FactoryLine Pro

AI-Native Material Flow Simulation
for Manufacturing SMEs

Local. Intelligent. End-to-End – From Concept to Digital Twin.

Version 1.1 – 2026

www.factorylinepro.com

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1. Executive Summary

Discrete manufacturing in Europe is under dual pressure: production lines must be planned faster and reconfigured more frequently, while costs and complexity continue to rise. Established simulation tools – designed for large enterprise structures – far exceed the budgets of many small and mid-sized manufacturers.

FactoryLine Pro closes this gap. The software is the first AI-native material flow simulation that runs entirely offline on the local workstation, covering an end-to-end workflow: from concept planning through virtual commissioning with PLCSIM Advanced to production-accompanying monitoring as a Digital Twin.

100% Offline	**3 Simulation Modes**	**AI-Integrated**
No cloud, no data transfer. AI runs locally on your machine.	Flow, Co-Sim (PLCSIM) and Hybrid – in a single tool.	Bottleneck analysis, optimization and SCL code generation via AI advisor.

IEC 61131-3 Logic	**Virtual Commissioning**	**Flexible Licensing**
FBD/Ladder editor with 27 standard and 5 FlowSim function blocks.	PLCSIM Advanced via SharedMemory: signal monitor, trace, timing analysis.	Subscription, Perpetual or Enterprise – tailored to your needs.

2. The Challenge: Simulation for Mid-Market Manufacturers

2.1 The Planning Gap

Approximately 45,000 discrete manufacturing SMEs in Germany, Austria and Switzerland plan their production lines based on experience, spreadsheets and gut feeling. Bottlenecks are only discovered during live operation, buffer sizing is unvalidated, and systematic what-if analysis simply does not happen due to a lack of tools.

2.2 The Cost Problem of Established Solutions

Leading simulation suites – Siemens Tecnomatix Plant Simulation, Dassault DELMIA, Rockwell Arena – require annual license fees of €15,000 to €50,000 per seat. Add server infrastructure, training costs and IT administration, and the total investment is frequently out of reach for a mid-sized company with 50 to 500 employees.

Solution	Annual License (approx.)	5-Year TCO / Seat
Tecnomatix Plant Sim	€25,000–50,000	€125,000–250,000
DELMIA	€20,000–40,000	€100,000–200,000
Rockwell Arena	€15,000–30,000	€75,000–150,000
FactoryLine Pro	**from €X00/month ***	**Significantly lower ****

* Entry-level subscription pricing. Perpetual and Enterprise licenses available. ** No server infrastructure, no cloud costs.

2.3 Cloud Dependency and Data Sovereignty

For manufacturing companies, data sovereignty is a fundamental requirement. Production data – cycle times, OEE values, machine utilizations – is strategic information. Cloud-based simulation solutions that transfer factory models to external servers pose an unacceptable risk for many operations. FactoryLine Pro runs entirely locally – not a single byte leaves the corporate network unless the user explicitly chooses otherwise.

3. The Solution: FactoryLine Pro

FactoryLine Pro unites three core principles: complete offline capability with local AI processing, an end-to-end workflow from concept planning to Digital Twin, and flexible licensing models for every company size.

3.1 Architecture

The hybrid architecture combines a modern React web application for data-intensive 2D editors and dashboards with an embedded 3D viewport (WASM) for immersive factory visualization. The backend drives the simulation engine, physics models and AI analysis. Communication runs exclusively via WebSocket (JSON) on localhost.

- **React 19 Frontend:** Vite 6, Tailwind v4, Zustand state management, React Flow for the 2D layout editor, AG Grid for signal monitor, Monaco Editor for SCL code, Recharts and uPlot for KPI dashboards
- **3D Engine:** WASM-embedded or pop-out window. Animated part movement, color-coded machine states, signal-state visualization
- **Backend:** Discrete event simulation, data models, result storage, configuration

3.2 Three Simulation Modes

Mode	Engine	Use Case
A – Flow	SimPy + Physics Timing	Material flow optimization, KPI analysis, Monte Carlo sweeps, bottleneck detection
B – Co-Sim	PLCSIM Advanced (SharedMemory)	Virtual commissioning, PLC program testing, signal verification, timing analysis
C – Hybrid	SimPy + PLCSIM (time domain)	Combined flow and PLC validation, regression tests after PLC changes

These three modes enable a seamless workflow: from early concept planning (Mode A) through virtual commissioning (Mode B) to combined validation (Mode C). No tool switching, no data conversion, one continuous model.

4. Core Features in Detail

4.1 2D Layout Editor

The React Flow-based layout editor enables intuitive factory planning via drag-and-drop. Machines, transport routes and flow components are placed from a comprehensive component library (Library and Inventory tabs).

- **12+ Machine Types:** CNC, Grinding, Assembly, Inspection, Welding, Storage, Packaging, Labeling, Cleaning, Heat Treatment, Painting, Drying
- **24 Conveyor Presets:** Roller, belt and chain conveyors; curves (45/90/180°); vertical conveyors (lift, spiral, paternoster); special (accumulating, telescopic, direct-on-line)
- **KUKA Robots:** KR 6 R700, KR 16 R2010, KR 60-3, KR 210 R3100 with configurable transfer programs
- **Flow Components:** Stoppers (manual/sensor/timer/batch), diverters (round robin/attribute/load balance/overflow), mergers (FIFO/priority/shortest queue)
- **Sensors:** Light barriers, RFID gates, vision stations – triggerable for speed zones on conveyors
- DXF import/export, JSON layout format (.fac), layout-to-simulation conversion at the push of a button

4.2 Physics-Based Simulation

The simulation engine models the physical conditions of the production line far beyond simple cycle time calculations:

- **Drive Train Model:** Motors (IE2–IE4, CMP Servo), gearboxes (R/F/K/S/P/W), variable frequency drives (MOVITRAC B, MOVIDRIVE B, MOVIMOT). Friction model.
- **Pneumatic Cylinders:** 5/2 and 3/2 valve control, spring return, 6 states (retracted–extending–extended–retracting–fault–moving)
- **Velocity Profiles:** Trapezoidal (acceleration/cruise/deceleration), sensor-triggered speed zones for positioning accuracy
- **Failure Models:** Motor overload, thermal overload, gearbox overload, belt slip, brake wear, VFD overcurrent
- **Stochastics:** Normal/lognormal distribution for cycle times, exponential/Weibull distribution for MTBF, Monte Carlo parameter sweeps with multi-seed analysis
- **Shift Models:** 1/2/3-shift operation, part type transformation (mass change, type change after processing)

4.3 AI Advisor

FactoryLine Pro integrates artificial intelligence as a central component of the planning workflow – not as an afterthought:

- **Multi-Provider:** Ollama (local LLMs – no data leakage), Anthropic or OpenAI compatible API – flexibly configurable based on requirements and data protection policy

- **Context-Sensitive Analysis:** The AI has full access to the factory model: machine configurations, transport routes, buffer utilizations, signal tables and historical simulation results.

- **Unified Advisor:** Unique cross-domain advisor that correlates material flow KPIs with signal-based timing data and energy consumption – no competitor offers this cross-domain intelligence

- **Structured Suggestions:** Optimization recommendations as concrete JSON changes with confidence scores, expected impact and rationale. Every suggestion requires explicit user approval.

- **SCL Code Generation:** Automatic generation of TIA Portal-compatible SCL code: timeout adjustments, part-present interlocks, handshake optimizations, complete station function blocks

- **AI Auto-Placement:** Imported components (e.g. from TIA Portal) are automatically arranged in the layout. TopologyInferrer analyzes signal names and TIA tags, LayoutPlacer calculates positions (LINEAR, U_SHAPE, L_SHAPE, SERPENTINE), PlacementAdvisor delivers up to 3 strategy alternatives.

4.4 Component Logic Editor (IEC 61131-3)

The integrated logic editor enables creation of component-level control behavior directly within the simulation environment – compliant with the IEC 61131-3 standard:

- **Two Equivalent Views:** FBD (Function Block Diagram) as a React Flow canvas and Ladder (contact plan) as a classic ladder representation. Both views operate on the same model.

- **27 Standard IEC Function Blocks:** Logic (AND/OR/NOT/XOR), Bistable (SR/RS), Edge (R_TRIG/F_TRIG), Timer (TON/TOF/TP), Counter (CTU/CTD/CTUD), Comparison (GT/LT/EQ/GE/LE), Arithmetic (ADD/SUB/MUL/DIV), Data (MOVE/SEL/MUX)

- **5 FlowSim-Specific FBs:** SEQUENCE (N-step sequence manager), CYLINDER_CTRL (6-state FSM), HANDSHAKE (station-to-station protocol), MOTOR_CTRL (ramp + fault management), SENSOR_DEBOUNCE

- **Logic Runtime:** Topological sort (Kahn's algorithm) for correct evaluation order. Cyclic execution with optional SignalTable integration for I/O synchronization.

- **6 Machine Templates:** CNC_BASIC, PRESS_BASIC, ASSEMBLY_STATION, CONVEYOR_CONTROL, ROBOT_CELL and EMPTY – for a quick start

- **Step Debugger:** Breakpoints, single-step execution, watch list, cycle counter and visual overlay with live values

- **SCL Export:** TIA Portal V17 compatible Structured Control Language code with FUNCTION_BLOCK, REGION blocks and full parameterization

4.5 Virtual Commissioning (PLCSIM Advanced)

The co-simulation capability connects the material flow simulation directly to the PLC program via Siemens PLCSIM Advanced and SharedMemory IPC:

- **Deterministic Sync Loop:** Configurable scan cycle time (default 10ms), bidirectional signal processing
- **Live Signal Monitor:** AG Grid with real-time filtering, direction indicators, cell flash on value changes, right-click forcing
- **Oscilloscope Signal Trace:** Waveform display with dual-cursor time measurement, zoom, replay of saved traces
- **Timing Analyzer:** Physics prediction vs. PLC actual times with color-coded assessment (OK/Warning/Violation, thresholds: 10%/25%)
- **Signal Recording:** Ring buffer (100K samples in RAM) or full recording (DuckDB streaming). Trace replay for offline analysis.
- **Hardware Interrupts:** OB40 simulation with auto-trigger on bound signal edges
- **Hybrid Scheduler:** Simultaneous co-simulation for multiple active stations on one PLC. Time-slice co-sim: one run_cycle() advances all stations.

4.6 Signal Flow Editor

The central tool bridging simulation and PLC programming:

- **Signal Naming Convention:** {component_id}_{actuator}_{signal}, e.g. ST10_Clamp_Y1
- **Visual Mapping:** Color-coded (green=input, orange=output, blue=analog, yellow=forced) with interactive diagram
- **PLC Address Management:** Siemens S7 format with automatic validation, byte/bit visualization of %I and %Q address space
- **Conflict Detection:** Automatic identification of overlapping addresses (duplicate bits, word/bit overlap)
- **Auto Address Assignment:** Configurable start addresses, automatic mapping, TIA Portal CSV export

4.7 Import, Export and Migration

FactoryLine Pro integrates seamlessly into existing tool landscapes:

TIA Portal

- **CSV Import:** Semicolon-delimited, UTF-8, German and English column headers, PLC address parsing (%I/%Q/%M with BOOL/WORD/DWORD)
- **Openness API:** Direct import from a running TIA Portal V15+ instance via pythonnet/.NET interop. No CSV intermediate step.
- **Component Derivation:** Reverse-engineering machines from signal names and TIA tags

WinMod

- **CSV and XML Import:** WinMod dot notation is automatically translated to FlowSim underscore convention
- **Migration Report:** Markdown report with signal matching and action recommendations

Naming Schema System

- **4 Built-in Schemas:** FlowSim, EPLAN P8, Simple, Siemens KKS. User-defined schemas with custom regex patterns.

Documentation and Test Generation

- **Signal Documentation:** Self-contained HTML file (inline CSS, print-ready, bilingual DE/EN) with address map, timing table, cross-reference
- **Test Generation:** Automatic regression tests from simulation scenarios (TestStationTimings, TestThroughput, TestSignalSequences)
- **DXF Export:** Machines, robots, zones, dimensions for CAD integration

5. Monitoring and Digital Twin

FactoryLine Pro evolves beyond a pure planning tool into a platform for continuous production operations. The monitoring system detects drift, forecasts maintenance needs and validates the simulation model against reality.

5.1 Drift Detection

The DriftEngine algorithm continuously compares target values (from the simulation) with actual values (from OPC-UA or PLCSIM data). Linear regression on deviation trends forecasts when warning and critical thresholds will be reached.

5.2 Predictive Maintenance

Weibull-based wear models estimate the remaining useful life (RUL) of individual components. Operating hours, cycle counters and measured degradation trends feed into the forecast. The system generates maintenance planning recommendations with urgency levels (INFO, WARNING, CRITICAL).

5.3 Alert Engine

Threshold- and drift-based alarms with full lifecycle (created, acknowledged, resolved). Optional AI analysis provides root cause assessment and action recommendations for each alarm.

5.4 Headless Simulation and Batch Analysis

For long-running simulations, FactoryLine Pro provides a command-line runner:

- **Time Ranges:** Hours, days or years (e.g. 365 production days in 3-shift operation)
- **Results:** hourly_kpis, machine_stats, daily_summary, shift_summary, conveyor_stats, simulation_meta
- **Monte Carlo:** Multi-seed parameter sweeps, aggregated in the database for statistical robustness analysis
- **CSV Export:** German Excel format (semicolon, decimal comma, UTF-8 BOM) for reporting workflows

6. KPIs and Metrics

6.1 Material Flow

KPI	Description
Throughput	Parts per hour at the line output
WIP	Parts in system (processing + buffers + transport)
Cycle Time	Entry-to-exit total time per part
OEE	Availability × Performance × Quality (Overall Equipment Effectiveness)
Bottleneck	Machine with highest utilization + longest blocking time

6.2 Machines and Conveyors

Metric	Description
Utilization	Working time / Total time (per machine, color-coded: Idle/Working/Blocked/Starved/Breakdown)
MTBF/MTTR	Reliability parameters (Exponential/Weibull distribution)
Motor Utilization	$M\_eff / M\_N \times 100\%$ (SEW drive train model)
Energy Consumption	kWh per conveyor, aggregated over simulation
Brake Wear	Accumulated work / Rated capacity × 100%
Thermal	Temperature vs. rated value (motor monitoring)

7. Licensing Models

FactoryLine Pro offers flexible licensing options that adapt to your project size and organizational structure:

	Subscription	Perpetual	Enterprise
Payment Model	Monthly / annual	One-time purchase	Individual
Target Group	Individual projects, evaluation	Permanent use, CapEx	Multi-user, multi-site
Updates	Included in subscription	12 months incl., then optional	Individual SLA
Support	Community + email	Email + priority	Dedicated, SLA-based
Co-Sim (PLCSIM)	Optional add-on	Included	Included
Monitoring/DT	Optional add-on	Optional add-on	Included
Multi-Client	–	Optional	Included (Master/Observer)

All licensing models include: Complete offline capability, local AI processing (Ollama), 2D layout editor, physics-based simulation, Component Logic Editor, DXF import/export, TIA Portal and WinMod import, headless runner, signal documentation.

CapEx Advantage of the Perpetual License: A one-time investment that can be capitalized as a fixed asset and depreciated over its useful life – a decisive advantage for investment planning in mid-market manufacturing.

8. Technology Stack

Layer	Technology	License	Purpose
Frontend	React 19 + Vite 6 + Tailwind v4	MIT	Web UI, editors, dashboards
2D Editor	React Flow (@xyflow/react)	MIT	Layout canvas
Data Grids	AG Grid + Monaco Editor	MIT/Community	Signal monitor, SCL editor
Charts	Recharts + uPlot	MIT	KPI dashboard, trace
3D Engine	Godot 4.6 (WASM)	MIT	Factory visualization
Simulation	SimPy (Python)	MIT	DES engine
Physics	Proprietary (Python)	–	SEW drive, cylinders, valves
AI/LLM	Ollama / Anthropic / OpenAI	MIT/Apache	AI analysis
Optimization	Google OR-Tools	Apache 2.0	Layout placement
Database	SQLite + DuckDB	PD/MIT	Result storage
Co-Simulation	PLCSIM Adv. (SharedMemory)	Siemens	Virtual commissioning
Desktop	Tauri v2 (optional)	MIT	Native app shell
i18n	react-i18next	MIT	German (default) + English

The infrastructure is built entirely on open-source components. License costs apply exclusively to the FactoryLine Pro software itself. Virtual commissioning requires an existing PLCSIM Advanced license from Siemens.

9. Typical Use Cases

9.1 Greenfield: Planning a New Production Line

An automotive supplier plans a new assembly line for axle carriers. The production planner creates the layout in the 2D editor, configures 15 machines, KUKA robots, conveyor routes with SEW drives and sensors. Within minutes, the simulation delivers throughput, OEE and bottlenecks. The AI advisor recommends enlarging the buffer before station 7 and generates the corresponding SCL code for the cylinder control. A Monte Carlo analysis with 1,000 seeds confirms the robustness.

9.2 Brownfield: TIA Portal Migration

An existing plant imports its PLC configuration via TIA Openness API. AI auto-placement recognizes the topology from signal names (ST10_Clamp_Y1, CV20_Motor_Enable) and automatically arranges stations in a U-shape layout. In hybrid mode, the timing analyzer validates the PLC program against the physics-based simulation – three timing violations in cylinder control are identified. The SCL generator delivers corrected code.

9.3 Virtual Commissioning

The automation engineer uses Mode B with PLCSIM Advanced. The live signal monitor displays all 247 I/O signals in real time. Via oscilloscope trace, the timing of the handshake sequence between station 3 and station 4 is verified. The Component Logic Editor models the sequence control as FBD with SEQUENCE block and CYLINDER_CTRL. After validation, the SCL code is exported for TIA Portal V17.

9.4 Batch Analysis and Reporting

The plant manager needs an annual forecast. The headless runner simulates 365 production days in 3-shift operation – without GUI, in a fraction of real time. The database results feed into the analysis: daily OEE, shift comparisons, machine downtime, energy consumption. CSV export in German Excel format enables direct further processing.

9.5 Production-Accompanying Monitoring

After commissioning, the monitoring system runs as a web app on the plant network. OPC-UA data sources provide actual values that are validated against the simulation model. Drift detection identifies gradual degradation, predictive maintenance forecasts component lifetimes via Weibull model. For critical deviations, the alert engine generates AI-supported action recommendations.

10. Security and Data Protection

FactoryLine Pro was designed for deployment in security-conscious manufacturing environments:

- **No Cloud Requirement:** The software runs entirely on the local machine. Not a single byte leaves the corporate network.

- **Local AI (Default):** Ollama processes all data locally on the GPU. No API calls, no data leakage. Cloud APIs (Anthropic, OpenAI) are a deliberate opt-in decision.

- **No Telemetry:** No usage data, no crash reports, no license checks to external servers.

- **Open Data Formats:** JSON (.fac), DuckDB, CSV, DXF, HTML. No vendor lock-in.

- **Multi-Client Security:** Master/Observer role model for concurrent access. Session tokens via UUID v4.

11. Product Development and Roadmap

FactoryLine Pro is under active development. The system is secured by over 1,620 automated tests (62 test modules).

Timeline	Feature	Description
Available	Flow Simulation (Mode A)	SimPy engine, physics modeling, KPI analysis, Monte Carlo
Available	Virtual Commissioning (Mode B/C)	PLCSIM Advanced, SharedMemory, hybrid mode, timing analysis
Available	Component Logic Editor	IEC 61131-3 FBD/Ladder, 32 function blocks, SCL export
Available	AI Advisor + Auto-Placement	Multi-provider AI, Unified Advisor, topology inference
Available	Import/Export	TIA Portal CSV/Openness, WinMod, DXF, signal documentation
In Development	Live Monitoring (Web App)	OPC-UA data sources, drift detection, production-accompanying
In Development	Predictive Maintenance	Weibull wear models, RUL estimation, maintenance planning
Planned	OPC-UA Live Connector	Real-time comparison: simulation vs. reality
Planned	SAP RFC/BAPI Integration	Automated data exchange with SAP ERP
Planned	PDF Reporting	Automated reports for management and customers
Planned	Multi-Line Layouts	Parallel production lines in a single factory model

12. Summary

FactoryLine Pro addresses a clear market gap: approximately 45,000 discrete manufacturing SMEs in the DACH region that need powerful simulation but can afford neither the budgets nor the IT infrastructure for enterprise solutions.

The software combines five unique differentiators:

1. Offline-First Full functionality without internet. AI, simulation and analysis run locally.	**2. AI-Native** AI as an integral component: bottleneck analysis, optimization, SCL code generation, auto-placement.
3. End-to-End Workflow From concept through virtual commissioning to production monitoring in one tool.	**4. IEC 61131-3 Logic** Integrated FBD/Ladder editor with 32 function blocks and TIA Portal SCL export.

5. Flexible Licensing

Subscription, Perpetual or Enterprise – tailored to every company. CapEx-eligible one-time licenses for mid-market manufacturers.

Ready for the Next Step?

Request a personal demo or start your free evaluation.

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