



Eliminating "Hidden Waste" in SMT Production Sites — A Total DX Solution Integrating Manufacturing, Warehouse & Logistics

**Next-Generation SMT Smart Factory Evolution:
How MES/WMS and Automated Logistics Drive Manufacturing Transformation**

White Paper for Manufacturing Executives & Factory Managers

NTT DATA TAIWAN SMDC (Smart Manufacturing Development Center)

INTRODUCTION



From Assembly Process to Strategic Process

Modern SMT (Surface Mount Technology) has evolved beyond a basic assembly process into a strategic process that determines product value and supply chain resilience.

Traditional kaizen alone cannot combat severe labor shortages and intensifying competition. What is required now is a strategic shift — formalizing frontline knowledge through digital technology and driving continuous improvement cycles with AI.

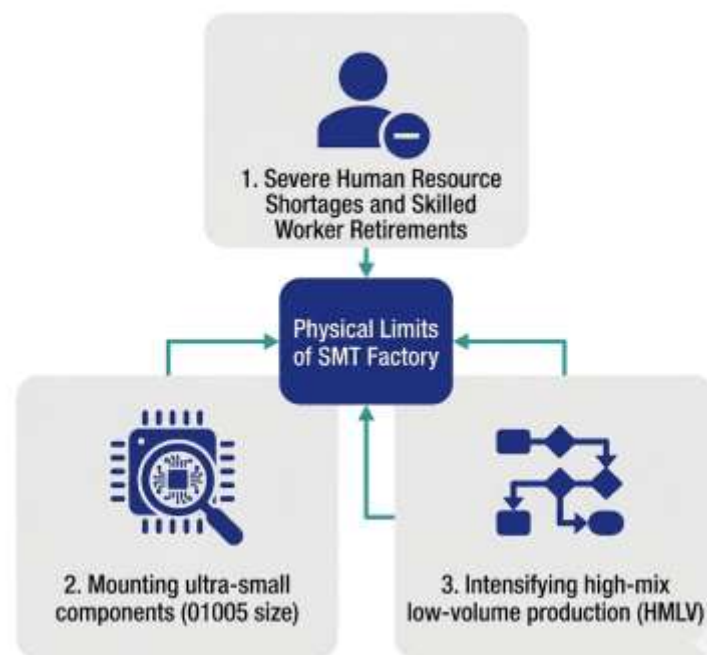
Only companies that master systems like MES, synchronize management and frontline data in real time, optimize equipment operations, and enhance shop-floor efficiency with AGVs and handheld terminals can establish next-generation competitive advantage.

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Chapter 1

Why Is SMT Transformation Required Now?



1. Severe Labor Shortage & Retiring Veterans

Skilled worker shortages are critical across manufacturing. SMT faces the disappearance of "tacit knowledge" (equipment fine-tuning, troubleshooting) as veterans retire. Only a fraction of manufacturers are investing in reskilling. Foreign operator training and language barriers compound the challenge.

2. Operational & Process Limits

High-mix low-volume (HMLV) production increases management burden: frequent changeover losses from mask swaps, program changes, and reel setups; analog paper-based records that delay data and cause input errors.

3. Rising Precision Requirements

01005 (0.4mm × 0.2mm) components demand placement accuracy of $\pm 25 \mu\text{m}$ to $\pm 10 \mu\text{m}$ — beyond human capability. Component management of thousands of micro-reels is SMT's unique burden. Incorrect components can lead to large-scale defects.

SMT Assembly Process Flow

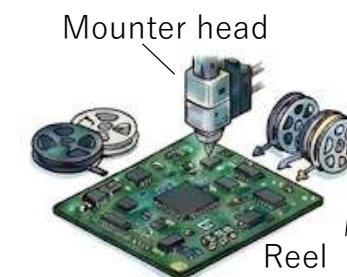
① Solder Printing

Cream solder is applied uniformly to the component pads on the PCB using a metal mask (stencil).



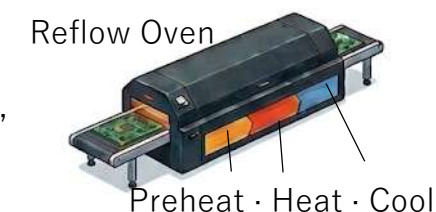
② Component Mounting

A mounter machine places electronic components at high speed and precision onto the correct positions on the board.



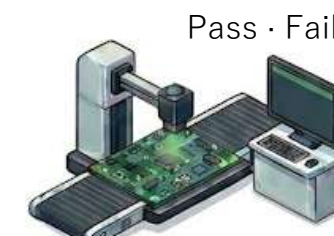
③ Reflow

The board passes through a reflow oven, where heat melts the solder and permanently bonds the components to the board.



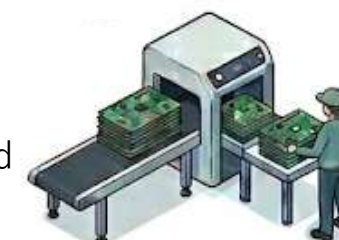
④ Visual Inspection (AOI)

Cameras (AOI system) automatically check for component misalignment, missing parts, and solder joint quality.



⑤ Post-Process / Finishing

As needed: back-side component attachment, manual correction, and operation verification to complete the board.



(Image)

Five Key Challenges in SMT Manufacturing

Management challenges in SMT manufacturing span from technical aspects demanding extreme precision to social aspects such as severe labor shortages.

1. Labor & Skills Transfer Crisis

Severe worker shortage across manufacturing. Disappearance of veterans' "tacit knowledge" (equipment fine-tuning, troubleshooting). Very few manufacturers invest in reskilling. Additionally: insufficient training time for foreign operators and language barriers in floor communication.

2. Operational & Process Limits

HMLV production increases management burden: (a) Changeover losses — metal mask swaps, program changes, reel setups restrict throughput; (b) Analog management delays — paper records and manual data entry reduce real-time visibility and generate critical input errors.

3. Complex Physical Component Management

Managing thousands of types of micro reels and materials is a uniquely heavy SMT burden. Workers waste time searching for the right parts. Incorrect component setup can result in large-scale scrap and defective products.

4. Escalating Quality Control & Inspection Costs

Product miniaturization and higher performance raise the difficulty of quality management. The solder printing process demands precise control and generates many defects, necessitating strict inspection regimes.

5. Information Silos

Different communication protocols across equipment manufacturers create information silos. It becomes difficult to feed downstream inspection results back upstream, or to correct downstream based on upstream deviations. Industry is advancing IPC-2591 (CFX) to resolve this.

These challenges piling up in SMT processes are a major factor reducing factory productivity — but addressing them individually is not a fundamental solution. Labor, processes, components, quality, and information are all intertwined, generating "invisible waste" throughout the entire shop floor. So what specific types of "waste" are actually occurring in SMT production? The next chapter takes a closer look at the reality.

For inquiries or questions, please [contact us](#). Free factory diagnostics available.

Chapter 2

Hidden "Waste & Costs" in SMT Production

In the environment described above, various forms of "waste" have become normalized across SMT processes, eroding profitability. These wastes are difficult to quantify and become "invisible management costs."

Location	Type	Description
Warehouse & Inventory	Searching Waste	Paper-based records → minutes wasted finding a single component
	Inventory Discrepancies (System vs. Physical Inventory)	Manual entry mismatch between ledger and physical stock → line stoppages or excess inventory
	Excess/Shortage	Line stoppages from system stockouts; excess stock ties up capital
	Quality Degradation (MSD mgmt)	Manual temp/humidity management causes material degradation and defects
In-Factory Transport	Transport Waste	Line workers push carts to deliver picked parts; causes fatigue and delayed supply
Manufacturing Execution & Planning	Changeover Waste	Frequent feeder swaps & program changes reduce utilization in HMLV production
	Mis-Setup Waste	Incorrect component setup (feeder mis-loading) leads to costly mass scrapping

It is important to look beyond the production line and identify challenges in warehouse operations and in-factory transport as well.

Visualization Approach Examples

Searching	Auto-tally time gap: dispatch → process start
Inv. Mismatch	Real-time stock sync + automatic alerts
Inv. Over/Under	Auto calculation of optimal stock & reorder points
Quality Degr.	Temp/humidity sensor linked to WMS expiry mgmt
Transport	Transport task log → operational time visibility
Changeover	Auto collect & analyze equipment OEE data
Mis-Setup	BOM matching log → error frequency recording

Key: Different waste types require different solutions. Combine MES for manufacturing waste, WMS+ERP for . Choosing the right system for each challenge is the first step.

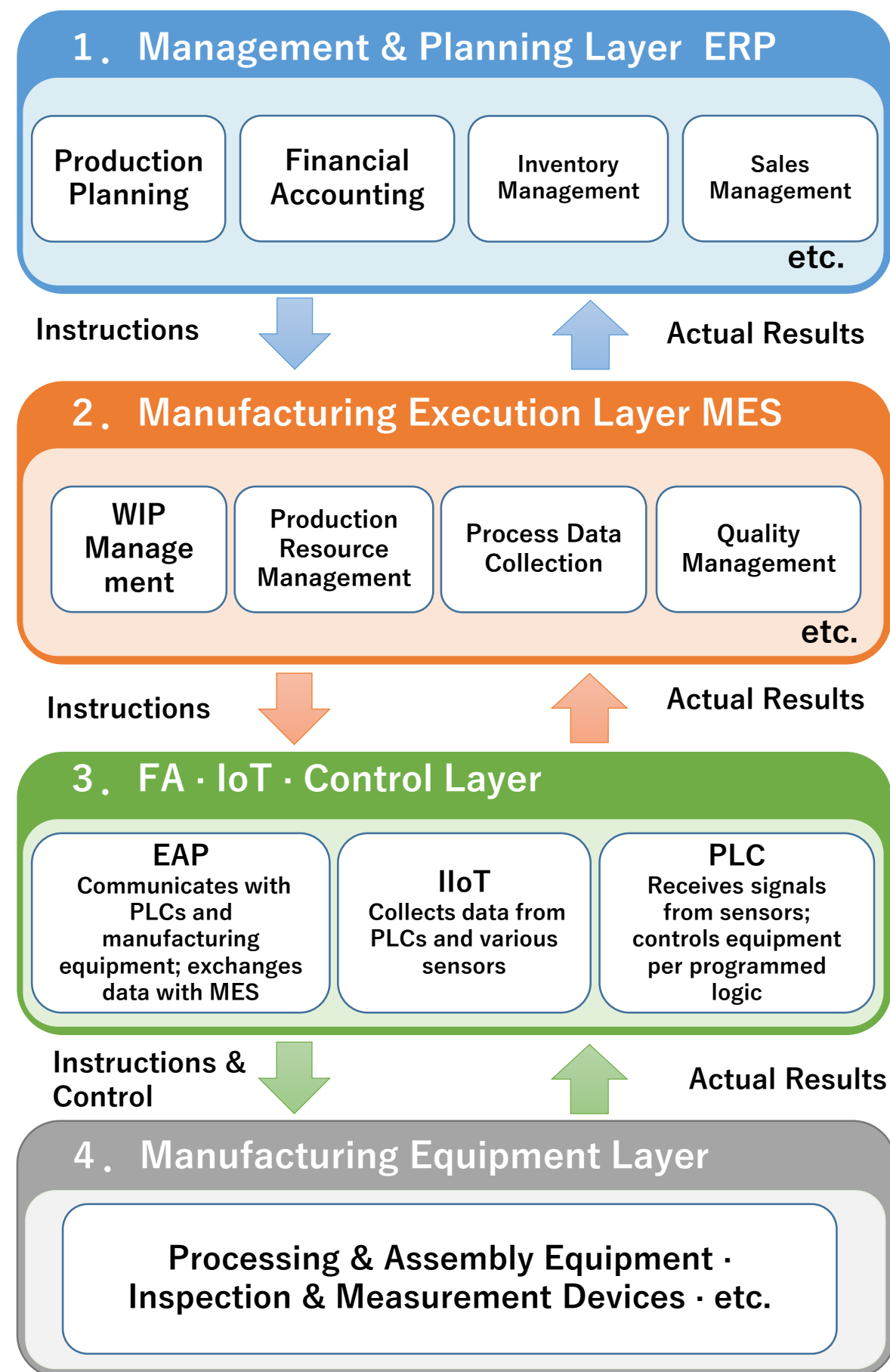
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Making the "Invisible" Visible — System Integration Architecture

To visualize latent waste, system implementation and information integration across all layers — from management to shop floor — is essential. This eliminates "information silos" and is the critical first step to addressing labor shortages and quality losses.

System	Role
ERP Management & Planning Layer	Optimizes human, material, and financial resources. Transmits production plans and resource allocation directives to MES based on order status.
MES Manufacturing Execution Layer	Translates ERP plans into shop-floor work instructions. Issues detailed directives to the FA layer and collects/analyzes actual results, reporting back to ERP.
EAP · IIoT · PLC FA · IoT · Control Layer	Interface between equipment and IT systems. EAP communicates with PLC/equipment; IIoT collects sensor data; PLC receives signals and controls devices per programmed logic. All feed real-time data upstream.
Shop-Floor Devices	Printers, mounters, reflow ovens, AOI, and other equipment. Perform actual processing and send operational data back to upper-level systems.

Expected effects: eliminate information disconnects; remove paper delays/errors; achieve real-time visibility; build a highly responsive and waste-free production system.



Chapter 3

Solution Deep Dive

How can the "waste" hidden in SMT processes be concretely improved using our proprietary MES "EXC-MES" and related solutions (※)? Here we introduce some specific solution examples.

EXC-MES: "Zero Downtime, Zero Defects" Manufacturing Execution

【SMT Process】



◆ Poka-yoke (Mis-setup Prevention)

Scans component, feeder, and equipment IDs against the BOM in real time. On mismatch, the system automatically interlocks (force-stops) the equipment, preventing human error at the source.

◆ Traceability Realization

Links each PCB serial number to the lot numbers of all mounted components. When a claim arises, instantly identifies "which lot, on which equipment, and when" it was produced.

◆ Real-Time Monitoring

Collects reflow oven temperature profiles and mounter status via EAP and IIoT. Detects abnormal parameters and triggers alerts before defects are mass-produced.

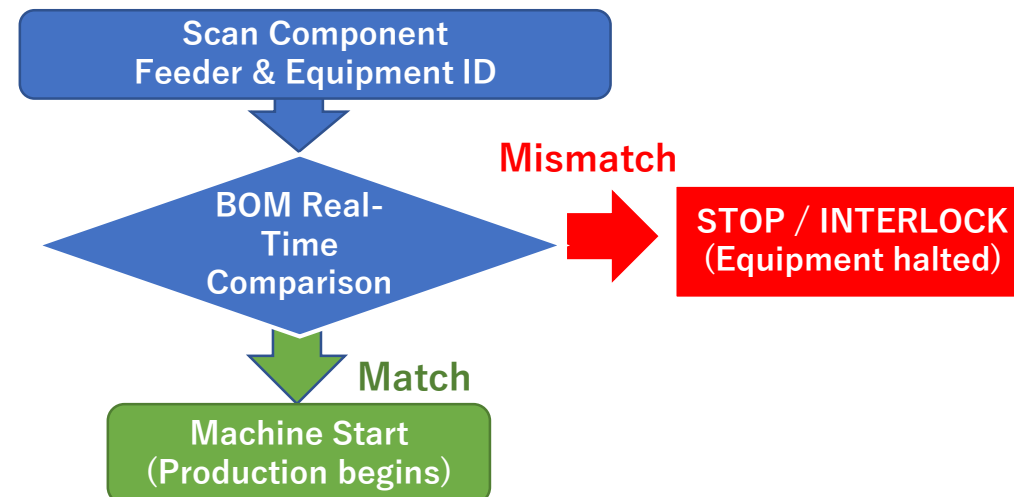
◆ AOI Inspection

Combines AI with AOI to optimize judgment criteria, reducing false positives in which non-defective products are incorrectly identified as defective.

What is EXC-MES (Excellent MES)? NTT DATA Taiwan's proprietary MES, tightly integrated with ERP and seamlessly connecting AI, IoT, and automated transport (AGV). Realizes end-to-end visibility through autonomy on the shop floor, eliminates information silos, and strongly supports data-driven business transformation and sustainable growth.

◆ Poka-yoke (Mis-setup Prevention)

⚠ Current Challenge: In HMLV production with many component types, incorrect components are set, leading to mass defective scrapping.



● Solution:

Barcode readers scan component ID, feeder ID, and equipment ID. MES compares these against the BOM in real time. If a mismatch is detected, MES immediately and automatically stops the equipment (interlock/forced stop), preventing human error at the source.

◆ AI-Assisted False-Positive Reduction

⚠ Current Challenge: Conventional AOI frequently misidentifies good products as defective ("false positives"), requiring time-consuming and costly manual re-inspection. Loosening thresholds increases escapes; tightening them increases re-check costs — a difficult dilemma.



● ✓ Solution:

An AI secondary-judgment module is introduced integrated with MES. AOI NG images are automatically re-analyzed by AI to distinguish true defects from false positives. The company's own quality standards are trained into the AI model. NG images are linked to manufacturing lot numbers in MES for instant reference by repair staff.

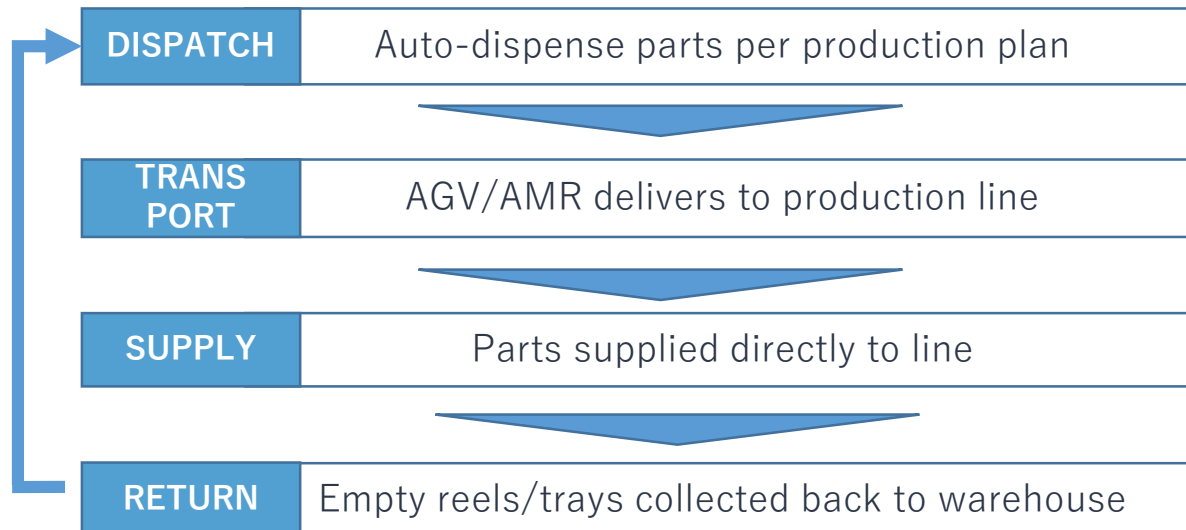
● → Results:

Inspection costs reduced 80%; false positive rate improved from 1.3% to 0.45%; escape rate improved from 0.93% to 0.07%.

SOLUTION ② : AGV/AMR: Fully Automated In-Factory Logistics

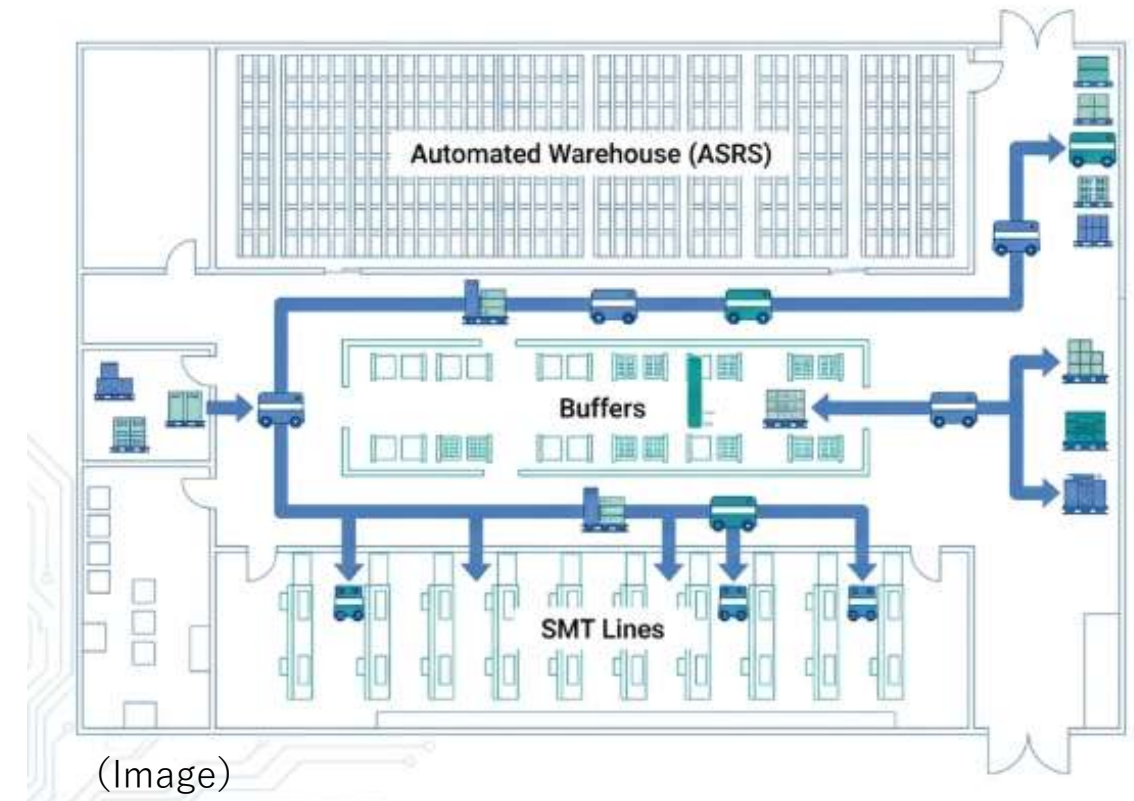
⚠ **Current Challenge:** Manual, operator-dependent transport by forklift and cart causes worker fatigue and "material waiting" that reduces line utilization.

Overview: A solution connecting the warehouse (WMS) and production lines (MES/equipment) so that material movement and information flow in sync — delivering the right quantity to the right place without delay. Manages everything end-to-end: advance preparation based on production plans, automatic supply to lines, usage actuals, and real-time inventory.



(Image)

◆ Unmanned In-Factory Logistics via AGV/AMR

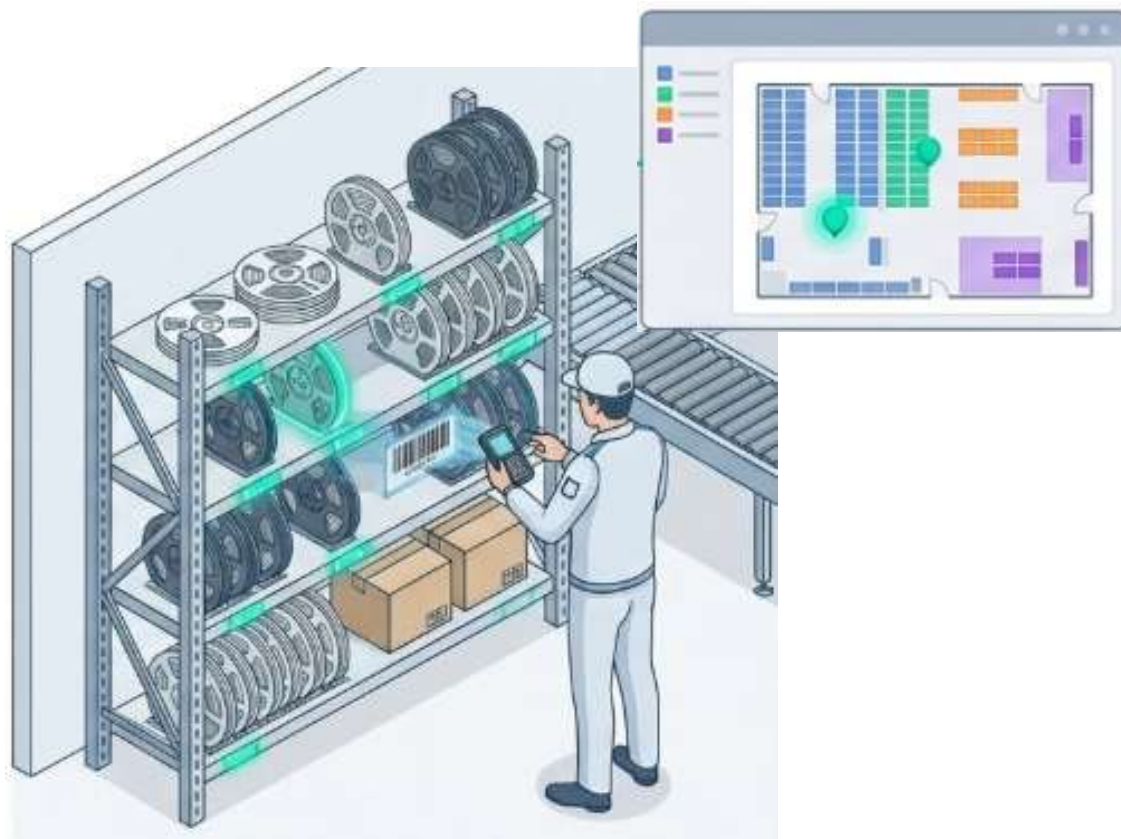


- **System-Driven JIT Supply** : WMS/MES automatically issues transport tasks to AGV based on production instructions. Delivers the right materials to SMT lines at exactly the right time.
- **Seamless Factory-Wide Connectivity** : Unmanned logistics across warehouse picking areas, factory grounds, warehouse-to-factory corridors, and inter-line PCB transport.
- **Advanced Sensing & Safety** : 3D SLAM navigation and automatic center-position correction even for non-standard pallets. Combines high safety standards with high transport accuracy.
- **Shift Workers to Value-Added Tasks** : Liberate staff from simple transport tasks; redeploy to higher-level quality control and equipment operations.

SOLUTION ③ : EXC-WMS: "Find Faster, Work Smarter" Smart Warehouse

⚠ **Current Challenge:** As component counts grow, warehouse staff spend increasing time searching for physical items.

WMS goes beyond mere paperless operations to maximize efficiency of SMT's uniquely complex component management. Fully digitalizes receiving/shipping, inventory counts, and stock movements using barcodes and RFID.



(Image)

WMS Implementation Results: Key Examples

BEFORE (Current Issues)	After) AFTER (WMS Solution)
✗ Daily manual entry: receiving/shipping info organized and re-entered into ERP	✓ Paperless Receiving/Shipping: PDA (handheld terminal) + barcode reader/RFID reduces data processing from hours to minutes. Eliminates manual entry errors.
✗ Picking based on paper lists and worker memory	✓ "Zero Searching" Digitized Picking: Warehouse mapping and Smart Rack (LED-lit shelf labels) guide staff to storage locations with light indicators. Drastically cuts search time.
✗ Expiry management not enforced; old inventory lingers	✓ Strict FIFO (First-In First-Out) Enforcement: Component expiry dates managed precisely by the system. Optimal picking targets auto-recommended, preventing stagnant inventory and disposal waste.
✗ ERP and shop-floor inventory data out of sync	✓ Real-Time ERP Sync: Receiving/shipping and stock change data synced to ERP in real time. "Ledger" always matches "physical" stock.

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Solution ④ · Advanced Production Planning (APS × RTD)

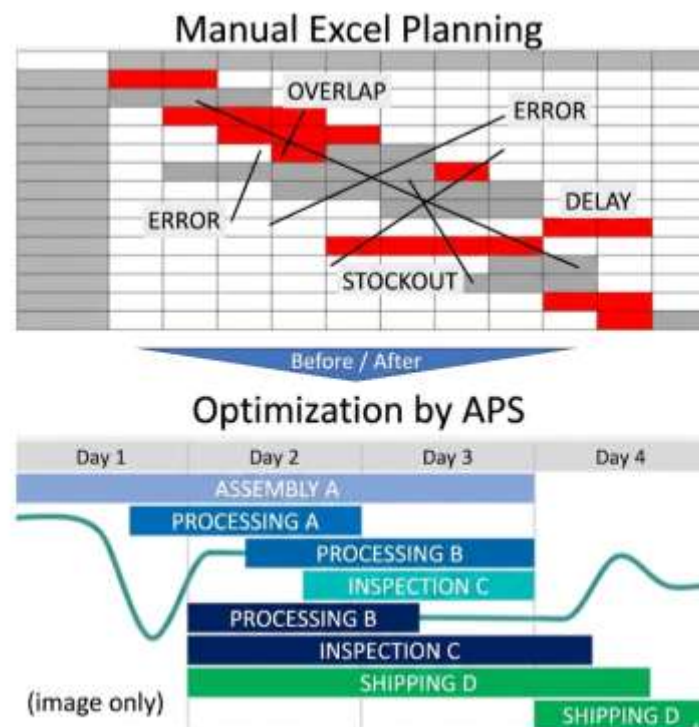
⚠ Challenge: As orders become smaller and more diverse, Excel-based manual scheduling has reached its limits.

◆ Advanced Production Scheduler (APS)

Considers ALL finite factory resources — equipment, personnel, tooling, and materials. Automatically calculates the optimal production sequence in seconds to minimize changeover loss and maximize equipment utilization under complex constraints.

◆ Real-Time Dispatching (RTD)

RTD (production dispatch module) re-assigns optimal tasks to shop-floor equipment and workers in real time, instantly responding to machine breakdowns, rush orders, or other rapidly changing production conditions. Minimizes production stagnation.



- **Benefit:** From error-prone Excel plans (duplicates, delays, stock-outs) to automatic optimized scheduling — equipment utilization maximized, changeover losses minimized.

Solution ⑤ · AI & IIoT-Powered Predictive Maintenance

⚠ Challenge: In micro-component processes, even slight equipment behavior changes cause mass defects. Reactive and time-based maintenance cannot prevent sudden failures or excess maintenance costs.

◆ AI & IIoT Predictive Maintenance

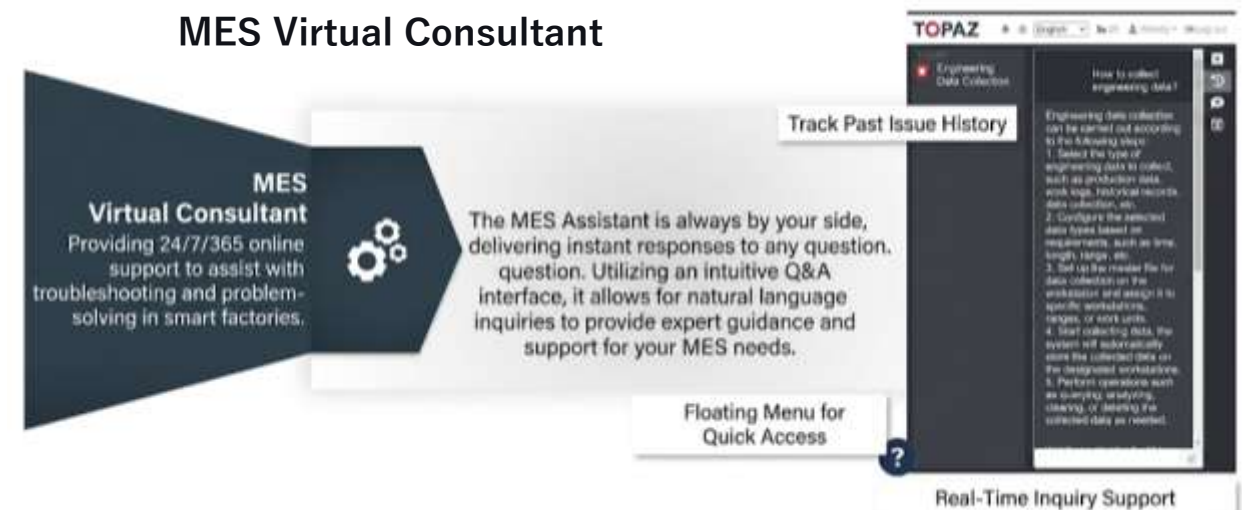
EAP and IIoT devices collect vibration, current, and temperature data in real time. An AI analytics platform connected to MES detects micro-deviations from normal. Machine learning models predict the Remaining Useful Life (RUL) of components, presenting optimal maintenance timing before failure.

◆ Virtual Consultant (Generative AI)

A 24/7 generative AI (virtual consultant) guides operators through root-cause analysis and specific improvement actions in a conversational interface — addressing skilled worker shortages and knowledge transfer challenges.

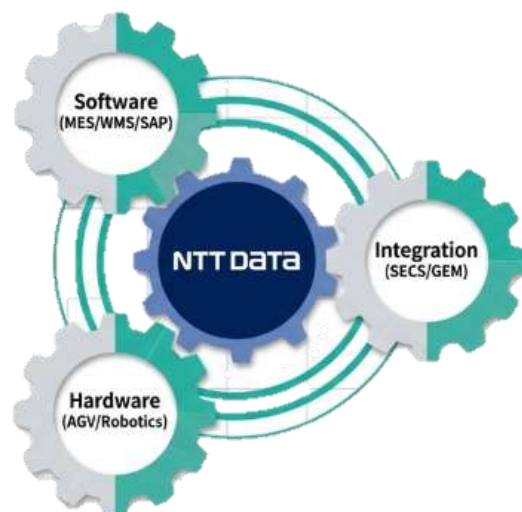
- **Real Case:** A chemical manufacturer used AI to predict filter lifecycle, extending usage time based on lifespan predictions and achieving 20% annual maintenance cost reduction.

MES Virtual Consultant



Why Choose NTT DATA Taiwan (SMDC)?

NTT DATA Taiwan holds unique and powerful strengths in SMT factory DX that no other provider can match.



- ① **Total Solution Package :** One of very few providers that delivers and controls MES, WMS, APS, Data Platform, EAP, AGVs, and automated warehouses — all in a single integrated engagement. Not just MES — complete hardware-to-software coverage.
- ② **Advanced System Integration Technology :** Taiwan's largest SAP consulting capability with 3,500+ global SAP clients in the NTT DATA Group. Seamlessly "vertically integrates" SAP ERP with shop-floor MES/WMS. Supports IPC-2591 (CFX) and SECS/GEM standard communication protocols for flexible connectivity with diverse FA equipment.
- ③ **Japanese Quality + Locally-Rooted Support :** Combines NTT DATA Group's renowned quality standards with deep Taiwan local consulting capability. Understands each company's current situation and proposes the optimal, cost-effective DX approach.
- ① **Global Reach :** Leveraging rich Taiwan implementation experience, solutions extend to overseas production sites. Supports cross-site standardization and efficiency improvements for companies with multiple global manufacturing locations.

Partnership That Continues After Go-Live: NTT DATA Taiwan's Concierge Support

"System implementation is not 'set and forget.' We provide everything needed to ensure successful on-site adoption and continue generating results."

- **Expert Consulting :**

Our consultants thoroughly interview your shop-floor challenges and design the optimal blueprint tailored to your facility.

- **Flexible Customization :**

We resolve hardware technical challenges too — including proprietary customizations such as XY tables (workpiece bases) and CCD cameras to connect IT (systems) and OT (equipment/FA). We provide flexible solutions tailored to customer requirements.

- **On-Site Education & Training**

In addition to a multilingual UI, we produce and provide dedicated operation training videos and educational content so that foreign operators can achieve proficiency in a short time.

- **Sustainable ESG Management Support**

Through paperless operations and replacing forklifts with AGVs for CO₂ reduction, we work together with our customers toward their sustainability and ESG goals.

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CASE STUDY① : EMS Manufacturer: MES + Smart Rack (LED-Lit Shelf Labels)

Challenges Faced

In a high-mix low-volume production environment, finding the necessary reels took several minutes per occurrence, and frequent changeovers were limiting production throughput. Additionally, manual component setup could not prevent BOM mismatches, and there was serious concern that mass defects could occur.

Solution Implemented

Deployed NTT DATA Taiwan's proprietary EXC-MES integrated with Smart Rack (LED-lit shelf labels). Synchronized with manufacturing instructions, the LEDs on target component shelves illuminate to realize "Digitized Picking." Also implemented automatic BOM matching of component/feeder/equipment IDs — on mismatch, machine operation is automatically prevented.

Results Achieved

TWD 2.85M

Annual Operating Cost Reduction

Digitalization of component management reduced annual costs by TWD 2.85 million

98%+

Inventory Accuracy

Achieved 98%+ accuracy between ledger and physical inventory

80%↓

Component Search Time

Reduced component search time by up to 80%

CASE STUDY② : Optical/Semiconductor Manufacturer: MES + AGV Integration

Challenges Faced

Workers walked 10+ km per day in the cleanroom transporting heavy components from the warehouse to production equipment — a harsh working environment. Inefficient manual carts caused material supply delays. The customer demanded high levels of automation and quality control.

Solution Implemented

"Deployed EXC-MES, IIoT, and AGV as an integrated solution, fully automating heavy transport. A proprietary high-precision positioning system (XY table + CCD camera) was developed to prevent lens damage during AGV loading. Equipment parameters are auto-configured via EAP, and remote utilization monitoring eliminates the need for floor visits."

Results Achieved

33%↑

Transport Efficiency

Improved transport/setup efficiency → annual production capacity increased by approx. USD 4 million

10%↓

Manufacturing Cycle Time

Shortened manufacturing cycle time; WIP (work-in-process) reduced by 23%

10 Employees Reassigned to Higher-Value Tasks

Personnel Optimization

All dedicated transport staff replaced by AGV and redeployed to higher-value work

CASE STUDY③ : LED Lighting Manufacturer: AI-Powered Quality Inspection Optimization

Challenges Faced

Conventional AOI machines generated many "false positives" (good products judged as defective), requiring manual visual re-inspection and incurring enormous labor costs and man-hours. The company was caught in a dilemma: loosening the judgment threshold increased escapes (missed defects), while tightening it increased re-inspection costs.

Solution Implemented

Introduced an AI secondary-judgment module. AOI NG images are instantly re-analyzed by AI to automatically distinguish true defects from false positives. The company's proprietary quality criteria were trained into the AI model. NG images are stored linked to manufacturing lot numbers within MES, enabling repair staff to immediately confirm defect content.

Results Achieved

80% ↓

Monthly Inspection Costs

Visual re-inspection work was drastically reduced, achieving 80% reduction in monthly inspection-related costs

0.93%

→ 0.07%

Escape Rate Improvement

Escape rate (missed defects) improved from 0.93% to 0.07%

DX Roadmap: "Start Small, Scale Big"

System implementation does not need to be done all at once. A phased approach aligned to your organization's current maturity level is the key to success.

Phase1 : Digitalization (Visibility)



MES

- Reduce paper-based work; digitalize production records with EXC-MES
- Secure end-to-end traceability
- Auto-collect key equipment OEE data via IIoT deployment
- Visualize inventory with EXC-MES

Phase 2 : Automation & Integration



AGV

- AGV/AMR deployment: unmanned transport, automatic supply to lines
- Seamless data integration of ERP, MES, and WMS
- Achieve ledger ↔ physical stock alignment in real time

Phase 3 : Autonomous Operations (AI- Driven)



- Automate complex scheduling with APS
- AI-powered predictive maintenance
- Build management dashboard via data platform
- Achieve autonomous, self-optimizing factory operations

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NEXT STEPS

Gain Next-Generation Competitive Advantage

While the environment surrounding SMT factories grows increasingly demanding, fully integrating systems and equipment promises to unlock overwhelming productivity and profitability gains.

To eliminate invisible waste and secure next-generation competitive advantage: NTT DATA Taiwan — deeply versed in both management and shop floor, IT and OT — serves as your trusted long-term partner.

NTT DATA Taiwan (SMDC) is advancing solution delivery not only in Taiwan but also for overseas production sites. We can address challenges across multiple sites for companies with manufacturing operations in Japan and globally.

Let's begin with a free diagnosis of your factory.

Contact & Free Factory Diagnosis

Our experienced consultants will answer your questions about hidden challenges in your factory and your smart factory roadmap.

【Contact】

smdc.inquiry@nttdata.com

**Please feel free to reach out.
(Japanese · Chinese · English
available)**



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