, is erroneously illuminated by a RED indicator, suggesting stock unavailability.

Moreover, in the Ambient WH process, the batch determination is carried out. However, the pick status of other main line items was updated to Not Relevant sometimes. Due to a false negative detected by the system, the pick planning procedure was paralyzed as these items were not excluded.

This technical noise translated directly into operational friction:

- Loss of Trust: Due to previous malfunctions of the 'RED' light, operators began to doubt the system. This resulted in time-consuming manual verification of stocks inside the Warehouse.
- Delayed Pick Planning: The trucks were often delayed due to the planner's inability to pick up the process with confidence, causing an overall delay in the outbound schedule.
- Inconsistent Logic: The Warehouse and shipping point had a stringent definition of stock availability check. As a result, we were unable to classify a scenario as "GREEN" (full stock available) and "YELLOW" (partial stock available, but in transit), which required more intelligent pick initiation.

2.2. Staging Lane Chaos and the MFS Coordination Gap

In the highly automated Heidelberg plant, the interplay between SAP EWM and the Material Flow System (MFS) reveals the sophisticated algorithms involved. The staging lanes (bays) are the essential staging area where goods from the automated high-bay Warehouse (HB WH) are ready for loading.

The problem was a severe lack of real-time visibility and control over this finite resource:

- Blind Allocation: Operators had no centralized tool to review the current utilization of staging lanes, which are crucial for the MFS to execute its transfer tasks.
- Manual Correction: Due to over-utilization of the staging lane, operators had to intervene manually, often too late, which led to MFS transfer halts and system errors. In fixing the door/lane, the process is not user-friendly as it is not all in one view.
- The Wave Number Paradox: To collate all the MFS pick tasks for large shipments of Returnable Containers (RC) or IBCs, the EWM generates a Wave Number. The design of the MFS is strict: once the picking starts for a Wave Number, that number cannot be reused. In the case where there was partial availability of shipment (e.g., 9 of 10 containers), the operator will trigger the first wave (WAVE 1). As the final container became available the next day, using WAVE 1 again would trigger a PICK CANCELLATION by MFS, requiring the process to restart from scratch and causing a considerable delay. The absence of a defined process for partial shipments supported by the system created operational chaos and stress.

2.3. Fragmentation of the Shipping Lifecycle

Shipping involves an essential process that includes Pick Planning, Picking, Packing, Loading, and Goods Issue. The old way of doing things took quite a long time for the operators to check multiple transactions and screens of a single TU or delivery. It resulted in the fragmentation of.:

- Reactive Management: Operators spent more time finding information than acting on it, which made it challenging to identify and resolve bottlenecks proactively.
- Inconsistent Prioritization: The standard sorting of SAP is prioritized chiefly based on the Planned Arrival/Departure date. Thus, it was not possible to prioritize Unplanned Deliveries based on the Planned Pick Start Date. This difference in sorting logic made daily planning even more complicated.

3. Solution: The Digital Cockpit – A Unified Command Center

The Digital Cockpit is a single tool that is a Fiori application, which comes in two parts. It is aimed at eradicating fragmentation and providing the operator with clarity, control, and confidence to run a high-volume automated shipping operation.

3.1. Part 1: The Shipping Monitor (The Navigator)

The operator's dashboard is the Shipping Monitor. It displays the most vital information and functions concerning Customer Shipments and Stock Transfer Orders.

3.1.1. The Intelligent Stock Availability Indicator

The core enhancement was correcting the Stock Availability Indicator logic. The system now intelligently excludes:

1. Text Line Items in the EWM Delivery.
2. Line items with a "Pick Status" of "Not Relevant" (e.g., after batch determination in the Ambient WH process).

Indicator	Condition	Operational Meaning
GREEN	Delivery Quantity is Completely Available in Stock at Storage Types.	**Go:** Initiate Pick Activities with complete confidence.
YELLOW	Partial or complete Delivery Quantity is not available but is in transit (from Production/3PL/Other Plants).	**Caution:** Initiate pick for available stock; monitor inbound flow for completion.
RED	Not Enough Stock is available at Storage Types, or the Product is not available in the identified packages.	**Stop:** Manual intervention or delay required; stock must be sourced.

This modification will make sure that the traffic light is genuinely reflective of physical stock in the relevant storage types. Also, the logic for the indicator became more flexible by validating the Check Stock Type Flag against the combination of Warehouse, Shipping Point, and Stock Availability Indicator itself. This facilitates that the flag can be full or blank. This helps with 'GREEN' indicators (full stock) while blanks will help for 'YELLOW' indicators (partial stock/in transit).

3.1.2. Unified Status Tracking and Prioritization

The monitor displays the status at multiple levels (TU, Delivery, Item) across all stages of the warehouse activity (Pick Planning, Picking, Loading, Goods Issue). It was essential to modify the sorting logic according to the operation.

- Execution Overview: Sorted in ascending order by Planned Arrival Date and Planned Arrival Time.
- Unplanned Deliveries: In the configuration table /ACNAAES/AB_007 using the custom parameter ZZPL_PCK_ST_DT, technical changes were made to sort according to the Planned Pick start date. This makes sure that deliveries that do not have a firm TU assignment will be prioritized on pick-up time for better resources.

3.2. Part 2: The Shipment Stage Lane Monitor (The Conductor)

The Stage Lane Monitor is the dedicated tool used to manage natural flow and coordination with the MFS, in particular, automated sites.

3.2.1. Real-Time Utilization and Dynamic Assignment

The monitor shows a visual review of the utilization of Staging Lane (Bay). It operates on a 15-minute interval. This live data allows the operator to use the 'Conductor' assignment, where the Warehouse Door / Staging Lane assignment for a shipment can be changed through an integrated pop-up screen. It is essential to do this so that bottlenecks or congestion are avoided when MFS performs its function. A check is done to check if the entered door is allowed for the Load Type taken from the TU, so that the physical constraints are not violated.

3.2.2. MFS Synchronization and Traffic Lights

To ensure that there is no ambiguity between EWM and MFS, a set of traffic lights was introduced for immediate feedback on MFS coordination:

- RED: Transportation Plan Finalized, but Release to MFS not completed. (Action required by the operator).
- YELLOW: Release to MFS Completed, but Load has not started. (Awaiting physical loading).
- GREEN: Load Started. (The process is underway.)

Such visual feedback will provide the operator with the precise moment to trigger the critical function TRANSFER WAVE in perfect sync with the automatic system.

4. Implementation Workflow: A Journey of Refinement

The realization was a blended project focusing on data integrity on the technical side and complex logic for MFS integration and advanced process support.

4.1. Technical Foundation and Data Integrity

The very first step was a technical cleanup of the EWM system as per the SAP standard for best practices. The custom logic to update EWM Delivery S/4 Shipping Point has been reverted, with an automated option. The standard SAP OSS Notes were implemented. This action was to ensure long-term system stability, maintainability, and that the solution can sustain future SAP upgrades. The technical team also worked towards optimizing the performance of the Fiori application by identifying and deactivating any non-essential technical events that were causing a delay when window selection, which reduced the time taken from "a few seconds" to almost instant.

4.2. Advanced Wave Management for Automated Picking

The implementation's most complex phase was the design of a strong system-enabled process for the automated picking of big containers (RC/IBC) through Wave Numbers.

4.2.1. The Transfer Wave Mechanism

When a TU/Delivery requires automated picking, the system provides a Wave Number, which is a unique number generated by SAP EWM in all its Pick (Stock Removal) tasks. The operator then triggers the 'TRANSFER WAVE' using the Shipping Monitor. The MFS receives these particulars of the wave, and this message indicates to them that the picking activities need to be started and the loading of containers in the designated Shipment Lanes.

4.2.2. Solving the Partial Shipment Paradox

To address the critical issue of partial shipments, a two-wave strategy was implemented:

- WAVE 1: The warehouse team begins a pick task for available stock (e.g., 9 of 10 containers) with WAVE 1, triggering the TRANSFER WAVE. The MFS is responsible for the pick and staging of the containers.
- WAVE 2: Once the remaining stock (10th container) is available (e.g., after production receipt the next day), the task will be picked by the warehouse operator in a new pick task in Wave 2. This is important because a reuse of Wave 1 will be punished by a pick canceled by the MFS. By eliminating a common source of error and delay, the system now supports the sequential, multi-wave approach.

4.3. The Pre-Labelling Solution and Two-Step Pick Process

The implementation also provides for the process of how the step pick process will work for unlabeled products packed in Jerrycans (JC) in the Ambient HB WH. This

process is crucial as the need for JC could be a full or partial withdrawal, requiring a controlled two-step process to ensure accurate labelling and inventory tracking.

4.3.1. The Two-Step Pick for Unlabeled Jerrycans

The entire process will happen in two distinct steps with a clear handover between the automated MFS and the human.

Step 1: MFS-Controlled Transfer to Pick Point

- Strategy: The system's picking strategy for unlabeled JC is to follow the current First Expiry First Out (FEFO) process.
- Action: The MFS is instructed to bring the unlabeled full pallet of Jerrycans from the high-bay storage type (e.g., **0030**) to a designated pick point (e.g., KEA1).
- Confirmation: The MFS confirms this step. This necessitates the implementation of a specific IDOC trigger configuration, whereby the trigger is only sent for storage type 0030 and for Jerrycan products.

Step 2: Operator-Controlled Labelling and Confirmation

- Action: The pallet, which contains the approach of the warehouse user, gets collected and fed into the KEA1 process, where labelling is done.
- Movement: The Product is then moved from the pick point to the Goods Issue (GI) Zone.
- Confirmation: The process KEA1 is used for pick-pack confirmation. An RF confirmation process is available in some instances where the KEA1 process is not used.

4.3.2. The Role of the Pre-Label Indicator

The Pre-Label Indicator is a functional enhancement that assists the operator in determining the following action to be performed. If the Pick Plan Status at the Delivery Line-Item Level is 9 and the Unit of Measure (UOM) is not Containers (i.e., targeting products like Jerrycans, Drums, etc), then this indicator gets activated.

- Decision Point: Once the labelling process (KEA1) has been completed, the pre-label indicator will guide the user's action. The user must ship the newly labelled pallet directly to the customer if the TU is planned. If the TU is not yet planned or the Product is needed for a later shipment, the user must move the Product back to ambient storage.
- Unplanned TU Scenario: The system creates the task under the Create WO By Background process for unlabeled pallets that come from production without a planned TU. The use of the Pre-Label Indicator is still present, and the next step is still a user action to consider the final location (ship now or back to ambient).

4.3.3. Handling Labelled and Mixed Pallets

The solution also streamlined the handling of already labelled pallets and complex mixed shipments:

- **Labelled pallets** can be moved directly to the shipping area. The peelable indicator is checked by the system, and the advanced TU is in place for this direct movement. Ad hoc jobs are to move a labelled pallet from the GI-Zone back to storage (e.g., 0030) using the ZCA1 process type to make changes to stock types.
- **Mixed Shipments:** For mixed cases of RC, IBC, and JC, the system is configured to move them to specific doors (e.g., D012 to D015). The **Shipment Stage Lane Monitor** is the primary tool for the operator to correct any door assignment issues, as no such validations were present in the previous system (D001 to D004 doors).

5. Results: Clarity, Control, and Confidence

The implementation of the Digital Cockpit has revolutionized the shipping operation from a reactive, uncoordinated process to a proactive, coordinated system.

5.1. Operational Efficiency and Error Reduction: A Quantitative Synopsis

The most important quantitative result will be a reduction in manual stock verification and MFS-related errors, leading to an improvement in KPIs.

KPI	Pre-Implementation State	Post-Implementation State (Synopsis)	Improvement Driver
Manual Stock Checks	High (due to false "RED" indicators)	Near-Zero	Intelligent Stock Availability Indicator (Exclusion of Text/Not Relevant items)
MFS Pick Cancellation Rate	Moderate (due to Wave Number reuse)	Eliminated	Advanced Two-Wave Management for Partial Shipments
Truck Turnaround Time	Inconsistent (due to staging bottlenecks)	Reduced and stabilized	Real-Time Staging Lane Utilization and Dynamic Assignment
Operator Trust in System	Low	High	Unified Fiori Interface and Reliable Traffic Light Logic

In response to the "red" indicator being eliminated, operators no longer need to spend much time manually checking counters and devote more time to value-added work. Additionally, the effective Wave Management process has achieved a smooth flow of complex, high-volume (RC/IBC) shipments without the costly disruptions of MFS pick cancellations. The automated process remains stable, which enables all efficiency gains to be realized.

5.2. Empowering the Operator: A Qualitative Synopsis

The warehouse team was significantly impacted qualitatively by the humanized design of the Fiori application. The warehouse team's involvement with applications changed. They became decision-makers instead of data-entry/clerks and troubleshooters.

- Proactive Management: The common perspective and intelligent traffic lights allow operators to deal with problems (a full staging lane or stock shortage) before they impact the schedule. This will facilitate timely intervention. The MFS Status lights (Red, Yellow, Green) visible on the Stage Lane Monitor offer immediate information about the status of the automation and the perfect timing for the essential TRANSFER WAVE function.
- Reduced Cognitive Load: The operator is able to make decisions without the worry of scrolling due to the combination of information and homogenization of feel, making maximum data visible on a screen at one time. The shipping process can be fully comprehended due to the level status tracking (TU, Delivery, Item).
- Confidence in the System: The move from frequently wrong and misleading information to a reliable source of what can be practically done has created a new level of confidence. Now this operator is not so much a system troubleshooter anymore, but the conductor.

6. Future Potential: Expanding the Horizon

The Digital Cockpit is not the end goal but the base for the logistics network, which should continue to grow. The focus for the future is standardization of successful processes, completion of the visibility loop, and data leverage for predictive logistics.

6.1. Network-Wide Standardization of Key Processes

The pre-labelling solution successfully implemented at Heidelberg offers a path to standardization at other sites. The aim is to ensure that the entire process is implemented efficiently in the entire logistics chain.

- Geographic Expansion: The Pre-Labelling solution will be extended to other warehouses, notably Berlin and Valencia. The same two-step pick process logic and Pre-Label Indicator functionality will be replicated in the new environments.
- UOM Expansion: Following on from the Jerrycans, it will be extended to products that are packed in other units of measurement, such as Drums and Cartons—a standardized procedure for labeling across the network that better ensures compliance and minimizes the risk of mislabeling.

6.2. Completing the Visibility Loop: Unassigned Deliveries

A key planned improvement is to include Unassigned Deliveries in the Shipping Monitor. At present, the monitor looks at the deliveries already allocated to TU. Creating a section for unassigned deliveries would help the warehouse planning team see the total outbound backlog.

- Proactive Allocation: With this new visibility, resources can be planned better and freight orders allocated proactively. The planned goods issue date can be configured to allow the planning team to use it as a sort order for unplanned deliveries. TU's creation will be allowed based on the planned goods issue date when the deliveries must be planned.
- End-to-End Transparency: This feature enhances visibility across the end-to-end shipping process. Makes the system not just a tool for execution management, but also strategic planning and backlog management.

6.3. Advanced Analytics and Predictive Logistics: Moving Beyond Real-Time

An impressive amount of data that is high-quality and consolidated makes its way to the Digital Cockpit. This helps the operation go from reactive to predictive through the power of the analytics.

- Predictive Staging: Models have been developed to predict the utilization of staging lanes based on the planned arrival of TUs, MFS transfer rates, and historical loading times. The system would suggest lane shifts hours ahead of time so that it can optimize the layout even before the trucks arrive.
- Dynamic Wave Planning: Using machine learning to improve the two-wave strategy for partial shipments continually. As soon as WAVE 1 is released, the WAVE 2 task can be created and reserved automatically with the expected production receipt time.
- Performance Benchmarking: With the help of multi-level tracking data, benchmarks for each shipping process (Picking, Loading, Goods Issue) can be established in detail to let the management choose a specific part to continuously improve.

7. Conclusion

The Shipping Monitor and Shipment Stage Lane Monitor are more than software features. They represent a successful humanization of the complex logistics system interface. The Digital Cockpit turns a fragmented, error-prone process into a streamlined, high-intelligence process by focusing on the operator on clarity, control, and confidence. The key takeaway of digital transformation is that the strongest technology is that which best empowers the people behind it. The result? The warehouse operator is now the confident conductor of a fully automated, high-performance shipping orchestra. The success of this project indicates that a targeted human system, in the recent automated Warehouse, helps the various ongoing operations to improve significantly.

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