Process automation

MES systems

BS UNI studies, Fall semester 2025/2026

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MES Systems (Manufacturing Execution Systems)

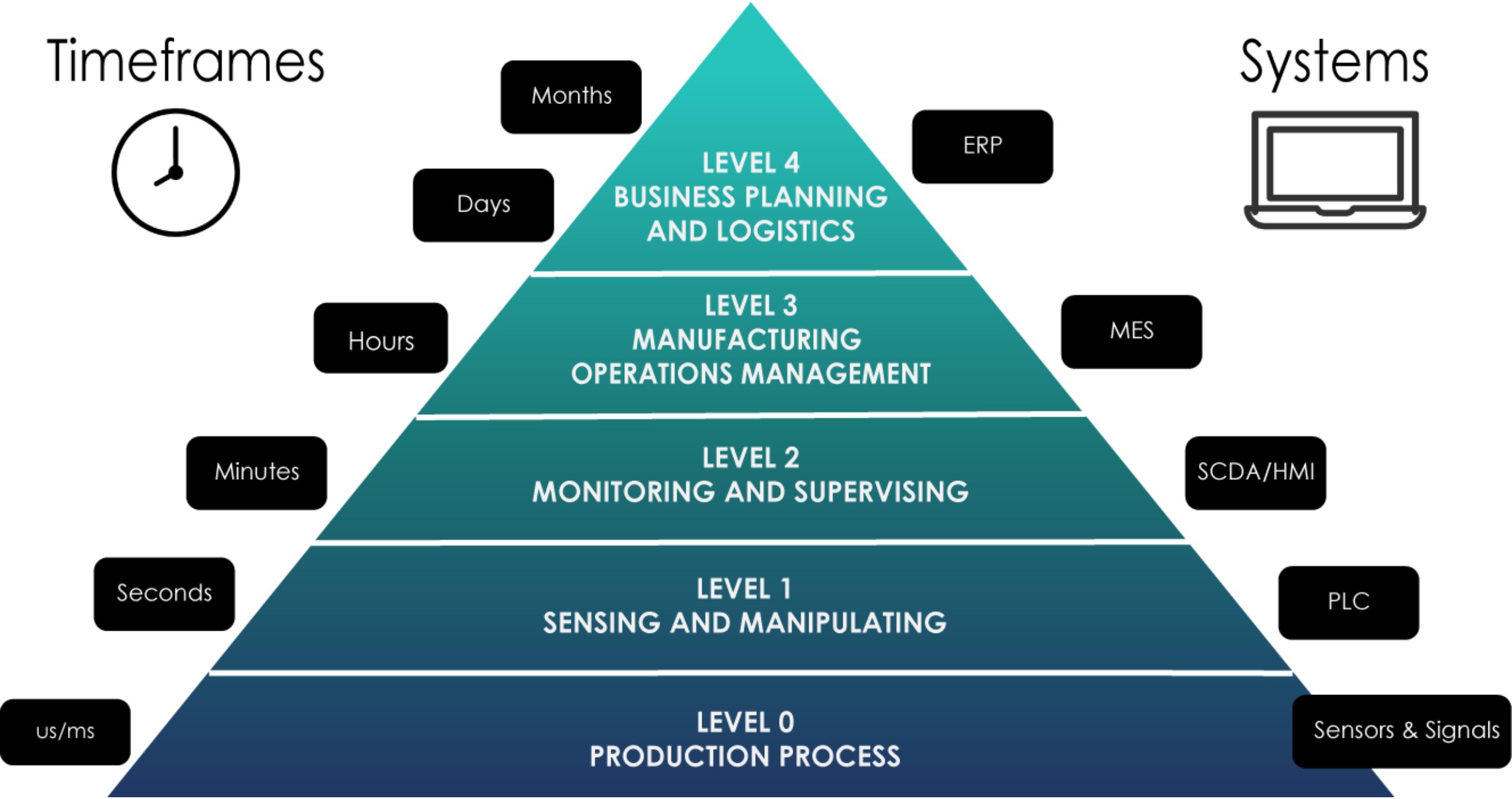
- **Key Points:** MES systems manage and control production processes in real-time.
  - They bridge the gap between business systems (like ERP) and operational systems (like SCADA/PLCs).
  - MES improves production efficiency, traceability, and quality.
  - Typical functions include production scheduling, inventory tracking, and quality management.
  - Integration with ERP systems allows seamless flow of information across production and business processes.

Needs

- **Customers:**
  - Demand top-quality products.
- **Manufacturers:**
  - All can afford good tools.
- **Where are the challenges?**
  - High adaptability.
  - Product variety.
  - Short delivery times.
  - High reliability of deliveries.
- **Consequence of getting closer to the customer:**
  - Increased costs.

Needs

- **Market Response**
  - **Connectivity**
    - Increased collaboration between manufacturers (globalization).
    - Purchasing simple components on the market, specializing in high-value segments.
  - **Dynamics**
    - Large fluctuations in the market due to the rapid spread of information.
    - Customers quickly change their habits.
  - **Individualization**
    - Customers require products tailored to their needs.
    - Results in a much greater variety of products.
- **The above reasons lead to:**
  - Increased complexity of production systems.
  - Greater risks.
- **Standardization of Integration**
  - 1980: CIM (Computer-Integrated Manufacturing).
  - 1990: MES (Manufacturing Execution System).


Timeframes
Systems
Months
Days
Hours
Minutes
Seconds
us/ms
ERP
MES
SCDA/HMI
PLC
Sensors & Signals
LEVEL 4
BUSINESS PLANNING
AND LOGISTICS
LEVEL 3
MANUFACTURING
OPERATIONS MANAGEMENT
LEVEL 2
MONITORING AND SUPERVISING
LEVEL 1
SENSING AND MANIPULATING
LEVEL 0
PRODUCTION PROCESS

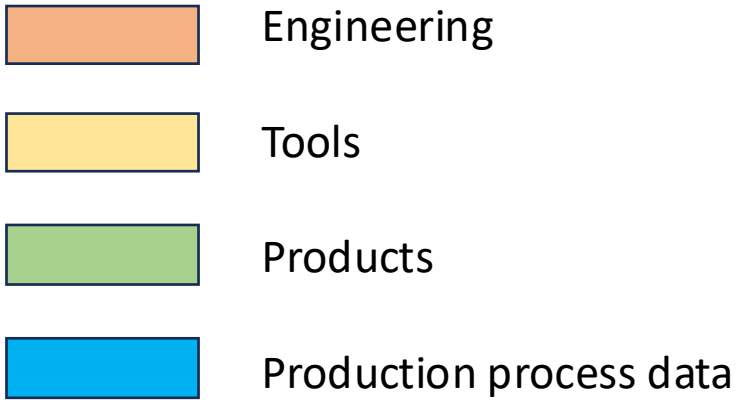
Standard ISA95

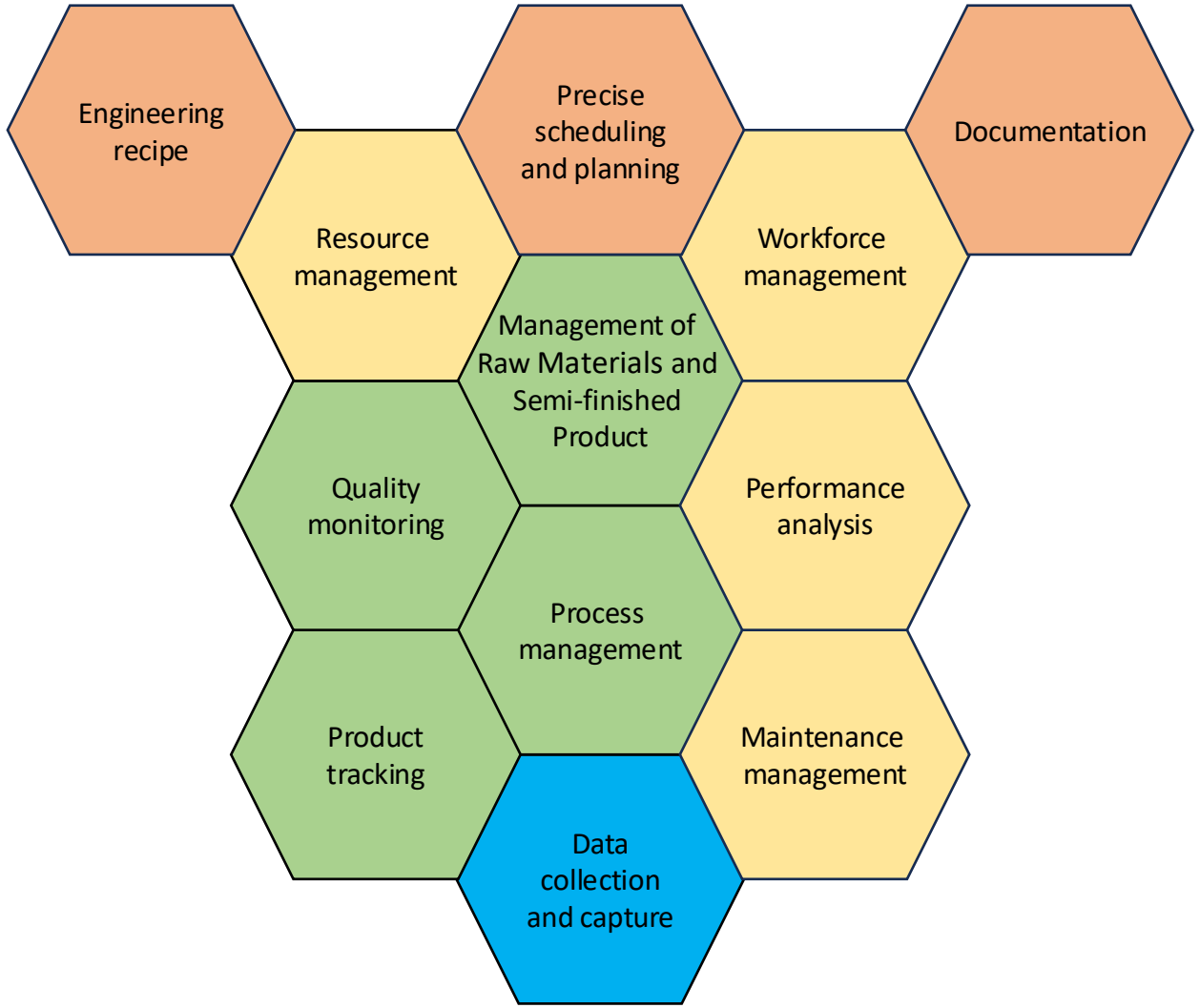
- **Separation of Business and Production Processes**
- **Definition of Integrating Functions**
  - Between business and production systems.
  - Between production systems themselves.
- **Specification of Information for Exchange**
- **Improvement of Production System Integration by Defining:**
  - Terminology.
  - Data structures.
  - Most common process models.
  - Transactions.
- **Identification of Standard Integration Points**

Standard ISA95

- **Hierarchy of Levels:**
  - **Level 4:** Business Planning & Logistics
    - Plant production scheduling, operational management, etc.
    - ERP (Enterprise Resource Planning) for enterprise resource planning.
  - **Level 3:** Manufacturing Operations & Control
    - Dispatching production, detailed production scheduling, reliability assurance.
    - MES (Manufacturing Execution System) for production management.
  - **Levels 2, 1, 0:** Control Systems
    - Continuous Control, Batch Control, Discrete Control.
    - SCADA (Supervisory Control and Data Acquisition) system + HMI (Human-Machine Interface) + PLC (Programmable Logic Controllers) + measuring and execution components + basic technology.
- **Interfaces:**
  - Interface addressed in **ISA 95.01 & 95.02** (linking Levels 4 and 3).
  - Model addressed in **ISA 95.03** (detailed modeling within Level 3).

MES functionality



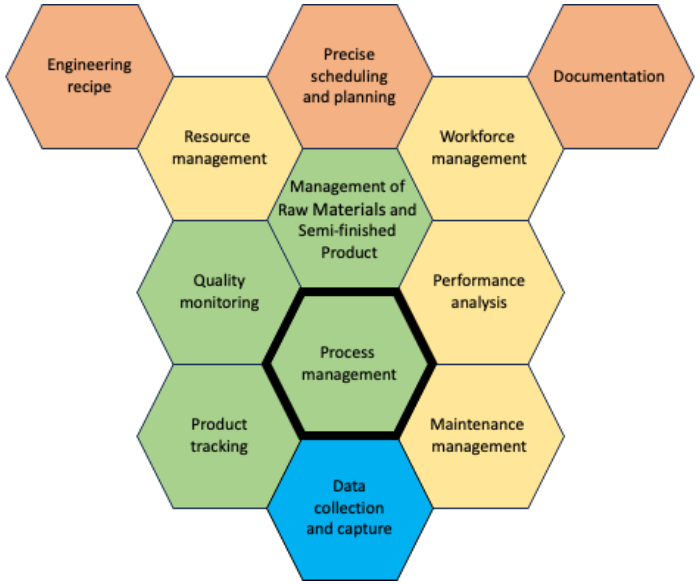


MES functionality (1)

Data Collection and Capture

- Monitoring, collecting, and organizing data about processes, materials, and commands
- Collecting and storing data from production systems (manual, automated)
- Displaying equipment and process status in real-time
- Reviewing past events (archive)

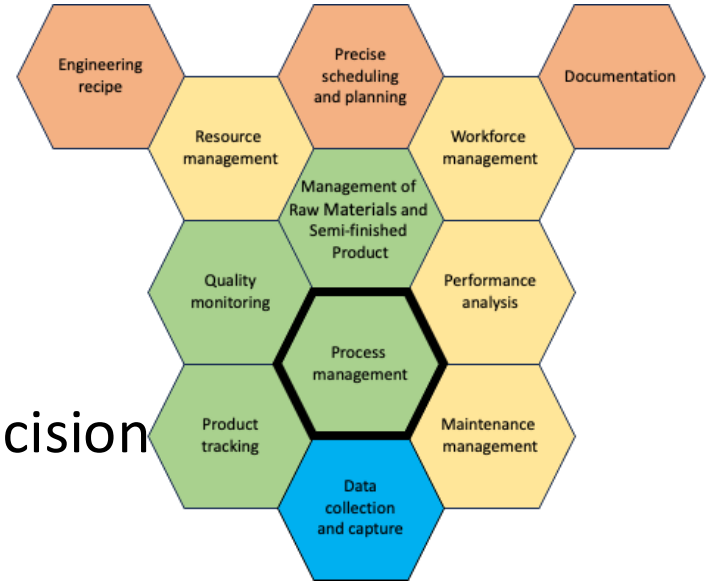
MES functionality (2)



Process Management

- These functions focus on:
  - Managing machines and equipment
  - Linking operations between machines (sequential operations)
- Directing workflow according to planned and actual production activities
- Managing the production flow:
  - Tasks, orders, packages
  - Assigning tasks to specific production units
  - Sequencing tasks, with the ability to adjust order and priority (within allowable limits and resource availability)

MES functionality (2)

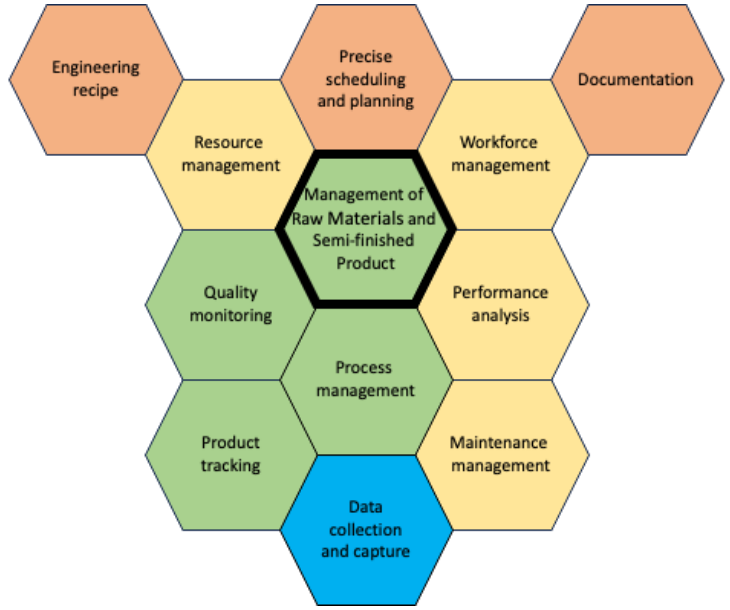


Process Management

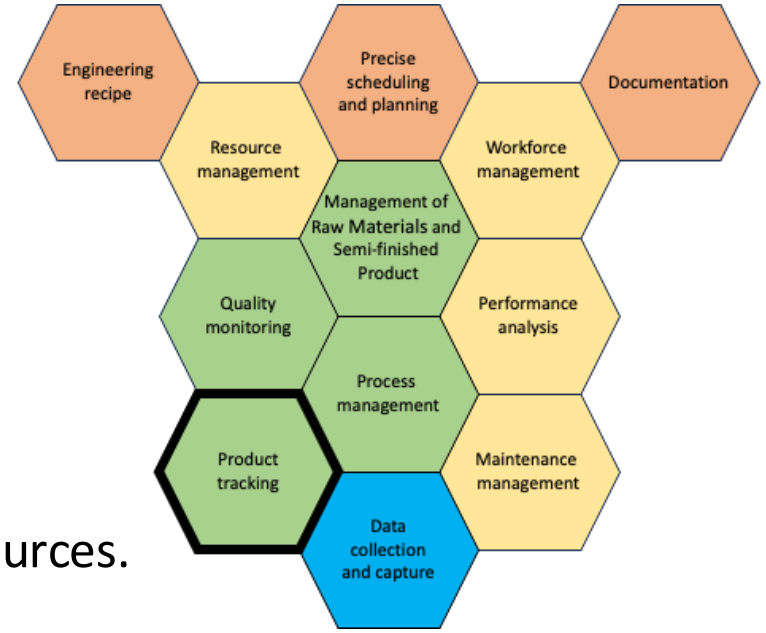
- Monitoring production with automatic corrections (decision process improvement and enhancement).
- Alarm management:
  - Alerts personnel when a process goes outside acceptable tolerances.
- Monitoring the amount of work completed in the process, including correction or re-manufacturing if necessary.

MES functionality (3)

- **Management of Raw Materials and Semi-Finished Products**
  - Issuing commands for the movement of raw materials and semi-finished products.
  - Signaling work units to start production.



MES functionality (4)



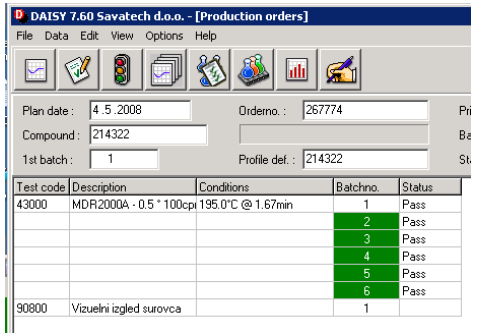
Tracking Products

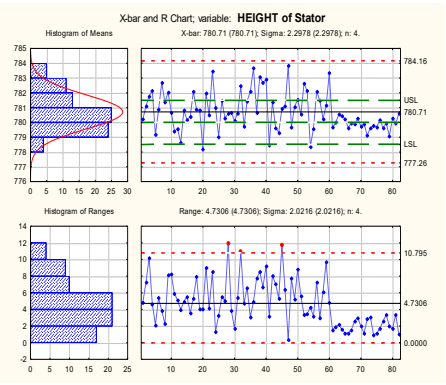
- Monitoring the status of orders and units.
- Creating a complete production history.
- Monitoring and tracking individual products:
  - Identifiers: order, package, product, supplier, revision, resources.
- These details must be accessible in cases of:
  - Defective quality, process changes, or identifying comparable products.
  - Recording information to allow tracking of semi-finished goods in final products.

MES functionality (5)

Monitoring Quality

- **Recording/Analyzing:**
  - Properties of raw materials (incoming inspection).
  - Products (outgoing inspection).
  - Processes according to defined requirements.
- **Real-Time Analysis:**
  - Ensuring proper quality monitoring.
  - Identifying problems that require special attention.
- **Recommending Corrections:**
  - Precisely determining the cause.
  - Tracking correlations between symptoms, actions, and outcomes.
- **Statistical Quality Control:**
  - For raw materials and products: integration with LIMS (Laboratory Information Management System).
  - Key metrics:
    - Average, standard deviation (σ), process capability (Cp).
    - Cp = (USL-LSL)/6σ (minimum of 2).
    - U/LSL: Upper/Lower Specification Limit.





MES functionality (6)

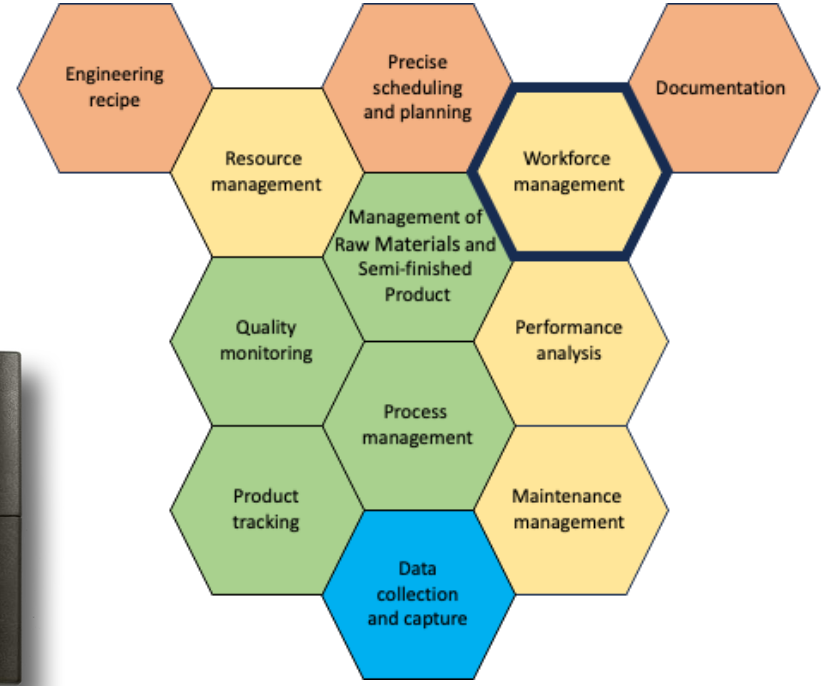
Resource Management

- Machines, tools, materials, other equipment, documentation, etc.
- Real-time status of resources.
- Reservation of resources based on scheduling and planning needs.
- Ensures equipment is properly configured for production.
- Tracks detailed history of resource usage.

MES functionality (7)

Workforce Management

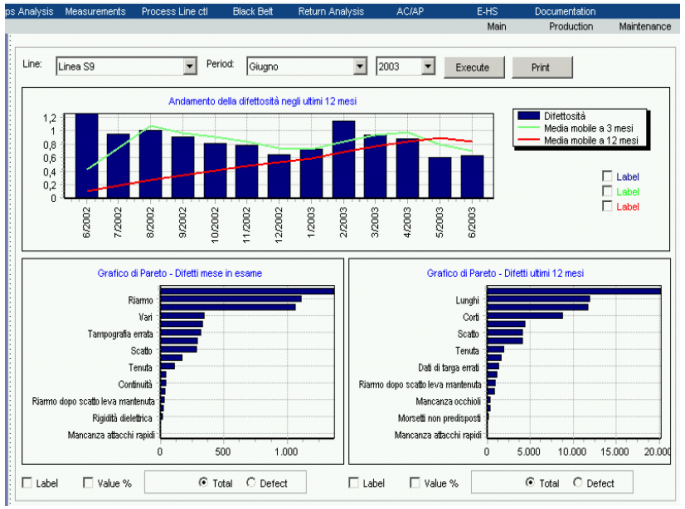
- Monitoring and guiding operators based on qualifications, work patterns, and business needs.
- Determining attendance and real-time status of personnel.
- Interaction with resource allocation to optimize tasks.
- Scheduling attendance based on needs.
- Precisely determining active work time/break time.
- Tracking worker or team performance for incentives.



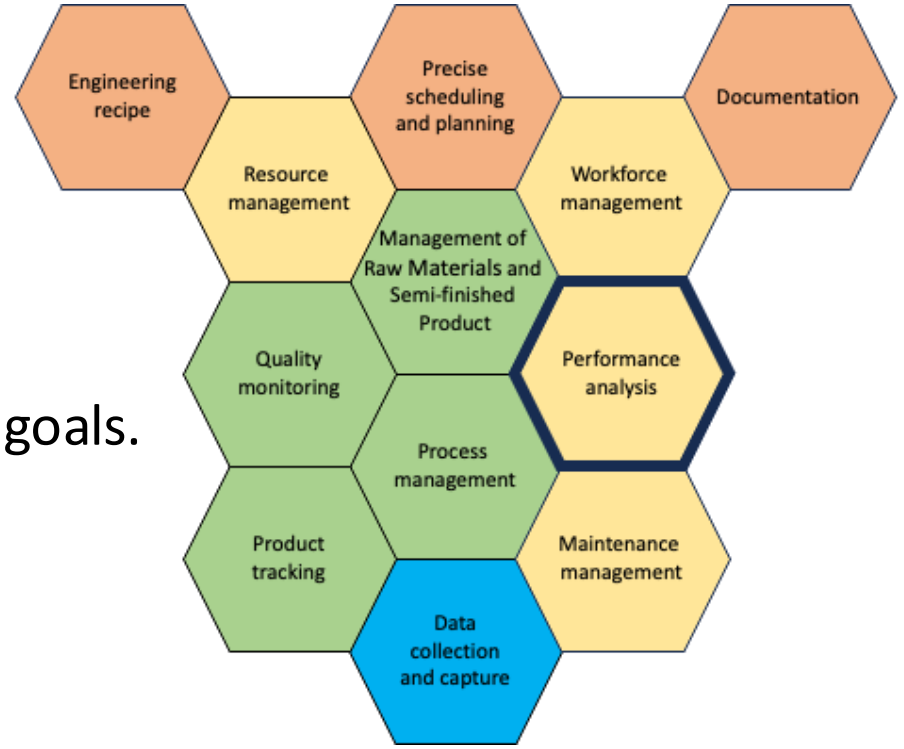
MES functionality (8)

Maintenance Management

- **Planning and executing activities** necessary for maintaining equipment and tools in the factory.
- **Ensuring the availability of tools and equipment**.
- **Scheduling and planning preventive inspections** of equipment, as well as responding to unexpected issues.
- **Archiving errors and their analysis** for better diagnostics and faster resolution of problems (predictive maintenance).

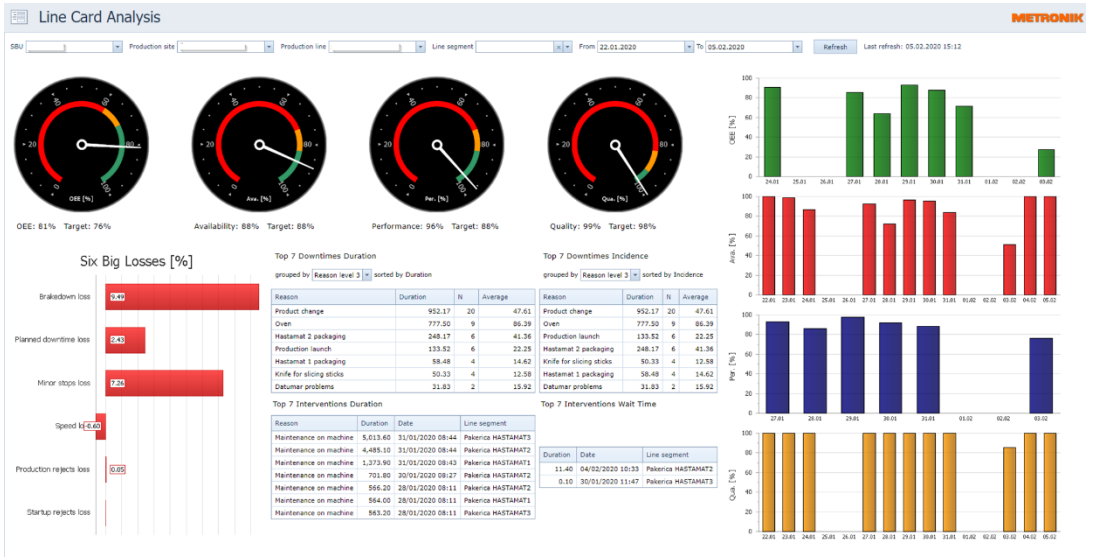


MES functionality (9)

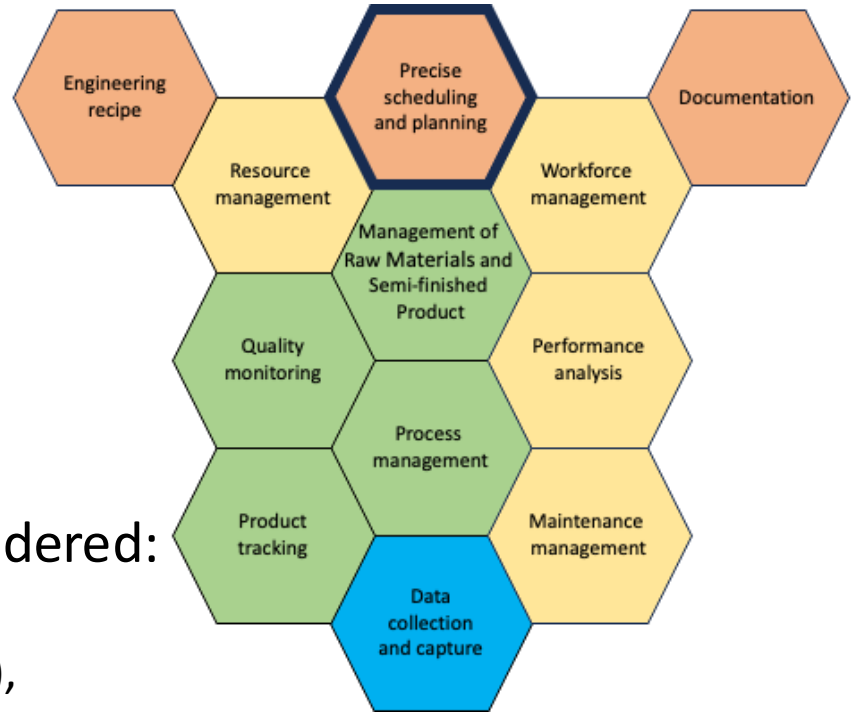


Performance Analysis

- **Comparison of measured production results** with set goals.
- **Aggregation of collected data**:
  - Production cost,
  - Manufacturing time (cycle time),
  - Resource utilization,
  - Alignment with the plan,
  - Statistical analysis/control,
  - Line availability (MTBF, tool change time),
  - How much is missing to reach theoretical capacity limits.
- **Comparison of current and historical values**.
- **Immediate notifications**:
  - Employee motivation.

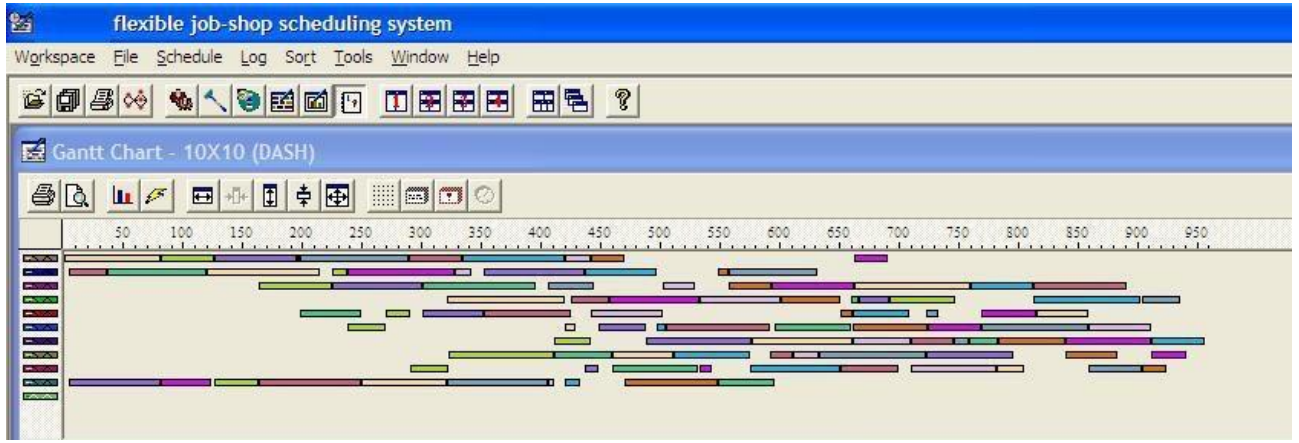


MES functionality (10)



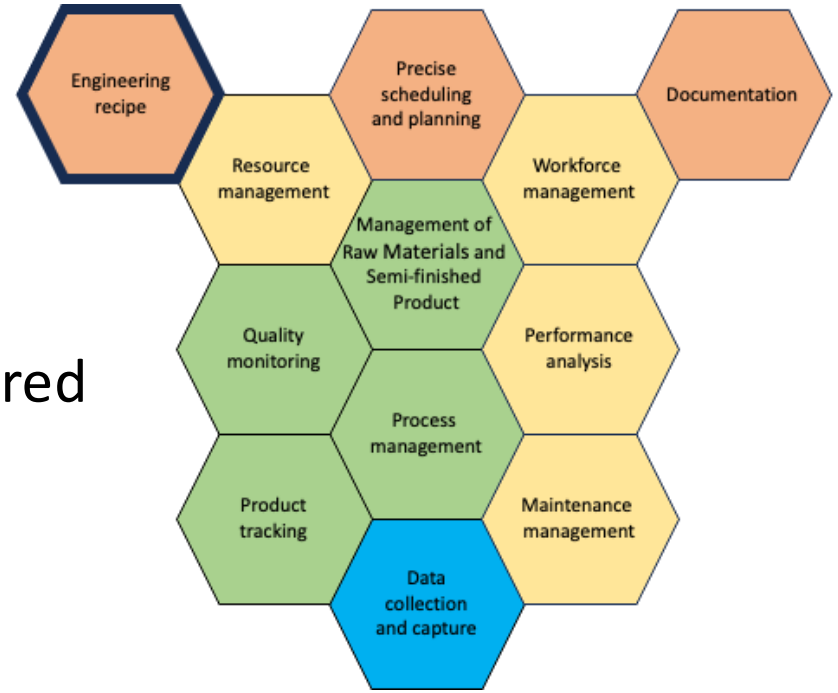
Detailed Scheduling and Planning

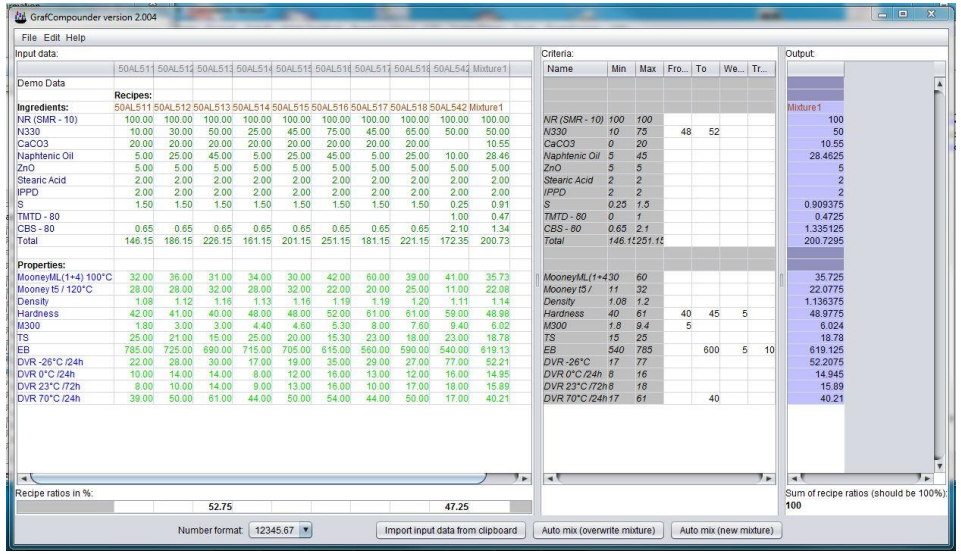
- **Optimization of production**.
- **Determining the sequence and timing** of activities, considering resource capacity.
- For **production line setup**, the following must be considered:
  - Priorities,
  - Equipment: characteristics, features, and rules (sequence),
  - Product features: shapes, colors, etc.
- Good task scheduling must recognize:
  - Overlaps and parallel operations
  - Alternative possibilities.
- Feedback loop.
- Ability to **adjust plans** based on the state of equipment and resources.



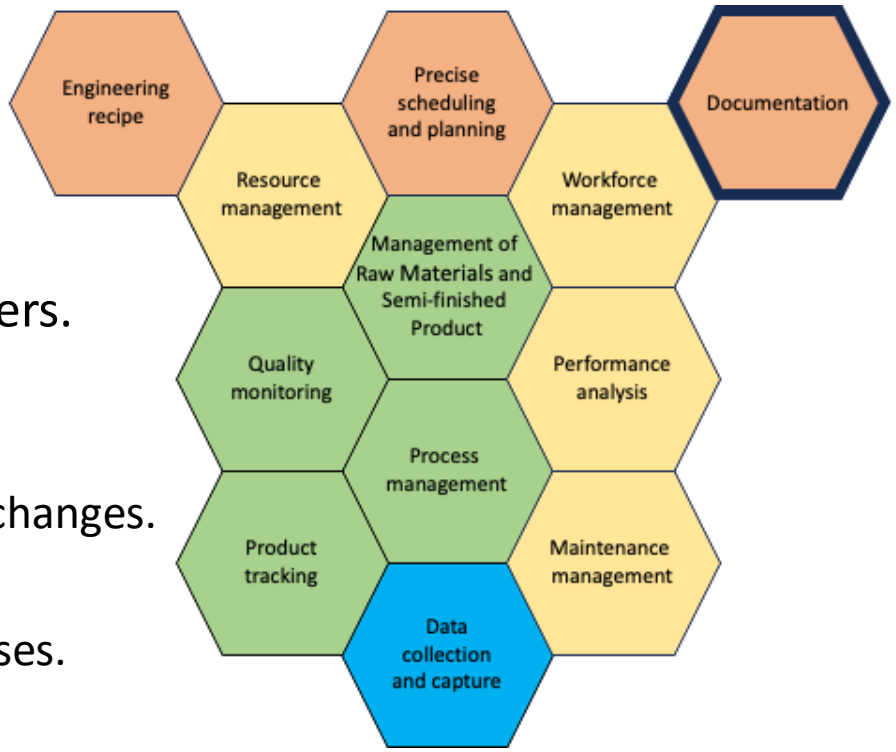
MES functionality (11)

- **Recipe Engineering**
  - **Mapping orders** to a detailed list of tasks required to manufacture the product.
  - **Version control** for recipes.
  - **Finding similarities** between recipes.
  - **Optimization**: improving and cost reduction.





MES functionality (12)



Documentation

- **Managing information** about products, processes, and orders.
- **Keeping records and forms** for traceability purposes:
  - Raw materials, intermediates, products, equipment.
  - Work instructions, recipes, drawings, standard procedures, changes.
- **Maintaining current valid documents** and forms:
  - Operators can use them as guides during production processes.
- **Communication during changes.**
- **Control and integrity of regulations:**
  - Environment, health, safety, corrective actions.

Example: pharma industry

Advantages of using MES

Better Utilization of Production Capacities:

- Reduced production lead times
- Lower inventory levels
- Reduced preparation and production costs
- Decreased waste

Products:

- Flexible production
- Improved quality
- Accurate delivery times
- Traceability

Data Analytics:

- Data consistency (no manual entries)
- Process optimization
- Analysis of losses

MES Tools

Manufacturers:

- Enterprise Information Systems
  - Modules for SAP R3
- Supervisory Systems
  - Technomatix (Siemens)
- Independent Solutions
  - MePIS (Metronik)
  - LIMES (Litostroj)
  - Zenon (COPA-DATA)
- Most functionalities are not fully supported
- Configuration:
  - Similar to supervisory systems

Process automation

MES systems

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