

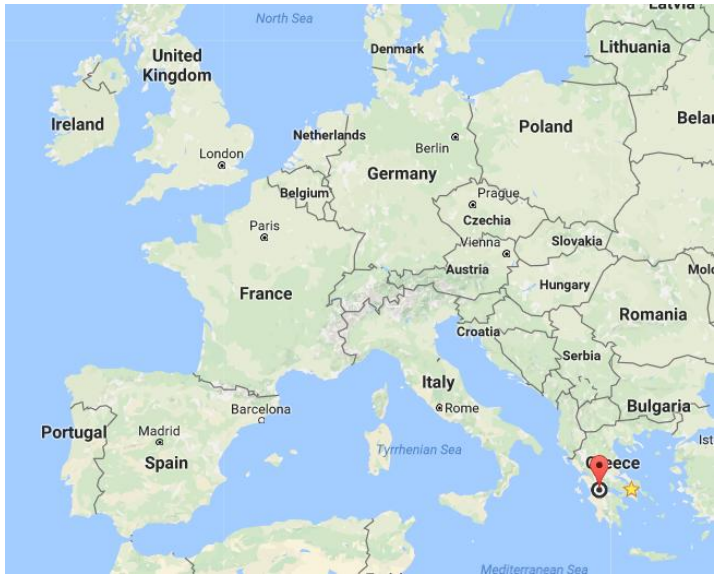
Artificial Intelligence and Digital Transformation: Shaping the Future of the Cosmetics Industry

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Laboratory for Manufacturing Systems and Automation

- ✓ LMS is involved in a ***number of research projects*** funded by the EC and European industrial partners.
- ✓ Particular emphasis is given to the ***co-operation with the European industry as well as with a number of "hi-tech" firms***
- ✓ LMS is organized in ***three different scientific groups***:
  - **Manufacturing Processes Modelling and Energy Efficiency**
  - **Robots, Automation and Virtual Reality in Manufacturing**
  - **Manufacturing Systems**









Outline

1 **Context**

Why production is the focus; the European and Greek landscape; digital foundations

2 **AI on the production line**

Mixing, filling and packaging, quality, maintenance, planning, compliance

3 **Digital twins, robots and people**

Twins in practice, reconfigurable production, physical AI, human-in-the-loop, GenAI

4 **Making it happen**

Sustainability, governance, barriers and a roadmap for SMEs

Context in cosmetics production

High variety, short runs

- Shades, sizes, formats, limited editions
- Frequent changeovers and small batches

Volatile demand

- Social media drives discovery (87% according to Unilever)
- Hard to align production with sales

Cost and supply-chain volatility

- Tariffs, input costs and geopolitical disruptions raise pressure on margins

Quality and regulation

- ISO 22716 (GMP), EU Cosmetics Regulation, MoCRA
- Traceability and documentation

Sustainability

- Energy, water and material waste
- Ecodesign requirements (ESPR)

Labour and skills

- Shortages of skilled operators; US alone needs 3.8 million more manufacturing workers by 2033 (Deloitte / Manufacturing Institute)

Sources: BeautyMatter, 2026 (Unilever, Deloitte); Cosmetics Europe; Personal Care Insights, 2026.

The landscape: an industry of SMEs

~9,000

SMEs involved in cosmetics manufacturing in Europe (2023)

259,244

people directly employed in the European cosmetics industry (2023); €11bn direct value added from manufacturing

>€1.7bn

Greek cosmetics retail sales in 2024; about 163 SMEs form the backbone

Implication for technology choices

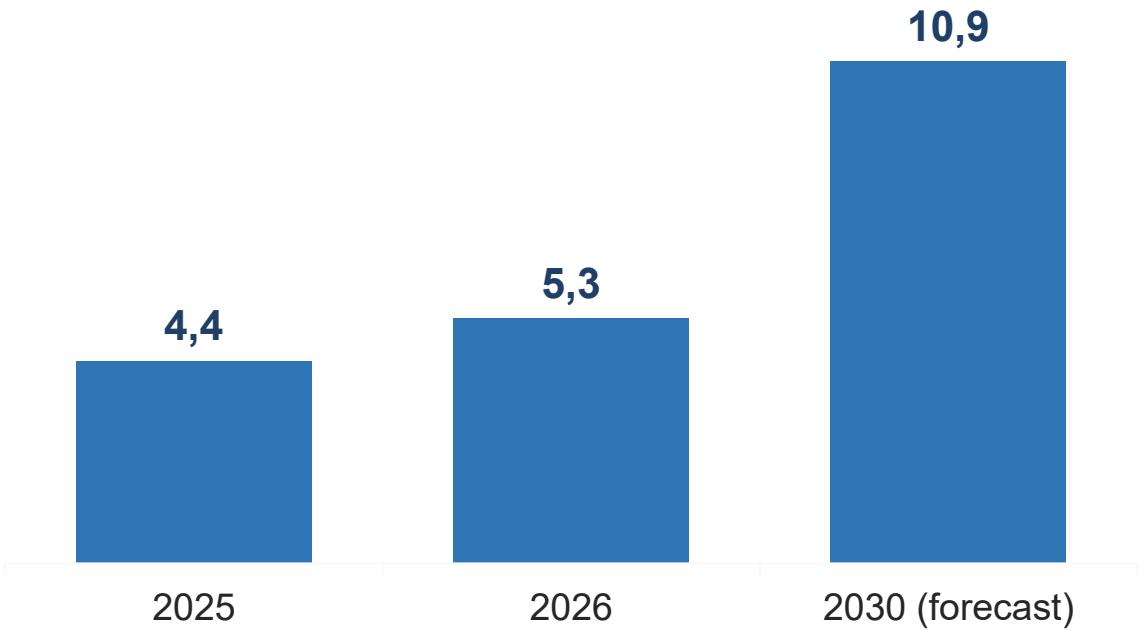
- Solutions must be modular, affordable and workable with existing (brownfield) equipment and limited in-house data-science capacity

Start small, prove value on one line, then replicate

Sources: Cosmetics Europe (cosmeticseurope.eu); ProtoThema / Cosmetics Europe-Euromonitor (Jul 2025).

Investment context: AI and digital twins are scaling

Global AI in beauty & cosmetics market, USD billion



≈ 20% CAGR. Covers the whole beauty sector, consumer-facing and operations.

$13bn → $259bn

Digital-twin market, 2023 → 2032 (Deloitte projection)

80%

of 600 surveyed manufacturing executives plan to put ≥20% of improvement budgets into smart manufacturing (Deloitte, 2025)

Sources: Research and Markets (AI in Beauty and Cosmetics Market Report 2026); BeautyMatter, 11 Aug 2026 (Deloitte). Analyst estimates.

Anatomy of cosmetics production: where AI and twins act

	Dispensing and weighing	Mixing and emulsification	In-process control and release	Filling	Capping, labelling, packing	Palletising and logistics
Typical pain points	Weighing errors; lot traceability	Batch-to-batch variability; viscosity, air	Waiting for QC; long hold times	Fill accuracy; overfill; changeovers	Label and code errors; format changes	Manual palletising; mixed pallets
AI / digital-twin levers	Digital dispensing; scan-based traceability	Soft sensors; golden-batch control; process twin	Predictive quality; automated release	Adaptive fill control; line twin	Vision inspection; quick-change formats	Cobot palletising; AMRs; scheduling

Process steps are a generic representation of batch-based cosmetics production; examples drawn from the sources cited on the following slides.

Digital foundation: from machines to decisions

Applications
Operator assistants · planner dashboards · quality and maintenance apps

AI and digital-twin services
Prediction · simulation · optimisation · anomaly detection

Data platform
Historian · MES · LIMS · ERP · data lake

Edge and connectivity
OPC UA · MQTT · gateways · IT/OT cybersecurity

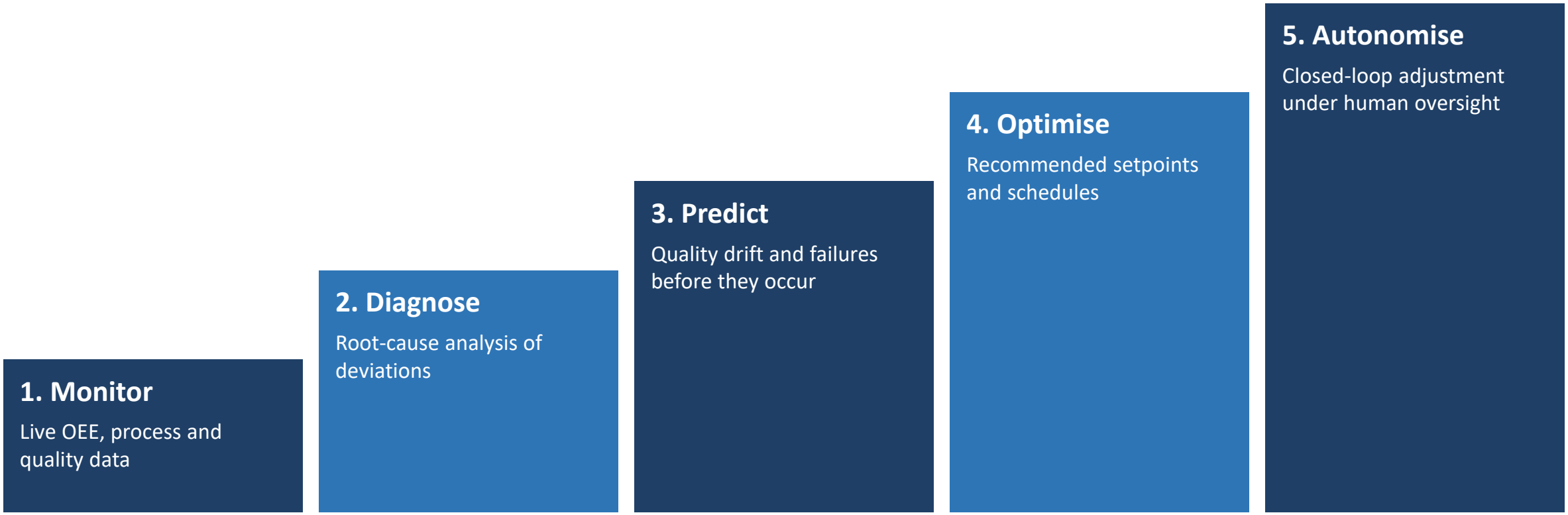
Shop floor
Mixers · fillers · vision systems · sensors · PLCs · robots

Prerequisites for scaling

- Clean, connected data
- Consistent standards across lines and sites
- Integration between enterprise software and factory systems
- Clear guardrails, safety controls and accountability

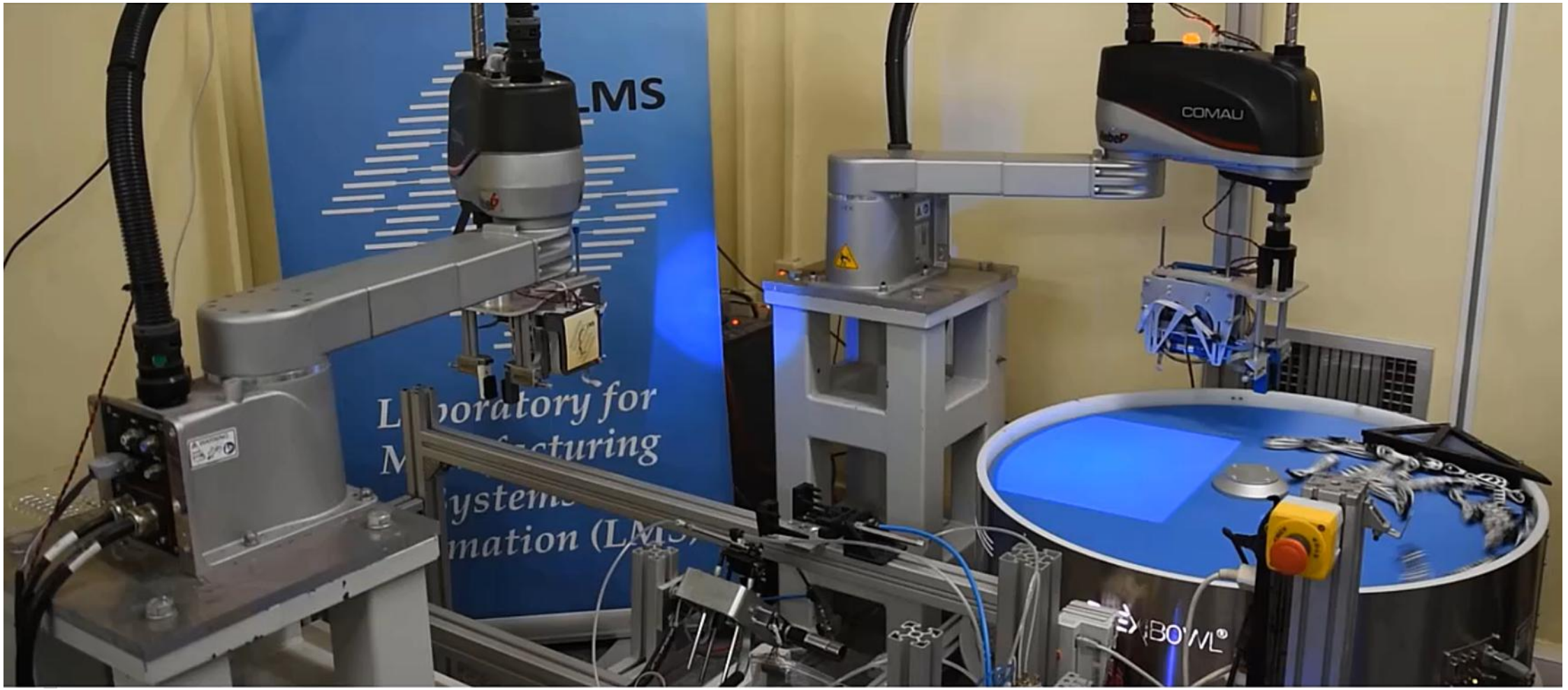
Prerequisites as reported by Unilever (BeautyMatter, 2026). Layer names and protocols: generic IT/OT reference architecture.

Levels of intelligence: from visibility to autonomy



Most value for SMEs sits in levels 1–3; as confidence grows, some adjustments can be automated, with human oversight (Unilever / Accenture)

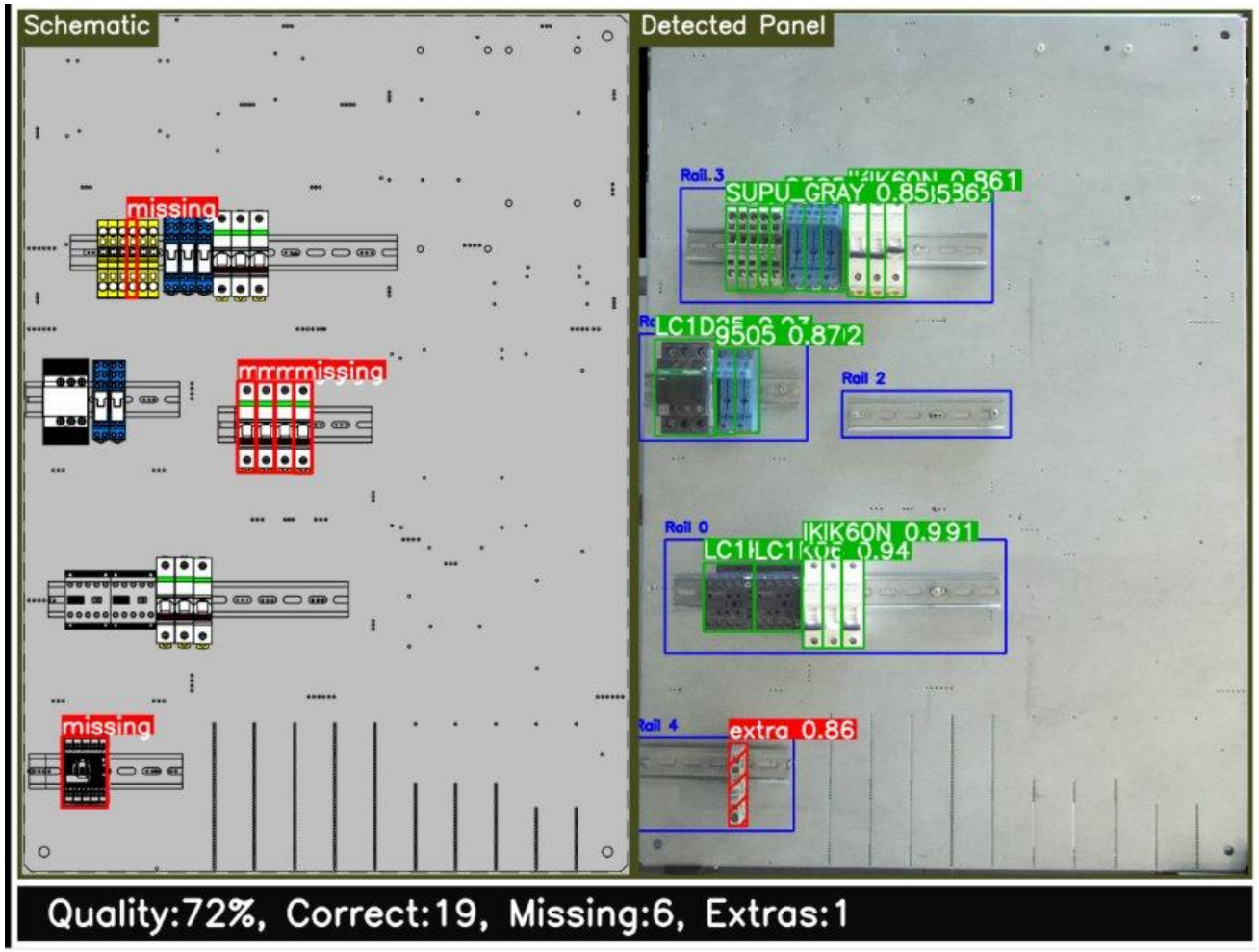
BiC case flexible packaging



Human-robot assembly of elevator electrical cabinets – KLEEMANN case



Human-robot assembly of elevator electrical cabinets



#	Description	Target	Achieved
1	Duration of inspection time	≤30 sec	10 sec
2	Deviation percentage from the manual inspection reference	≤5%	3.6%
3	Automated quality inspection process	100%	100%

What AI solution was tested?

- Complete vision pipeline for comparing AI-based results with CAD contents to calculate the quality score.

Flexible automation – PSA case



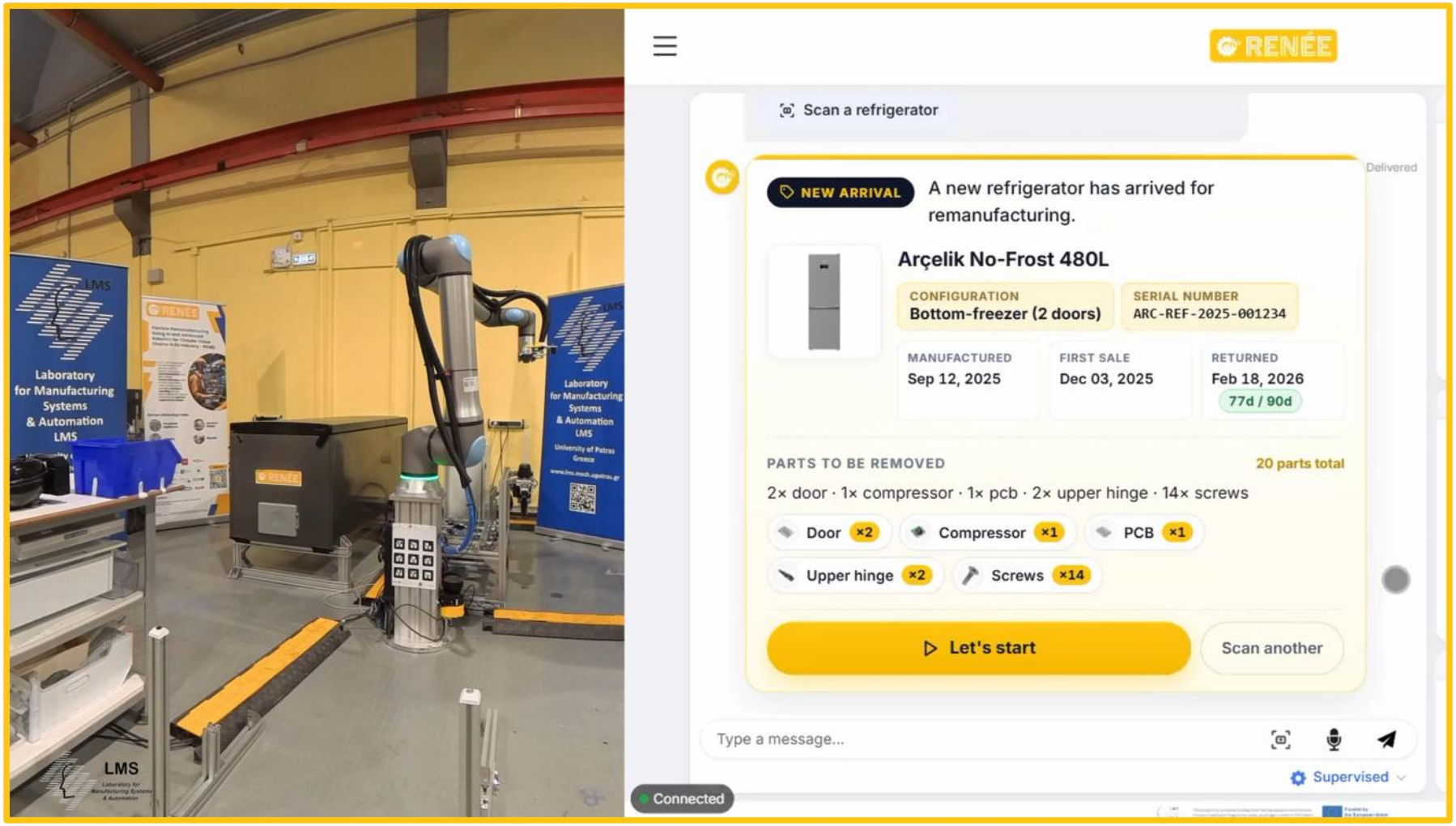
Flexible automation – towards humanoids in production



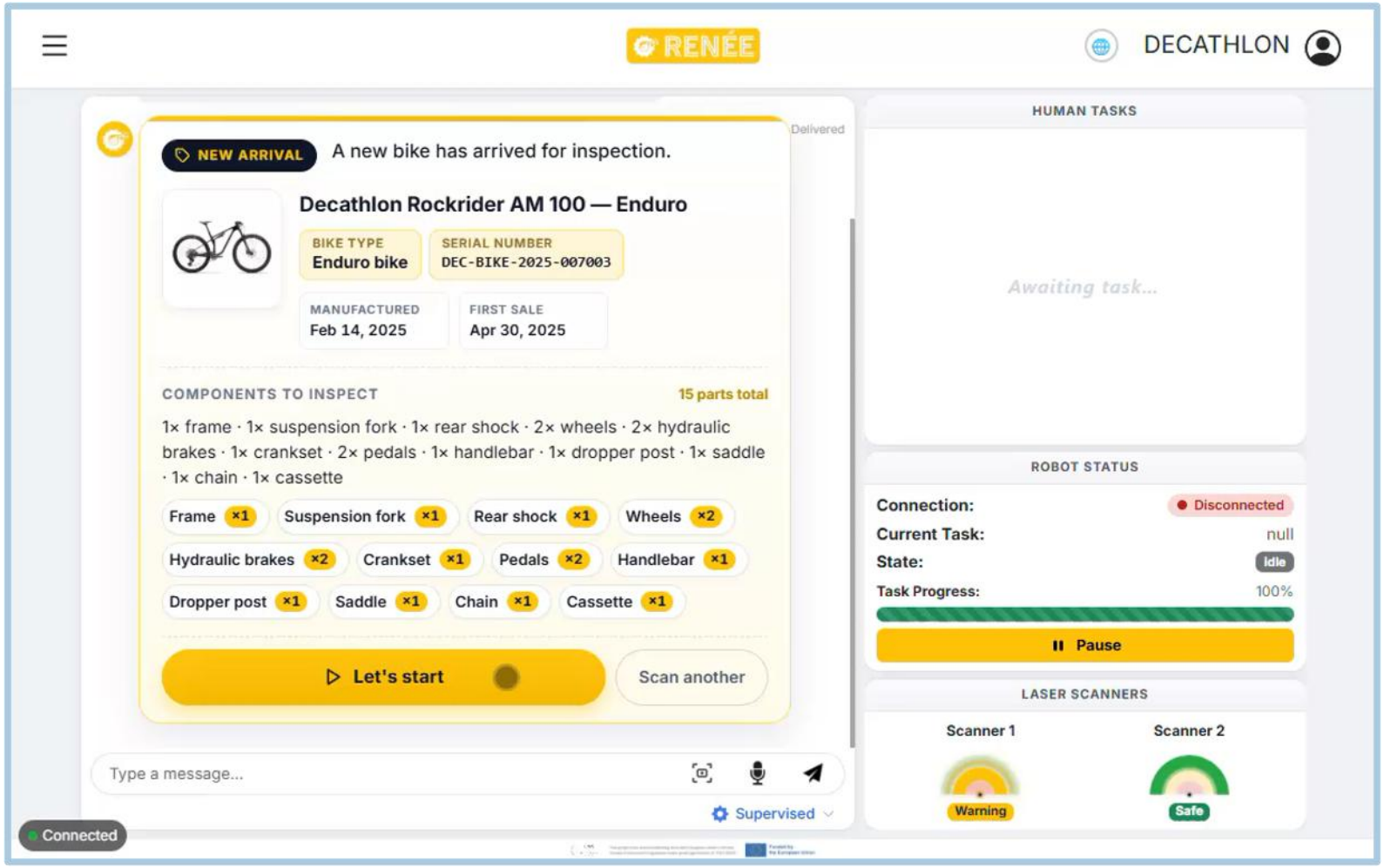


China showcases advanced humanoid robots at 2025 World Robot Conference in Beijing, Humanoid Robots make their debut in Shanghai’s factories as “interns”

Humans' cooperation with AI agents



Humans' cooperation with AI agents



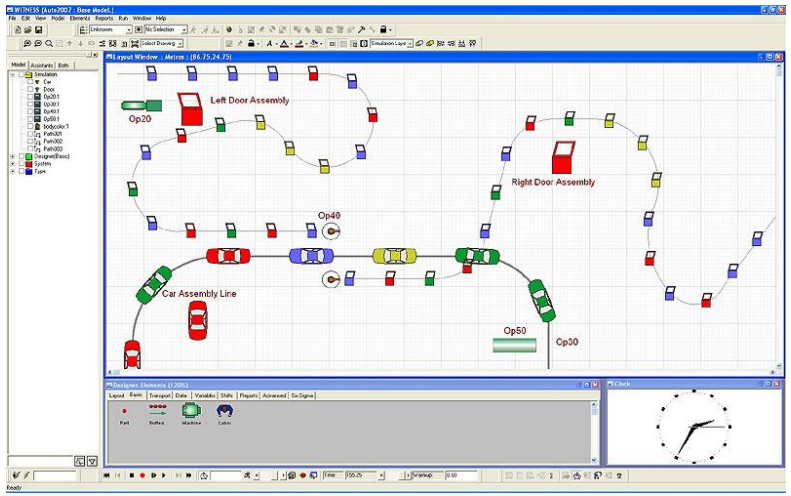
Services/ Maintenance/ Optimization

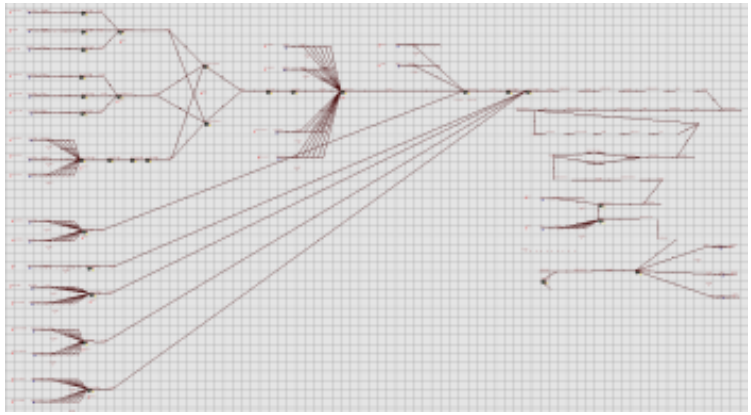


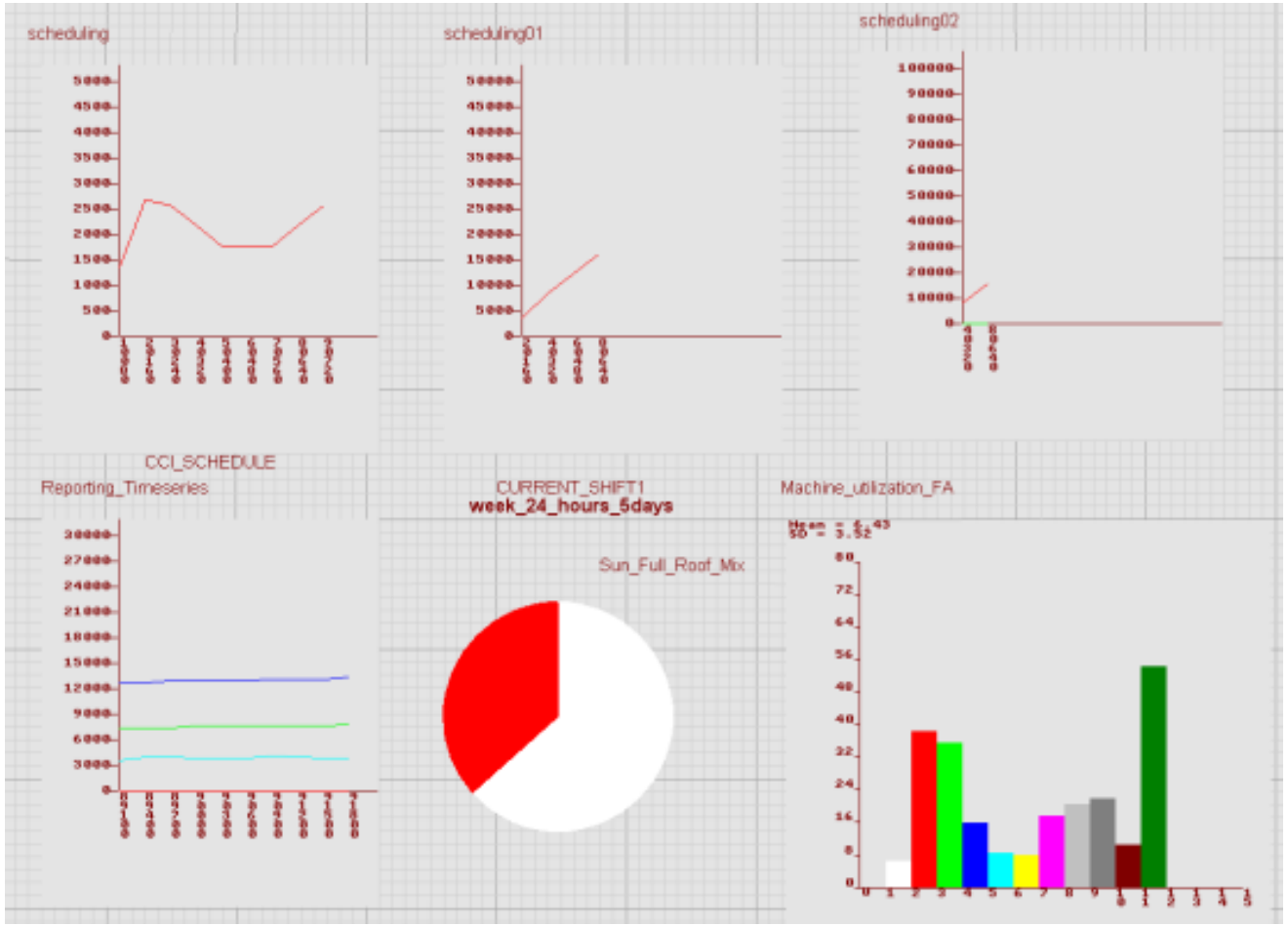
Shop floor human simulation



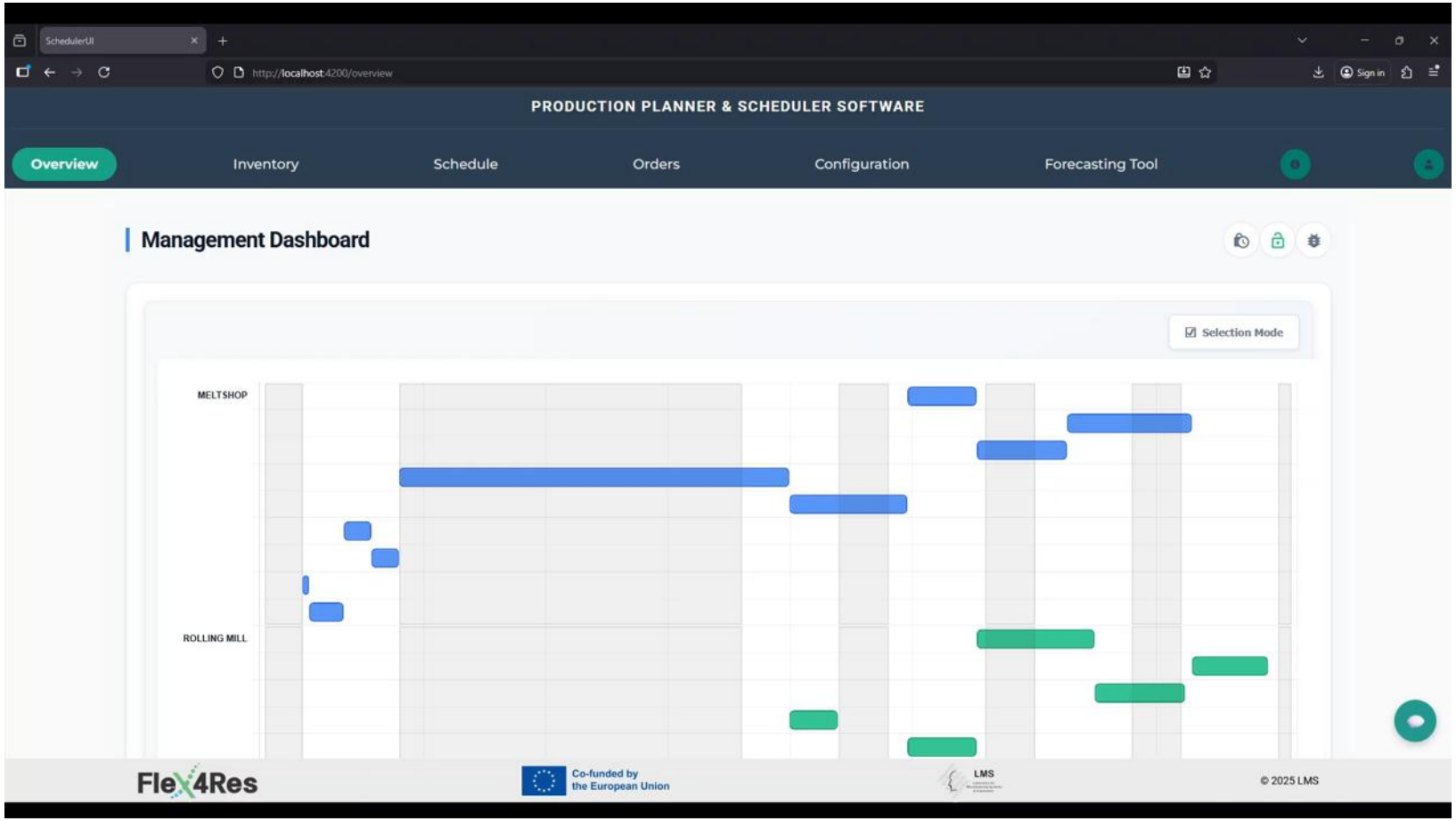
Simulation of production processes and flows







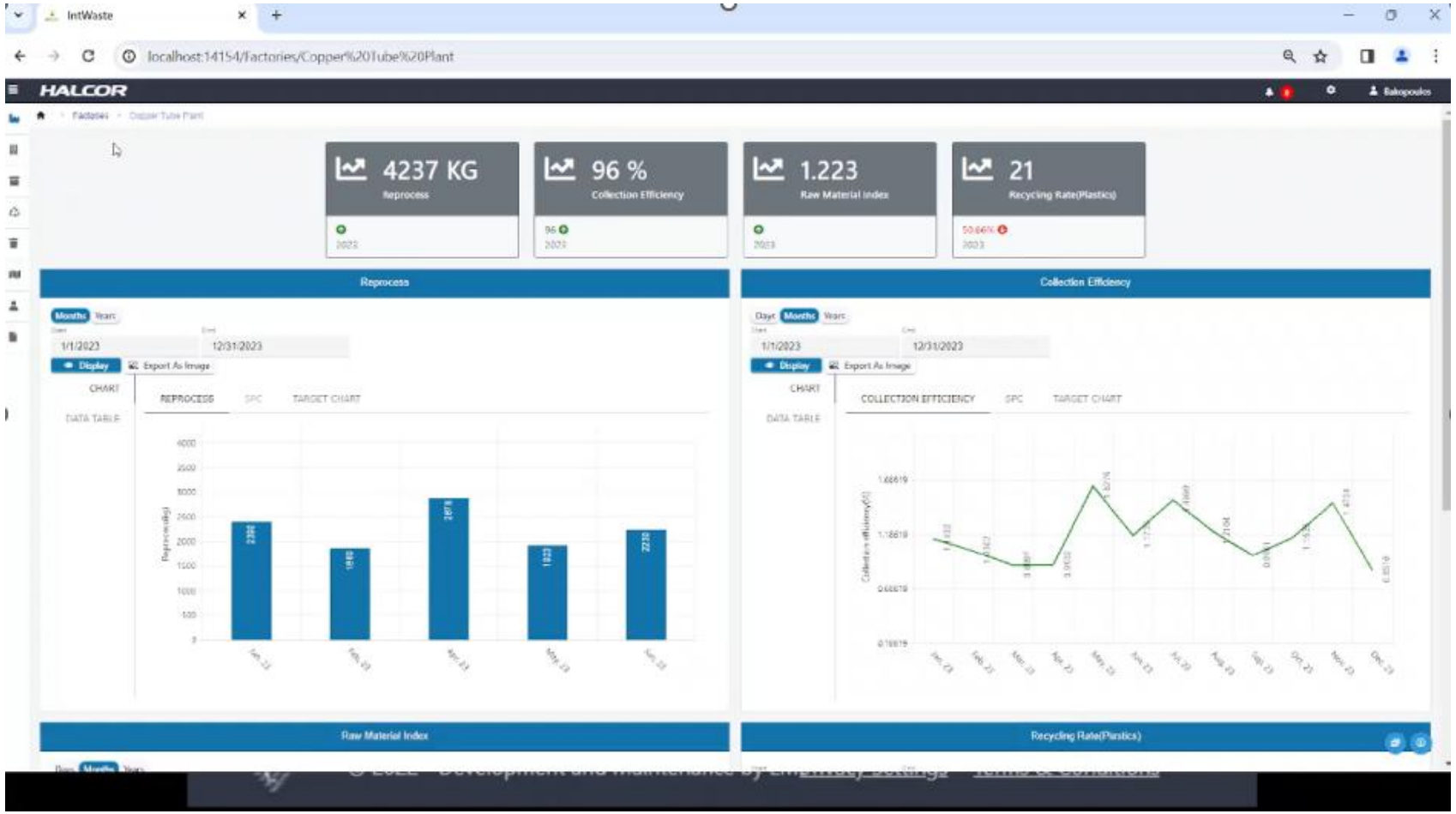
Production scheduling



Method / Approach

- Combines two connected tools:
  - Production Planner
  - Production Scheduler
- Planner: MIP-based mid-term production planning
- Scheduler: heuristic algorithms for short-term job scheduling, resource allocation and shift assignment
- GUI and LLM assistant support planners in decision-making
- Integrated with ERP, forecasting tools, middleware and shop-floor data

Industrial Analytics and Visualization



Value proposition

- Monitor and analysis of Key Performance Indicators (KPIs)
- Dashboard

Key features

- IoT sensor data (SW+HW)
- Data collection and aggregation
- Pattern identification/ behavior analysis/ Estimation

Deployment

- Cloud-based service
- On-premise

Materials Tracking in Warehouse

Value proposition

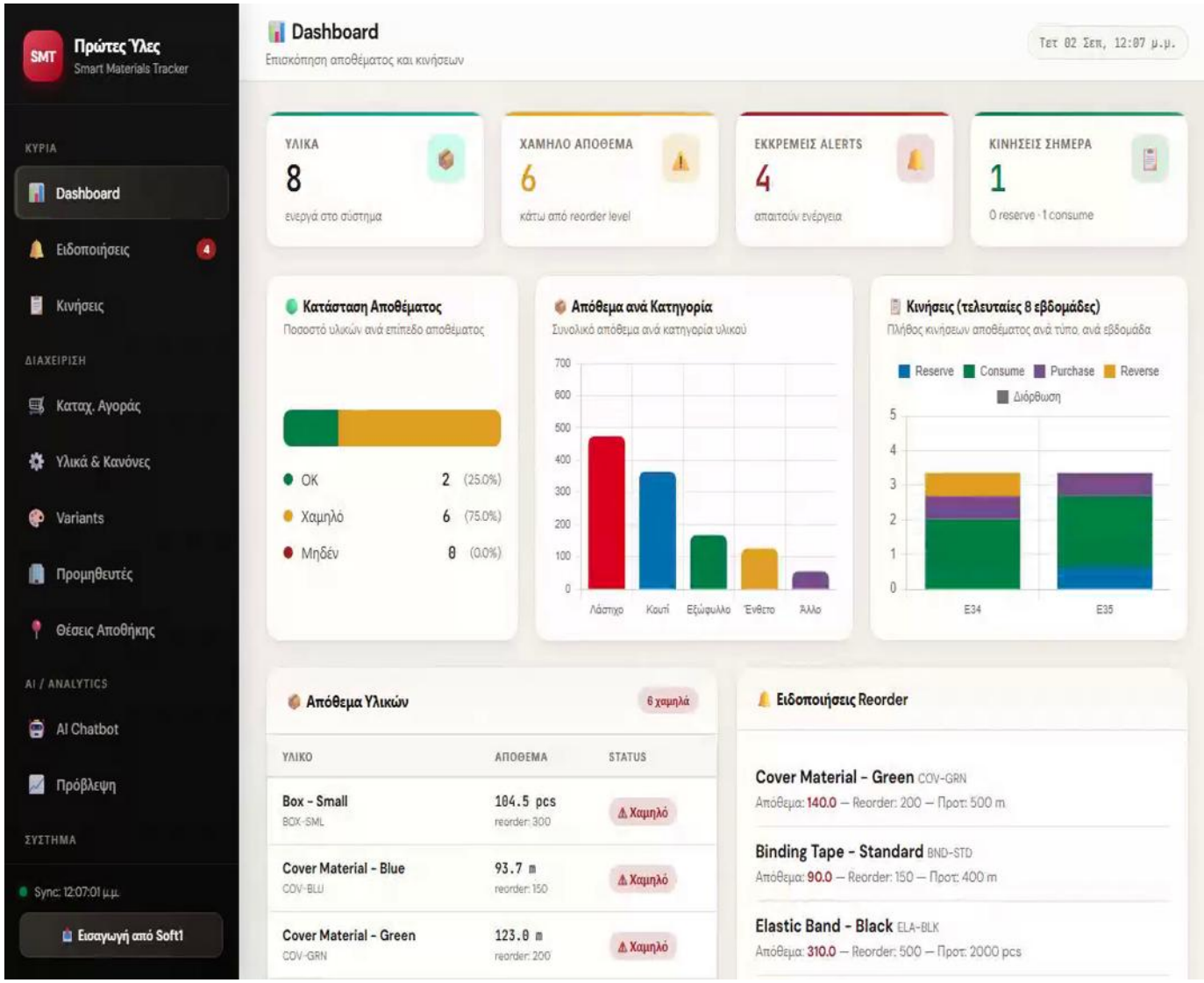
- IoT based warehouse monitoring tool

Key features

- Recommend storing and handling practices
- Enable track&trace through IoT
- Allow for warehouse analytics and alerts generation

Deployment

- Cloud-based service
- On-premise
- Mobile-app



AI use cases in cosmetics manufacturing: at a glance

Process and quality

- Emulsion stability prediction
- Real-time colour matching
- Fill weight / volume control
- Label and packaging inspection

Fill ±0.1%, 15–25% less overfill; inspection >99.7%

Reliability and hygiene

- Predictive maintenance (mixers, fillers)
- Microbial contamination risk modelling

30–45% fewer maintenance-driven stoppages

Compliance and documentation

- INCI / restricted-substance checks
- Batch-record automation
- Adverse-event signal detection
- Regulatory document and SOP gap analysis

Regulatory effort –40–55%

Planning and supply

- Supplier quality scoring and risk
- Demand-driven scheduling
- Virtual line-change planning (Estée Lauder)

Fewer changeovers; dynamic supplier risk ratings

Where it lands on the line: OEE = Availability × Performance × Quality

Availability

- Predictive maintenance, guided changeovers
- Scheduling that groups similar formats

Performance

- Stop-cause analytics; adaptive line speed
- Line balancing with a digital twin

Quality

- Inline vision; adaptive fill control
- Early drift detection, closed-loop feedback

Quantified benefits are vendor-reported claims (iFactory; Schubert; BeautyMatter) – indicative only, not independently validated. Levers: synthesis.

Physical AI, robots and people in the loop

See → Understand → Decide → Act → Adapt

- Two robotic arms sort hundreds of different packages without per-package programming

Cobots at the end of the line

- Palletising as the bottleneck;
- Cobots to feed components

Logistics automation

- Unilever Hefei: ~120 robots, orders 75% faster
- Dermalogica drones: 52 scans/year, +600% vs manual

People in the loop

- Assistants, AR remote assist, cobots remove repetitive loads
- Guardrails and human approval; training and acceptance matter



Sources: Robotiq (vendor); Schubert; BeautyMatter, 2026; L'Oréal. Vendor and company claims.

Generative and agentic AI in the factory

Copilots for operators and engineers

- Natural-language access to SOPs, maintenance history and set-up instructions
- Estée Lauder 'Ella' supports issue resolution and changeovers

Agents for monitoring and response

- Analytics plus AI agents predict maintenance needs and help teams respond to changing conditions
- Some actions automated with human oversight

Document intelligence

- Standard Operating Procedure gap analysis against Good Manufacturing Practice and regulatory requirements
- Batch-record review and exception flagging

Guardrails

- Access only to validated data · human approval for any process change · full audit trail · clear accountability

Sources: BeautyMatter, 2026; The Manufacturer, 25 Jun 2026; iFactory (vendor).

What the use cases can deliver: summary of potential benefits

Quality and yield

Fill accuracy ±0.1%

Inspection detection >99.7%

- Early drift detection and closed-loop correction
- Fewer rejects, rework and start-up losses

Availability and reliability

30–45% fewer stoppages

- Predictive maintenance of mixers and fillers
- 95% of process-flow restrictions predicted (Unilever twin)

Productivity and flexibility

+10% capacity · ≥92% OEE

- 14 formats on one line, changeover <15 min
- Fewer changeovers, higher utilisation, shorter lead times

Waste, energy and resources

–20% waste · 15–25% less overfill

- Lower thermal energy use (Unilever Haldia twin)
- Up to 40% fewer stability failures

Compliance and traceability

–40–55% regulatory effort

- Batch-record closure from days to hours
- Digital audit trail; human sign-off retained

Logistics and people

Orders 75% faster · logistics –24%

- Inventory counts +600% (drones); payback of cobot palletising 12–24 months
- Training time –75% with guided systems; less repetitive handling

Pilot one line, measure against a baseline, then replicate

All figures are company- or vendor-reported– indicative only, to be validated in a pilot.

Teaching Factory: Testing and Experimentation Facilities





Teaching Factory: facilities







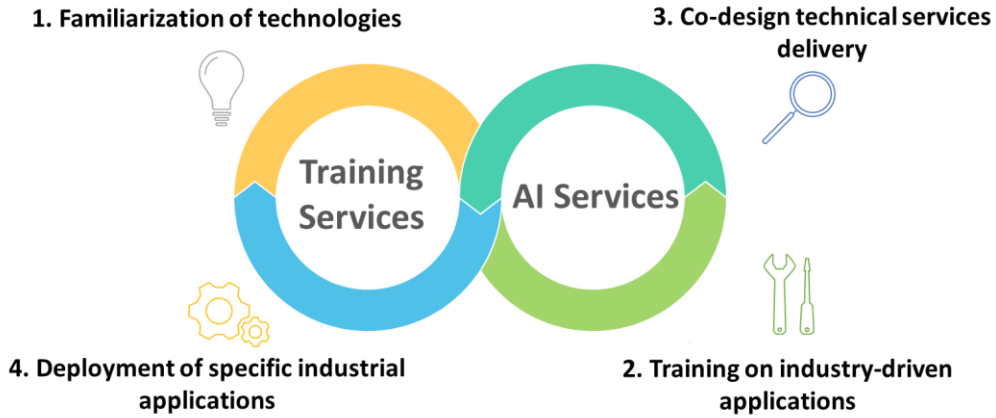




Teaching Factory: training services

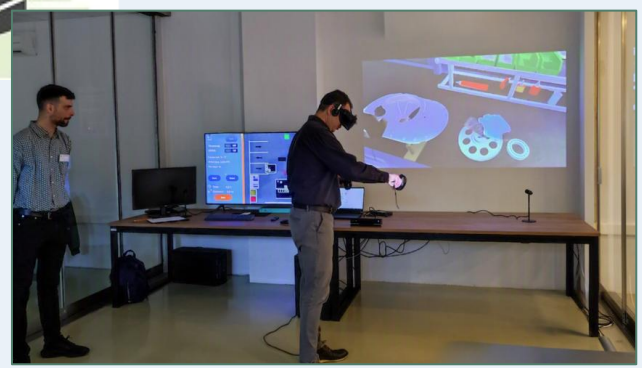
Continuous training – training approaches

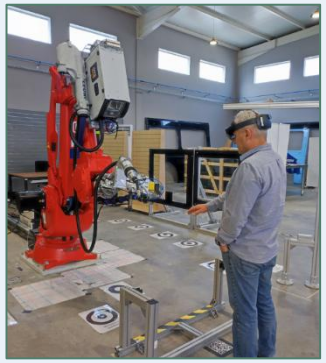
- Upskilling, reskilling etc.
- Training and education services structuring – AI focus, new disciplines, skills
- Teaching factory concept





Training Services designed and delivered based on international standards.









Teaching Factory: Companies worked with TF-CC



Pedestrian detection at industrial vehicles



Training on Safety Scenarios via Industrial Metaverse



Ergonomic analysis on production station



Robotized assembly

SIDENOR STEEL INDUSTRY S.A.
ecoreset
VINSERVICE MICRO MATIC
Alumil
DOJRAN STEEL MANUFACTURING AND TRADE COMPANY SIDENOR GROUP
SOVEL
HALCOR
STOMANA INDUSTRY S.A.
ERLIKON
ELVALHALCOR
GE SUPPLIES INDUSTRIAL MATERIALS • TOOLS • SERVICES we know what works!
BIC
HERON engines
KLEEMANN
m-shipping.gr
PHILIP MORRIS INTERNATIONAL

Roadmap for SMEs: a pragmatic path

1	2	3	4	5
Select	**Connect**	**Pilot**	**Scale**	**Govern**
One line, one use case, clear KPIs	Sensors, gateways, MES / data platform	With a technology partner; baseline first	Replicate to other lines; add twins	Validation, oversight, skills

KPIs to track from day one

OEE	**First-pass yield**	**Changeover time**	**Scrap and overfill**	**Unplanned downtime**	**Energy per kg**

Define the use case and workflow pain points first; partner with specialist technology firms; keep process know-how as differentiator.

Sources: adapted from BeautyMatter, 11 Aug 2026; Robotiq (replicate line by line).

Key takeaways

1. **AI and digital twins deliver measurable results in production**
2. **Value comes from the whole chain: process, quality, maintenance, planning, compliance**
   Data foundation first, then use cases
3. **Flexibility is the key requirement: reconfigurable lines, quick changeover, physical AI**
   High-mix, small-batch production
4. **People stay in the loop: assistants, skills and oversight**
   Human centricity perspective
5. **SMEs can start small: one line, clear KPIs, partners, governance**
   Pilot, measure, replicate

Thank you for your attention!



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