INOVIQ
TECHNOLOGIES
Engineering Intelligent Industry

MANUFACTURING EXECUTION SYSTEMS (MES)

A PRACTICAL CUSTOMER GUIDE

Modules, standards and deployment options, adopted one step at a time
Companion to the INOVIQ Digital Transformation Primer and Maturity Self-Assessment

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1 EXECUTIVE SUMMARY

A Manufacturing Execution System (MES) is the software layer that turns a production plan into finished, recorded product. It tells people and machines what to make and how, captures what actually happened, and gives every level of the business an accurate, real-time picture of production, quality and material.

MES has a reputation for large, long and expensive projects. It does not have to be that way. Modern MES is modular: a plant can start with one capability on one line, prove the value within weeks, and add modules as each one becomes part of daily work. The deployment model is equally flexible, with cloud, on-premises and hybrid options.

Key messages

- **MES closes the gap** between business plans in ERP and real-time control on the shop floor.
- **It is a set of modules,** not one monolith: production, quality, material, maintenance, performance and more.
- **Start where the pain is:** downtime visibility, paper reduction or traceability, then grow step by step.
- **Build on standards** (ISA-95 above all) so modules, systems and sites fit together as you grow.
- **Choose the deployment model per need:** time-critical execution near the line, analytics and multi-site services where convenient.

2 WHAT AN MES IS AND WHERE IT SITS

The ISA-95 standard describes a manufacturing enterprise in levels. MES lives at Level 3, between business planning at Level 4 and the control systems at Levels 0 to 2. Orders and master data flow down; actual results flow up. Without an MES, that exchange often runs on paper, spreadsheets and phone calls.

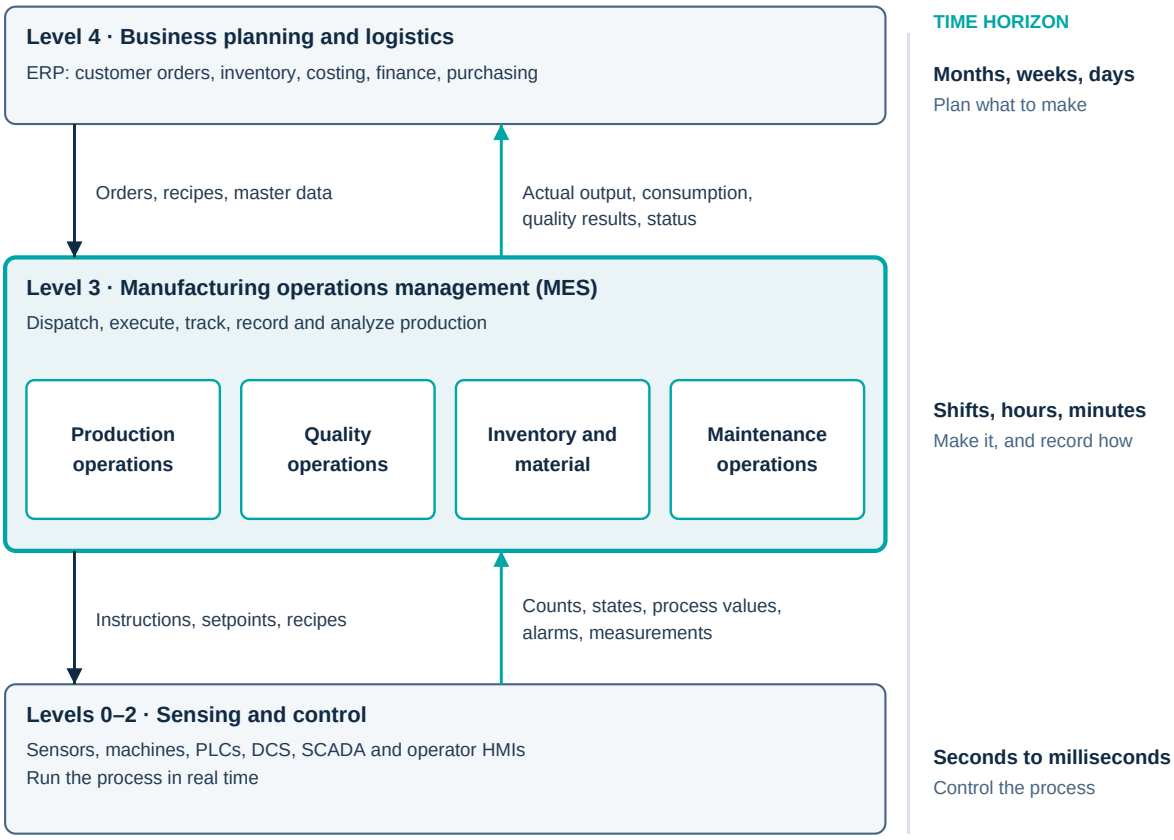


Figure. MES sits at ISA-95 Level 3. It translates plans into instructions and reports actual results back, working in shifts, hours and minutes, between the long horizons of ERP and the real-time world of control.

	ERP (Level 4)	MES (Level 3)	Control (Levels 0–2)
Main question	What should we make, and when?	How is it being made, right now?	How do we run this step safely?
Typical users	Planning, finance, purchasing, sales	Operators, supervisors, quality, production engineers	Operators, control engineers
Data granularity	Orders, totals per day or week	Each order, lot, unit, step and event	Signals every second or faster
Records	Financial and inventory transactions	Production, quality and genealogy records	Process trends and alarms

3 THE MODULES OF AN MES

An MES is a family of functions. ISA-95 groups them into four areas: production, quality, inventory and material, and maintenance operations. Each module below can be implemented on its own and connected to the others later.

Module	What it does	Typical benefit
Production order management and dispatching	Receives orders from ERP, releases work to lines and stations in the right sequence	Right job, right line, right time; fewer verbal instructions
Data collection and machine integration	Captures counts, states, cycle times and process values automatically	Accurate data without manual entry
Performance analysis (OEE and downtime)	Tracks availability, performance and quality losses with reasons	Losses made visible and prioritized
Electronic work instructions	Shows step-by-step instructions, drawings and checks at the workstation	Consistent execution; faster training
Production reporting and electronic records	Records start, finish, quantities, scrap and sign-offs; electronic batch or device history records	No paper; faster order closure and release
Quality management	In-process inspections, SPC, sampling plans, non-conformance and corrective actions	Problems caught at the source
Genealogy and traceability	Links lots, serial numbers, materials, equipment and people at every step	Fast, precise recalls and investigations
Material and WIP tracking	Tracks material issue, consumption, location and work in progress; weigh-and-dispense where needed	Accurate inventory; fewer shortages
Detailed scheduling	Sequences orders by capacity, changeovers and material availability	Shorter lead times; fewer changeovers
Recipe and specification management	Holds versions of recipes, parameters and specifications; downloads them to equipment	Correct settings every time
Labor and skills management	Records who did what; checks training and certification before a task	Compliance and accountability
Maintenance integration	Feeds run hours, counts and fault events to maintenance; blocks use of unavailable equipment	Condition-based maintenance; fewer failures
Document control	Delivers the current, approved version of each document to the floor	No outdated drawings or procedures in use
Energy and sustainability tracking	Attributes energy and utilities to orders, products and lines	Energy per unit; lower cost and emissions

4 START SMALL: STEP-BY-STEP ADOPTION

The traditional “take all or nothing” MES project tries to define, configure and switch on every function at once. It promises a complete solution but carries long timelines, heavy change for the workforce and delayed returns. A modular approach starts with the module that removes the biggest pain, proves it on one line, and adds the next when the first is part of daily work.



Each step delivers value on its own. A shared data model and integration layer connect them.

Figure. A typical adoption path. The order is a guide, not a rule: a regulated plant may start with electronic records and traceability, a high-mix plant with dispatching and scheduling.

Aspect	All at once	Step by step
Time to first benefit	Often a year or more	Weeks to a few months
Upfront investment	Large, committed before value is proven	Small; each step funded by results of the last
Risk	High: many changes go live together	Low: one change at a time, easy to reverse
User adoption	Steep learning curve; resistance likely	Gradual; early wins build confidence
Fit to needs	Requirements guessed up front	Requirements refined by real use
Main condition for success	Strong program management	A common data model and integration approach from day one

Making a modular approach work

- **Fix the foundations once:** an ISA-95-based equipment and material model, naming standards and an integration layer that every module uses.
- **Choose modules that stand alone** yet share data, and a licensing model that lets you buy only what you use.
- **Pilot on one line or area,** then replicate the proven configuration as a template to other lines and sites.
- **Integrate in steps:** start with simple, one-way interfaces (for example, orders from ERP) and add more as modules mature.

5 INDUSTRY STANDARDS FOR MES

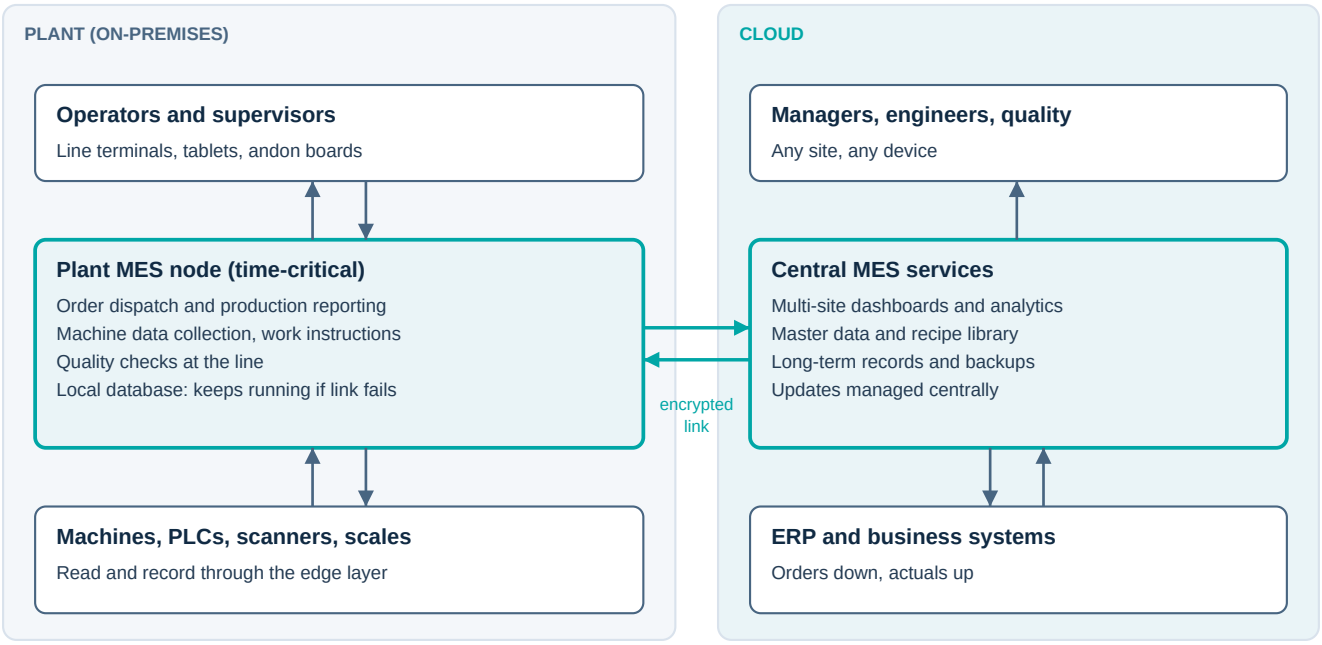
Standards make MES modules, systems and sites fit together, reduce custom integration and keep options open for the future. Ask for standards support explicitly in any requirements or tender documents.

Standard	What it covers	Why it matters for MES
ISA-95 / IEC 62264	Enterprise-control integration: levels, activity models, and object models for orders, materials, equipment and personnel	The reference model for MES scope and for ERP–MES interfaces
B2MML	XML implementation of the ISA-95 data models	Ready-made message formats for ERP–MES integration
ISA-88 / IEC 61512	Batch control: recipes, procedures and equipment models	Recipe management and execution in batch and hybrid plants
ISO 22400	Key performance indicators for manufacturing operations management	Consistent definitions of OEE and other MES KPIs across sites
OPC UA (IEC 62541) and MQTT	Secure, open data exchange with machines and between systems	Vendor-neutral machine integration and event messaging
ISA-101	Design of operator interfaces (HMI)	Clear, consistent MES screens at the workstation
IEC 62443	Security of industrial automation and control systems	Securing MES and its links to control and business networks
21 CFR Part 11 and EU GMP Annex 11	Electronic records and signatures in regulated industries	Requirements for electronic batch records and audit trails
GAMP 5	Risk-based validation of computerized systems	Practical approach to validating MES in life sciences
ISO 9001, IATF 16949, ISO 22000	Quality management systems for general, automotive and food manufacturing	MES provides the records and controls auditors expect
ISO 50001	Energy management systems	Energy data per order, product and line

6 CLOUD, ON-PREMISES OR HYBRID MES

MES can run on servers in the plant, as a service in the cloud, or as a hybrid of the two. There is no single right answer: the choice depends on how time-critical the functions are, how reliable the site's connectivity is, regulatory needs, the number of sites and the IT skills available.

Criterion	On-premises	Cloud	Hybrid
Where it runs	Servers in the plant or company data center	Provider-hosted service, accessed over the internet	Execution on site; central services in the cloud
Dependence on internet link	None for plant operation	High; an outage can stop execution	Low; plant node keeps running and syncs later
Response time at the line	Fastest, predictable	Depends on network latency	Fast for time-critical functions
Upfront cost	Higher: hardware, licenses, installation	Lower: subscription	Moderate
Ongoing effort	In-house IT for servers, backups, upgrades	Provider handles infrastructure and upgrades	Shared: small site footprint, central upgrades
Customization	Highest	Configuration within the service's options	High at site, standard centrally
Multi-site roll-out and comparison	Harder; each site separate	Easiest; one platform for all	Easy; central templates and dashboards
Data residency and control	Fully in-house	Depends on provider regions and contract	Sensitive data can stay on site
Validation (regulated)	Well understood; controlled change	Needs supplier qualification and change control on provider updates	Combination of both approaches
Best suited to	Single large sites, strict latency or isolation needs, limited connectivity	Multi-site, smaller sites, fast start, limited IT staff	Most plants that need both resilience and central visibility



Time-critical execution stays on site; analytics, master data and multi-site services run in the cloud.

Figure. A hybrid MES keeps time-critical execution and a local database at the plant, so production continues if the internet link fails, while central services handle analytics, master data and multi-site visibility.

A simple rule for choosing

Keep functions that stop production if they stop (dispatching, data collection, work instructions, label printing, quality checks at the line) as close to the line as possible. Move functions that tolerate a short delay (dashboards, analytics, reporting, master data management, cross-site comparison) wherever they are cheapest and easiest to run. Whatever the model, confirm backup, recovery and data export arrangements in the contract.

7 QUICK WINS: PRACTICAL STARTING POINTS

These starting points need modest investment, little change to equipment, and show results within weeks. Each one becomes a building block of a wider MES. Benefits depend on the site; measure a baseline first.

Quick win	Problem it solves	What to implement	Typical benefit	Time to value
Real-time downtime and OEE tracking	Downtime recorded late, inaccurately or not at all	Automatic machine states plus operator reason codes on a line terminal	True losses visible; focus on the top downtime causes	4–8 weeks
Paperless production reporting	Paper travelers, late order closure, data re-typed into ERP	Start, stop, quantity and scrap booked at the line; sent to ERP	Accurate inventory and order status; less clerical work	6–10 weeks
Electronic work instructions and checklists	Outdated printouts, inconsistent execution, slow training	Current, approved instructions and sign-off checklists on tablets	Consistent quality; faster onboarding	4–8 weeks
Digital in-process quality checks	Paper check sheets reviewed too late to act	Checks entered at the line with limits, SPC charts and alerts	Drift caught early; less scrap and rework	4–8 weeks
Label printing and scan-based traceability	Manual labels, mix-ups, slow trace during complaints	System-generated labels; scans at material issue and pack-out	Trace a lot in minutes, not days	6–10 weeks
Line-side performance boards	Teams do not know if they are on target until the end of shift	Large screens showing plan vs actual, rate and current stop	Faster reaction; ownership at the line	2–4 weeks

Worked example: two steps on one packaging line

A packaging line records production on paper travelers that are typed into ERP the next day. Downtime is noted by hand, if at all. In the first step, machine states are captured automatically and operators pick a stop reason on a line terminal. Within a few weeks the team sees that changeovers and two recurring jams account for most lost time, and acts on them. In the second step, order start, finish, quantity and scrap are booked on the same terminal and sent to ERP, removing the paper travelers. Electronic quality checks follow as step three, on the same data model and screens.

8 IMPLEMENTATION APPROACH

Phase	Key activities	Output
1 Assess	Map current processes, paper forms, systems and pain points; measure baseline KPIs; check network and data readiness	Prioritized pain points and baseline
2 Define	Choose the first module and pilot line; agree the ISA-95 data model, naming, integration approach and deployment model	Scope, architecture and success measures
3 Configure	Set up master data (products, routings, equipment, reason codes); configure screens with operators; build simple interfaces	Tested configuration on the pilot line
4 Go live	Train by role; run in parallel with paper briefly if needed; provide on-floor support for the first weeks	Module in daily use
5 Prove and extend	Compare with baseline; refine; package the configuration as a template; add the next module or line	Measured results and a repeatable template

- **Master data is the critical path.** Product, routing, equipment and reason-code data must be clean before go-live.
- **Design screens with operators,** on the actual workstation hardware, in the actual environment (gloves, noise, lighting).
- **Integrate through standard interfaces** (ISA-95 messages, OPC UA, MQTT) rather than custom point-to-point links.
- **Plan for regulated needs early** where they apply: audit trails, electronic signatures and validation effort.

9 MEASURING VALUE

Agree KPIs and a baseline before the first module goes live. Using the ISO 22400 definitions keeps results comparable across lines and sites.

Area	KPIs	Typical MES modules
Productivity	OEE, availability, throughput, changeover time	Data collection, performance analysis, scheduling
Quality	First-pass yield, scrap and rework rate, complaints	Quality management, work instructions
Delivery	Schedule adherence, lead time, WIP level	Dispatching, scheduling, material and WIP tracking
Compliance	Record review and release time, audit findings	Electronic records, genealogy, document control
Cost	Labor hours per unit, clerical effort, inventory accuracy	Production reporting, material tracking
Energy	Energy per unit produced	Energy tracking, data collection

10 PITFALLS TO AVOID AND NEXT STEPS

1 Trying to implement every module at once before any value is proven.

2 Copying paper processes onto screens instead of simplifying them.

3 Underestimating master data preparation and ownership.

4 Leaving operators out of screen and workflow design.

5 Building custom point-to-point interfaces instead of using standards.

6 Choosing a deployment model without testing site connectivity.

7 Over-customizing, which makes every upgrade expensive.

8 Measuring go-live dates instead of business results.

Next steps

- ☐ List the paper forms, spreadsheets and manual steps between ERP and the shop floor
- ☐ Identify the biggest pain: downtime, quality escapes, traceability or order status
- ☐ Pick one quick win from Section 7 and one pilot line, and record a baseline
- ☐ Agree the data model, integration approach and deployment model (Section 6)
- ☐ Go live, measure, and decide the next module with real results

Important: This guide is general guidance, not a design specification. Benefits and timelines are indicative and depend on site conditions. For an MES readiness assessment or a quick-win pilot, contact INOVIQ Technologies at www.inoviqtech.com.