

BIKEBOTIX
SOLUTIONS IN MOTION

SAL

SMART AERIAL LINE

Production Management and Takt-Time Monitoring System for Overhead Bicycle Assembly Lines

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The SAL overhead line



SAL — Smart Aerial Line

SAL is a modular overhead bike assembly line dedicated to the assembly of traditional and electric bicycles (up to 40 kg). Flexible and reconfigurable, it features millimeter-adjustable workstations, a smooth and energy-efficient conveyor system, and 360° rotating clamps for optimal ergonomics.

Industry 4.0 compatible, it frees up floor space, streamlines component supply, and ensures simple maintenance.

40 kg

Maximum weight per bicycle

360°

Rotating clamps for optimal ergonomics

4.0

Industry 4.0 compatible



- Millimeter-adjustable workstations
- Smooth and energy-efficient conveyor system
- Flexible and reconfigurable structure
- Traditional and electric bicycles

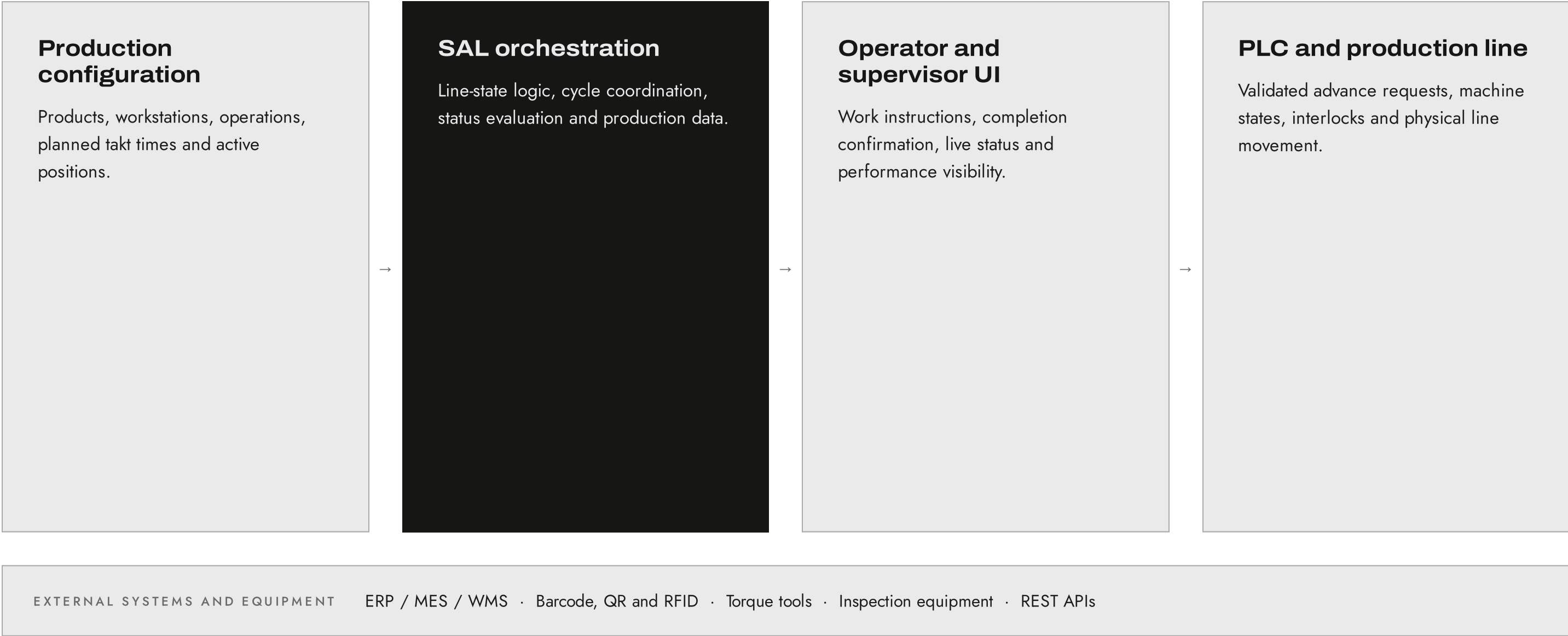
Purpose and operational context

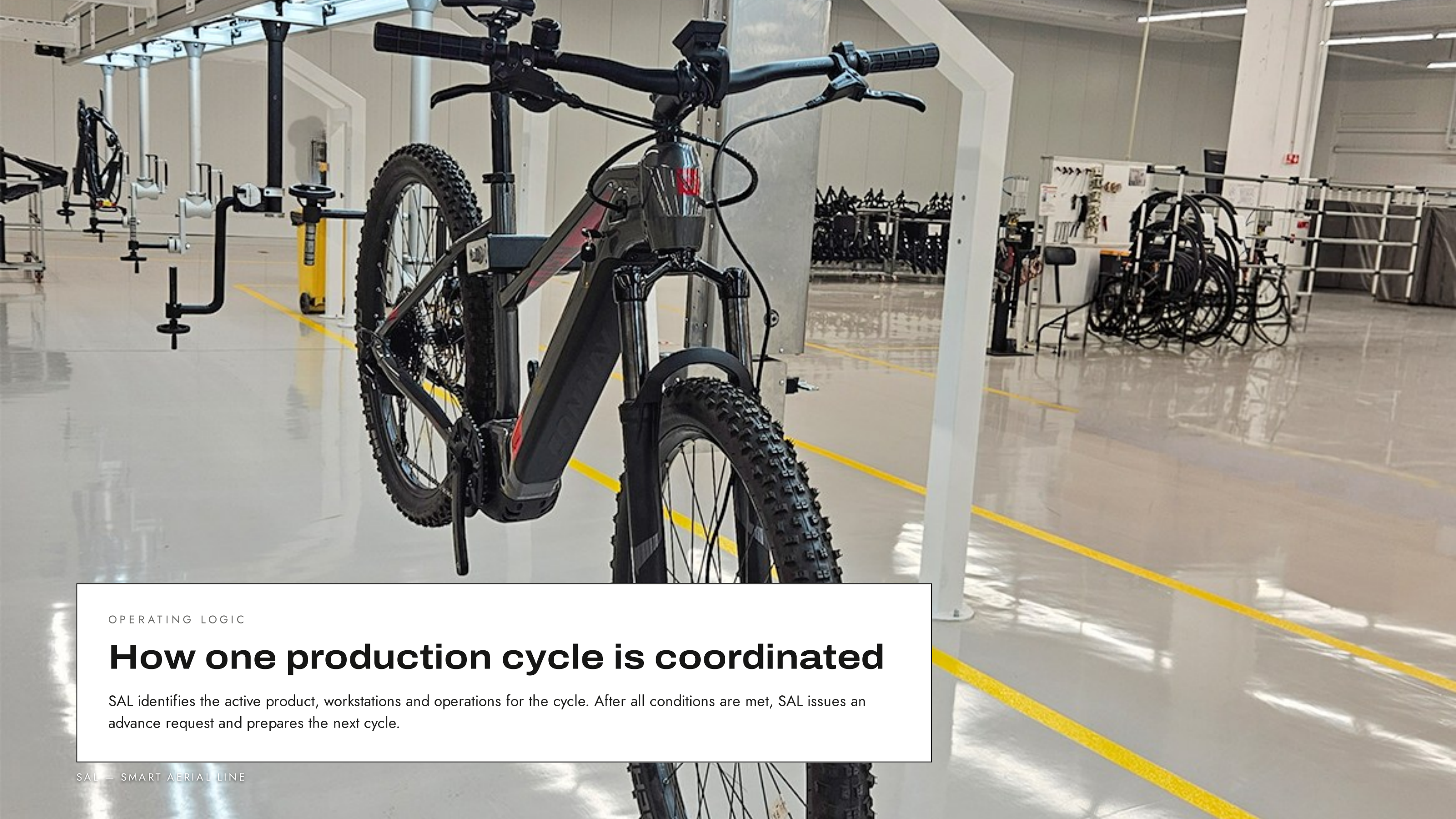


Production challenge	SAL response
Limited real-time visibility – The slowest workstation is not always identified during the cycle. – Takt-time deviations are difficult to compare across stations, shifts and products. – Waiting time, operation time and line delays are often recorded together. – Process improvements can depend on observation instead of consistent production data.	A coordinated digital workflow – Defines workstations, operations, expected takt times and active production positions. – Monitors completion and actual cycle time for every relevant workstation. – Coordinates the production sequence and prepares the next cycle after completion. – Provides structured information for supervision, capacity analysis and line balancing.

Scope boundary — SAL coordinates the production workflow. Machine safety, emergency functions and motion interlocks remain under the control of the safety-rated PLC and electrical control system.

System overview





OPERATING LOGIC

How one production cycle is coordinated

SAL identifies the active product, workstations and operations for the cycle. After all conditions are met, SAL issues an advance request and prepares the next cycle.

How one production cycle is coordinated



01

Load the current process

SAL identifies the active product, workstations and operations for the cycle.

02

Present workstation tasks

Each operator receives the information relevant to the assigned production position.

03

Measure actual cycle time

Elapsed time is monitored independently for every active workstation.

04

Confirm completion

Operators or connected equipment confirm that the required operations are complete.

05

Evaluate active positions

SAL verifies completion only for the stations relevant to the current line state.

06

Prepare line advancement

After all conditions are met, SAL issues an advance request and prepares the next cycle.

Dynamic line-state management



State 01

Line filling

Products enter progressively. Only positions that currently contain a product participate in cycle completion.

1

2

3

4

5

6

7

8

RELEVANT STATIONS ONLY

State 02

Normal running

All configured production positions are active and must complete their assigned operations before advancement.

1

2

3

4

5

6

7

8

ALL CONFIGURED STATIONS

State 03

Line emptying

As products leave the line, empty positions are progressively excluded while remaining products continue normally.

1

2

3

4

5

6

7

8

RELEVANT STATIONS ONLY

Active production positions are shown in black; excluded positions do not participate in the current cycle.

Core SAL software capabilities



CAPABILITY	OPERATIONAL FUNCTION	PRODUCTION RELEVANCE
Process definition	Defines products, workstations, operations and planned takt times.	Creates a controlled digital representation of the assembly process.
Dynamic station logic	Activates only the positions relevant to filling, running or emptying.	Prevents empty positions from creating false waiting conditions.
Cycle monitoring	Measures actual elapsed time for every active workstation.	Shows where takt targets are met or exceeded.
Completion coordination	Evaluates completion status across all relevant workstations.	Coordinates the transition to the next production cycle.
Operator interaction	Presents assigned work and captures operation-completion confirmation.	Supports consistent execution and clear workstation status.
Production visibility	Displays line status, pending positions, cycle progress and output information.	Gives supervisors a current view of line performance.
Production records	Retains cycle and workstation data according to the agreed project scope.	Supports bottleneck analysis, reporting and continuous improvement.

Role-specific production visibility



Operator

Operator workstation interface

- Current product or bicycle model
- Assigned operation and work instruction
- Planned takt time and current elapsed time
- Workstation and line status
- Completion confirmation
- Process messages, images or visual references
- Component, tool or quality prompts when required

Supervisor

Supervisor and production view

- Current line state and active workstations
- Completed, pending and delayed positions
- Current cycle duration and takt deviation
- Output by hour, shift or production batch
- Recurring workstation bottlenecks
- Planned versus actual production
- Historical analysis and reporting, when included

Production benefits and how they are evidenced



BENEFIT	OPERATIONAL MECHANISM	EVIDENCE AVAILABLE FROM SAL
Bottleneck identification	Completion and cycle time are evaluated per active station.	Delayed station, delay duration and recurrence.
Improved line balancing	Measured operation times can be compared across workstations.	Cycle-time distribution and repeated takt overruns.
Reduced waiting	Finished stations are distinguished from the station blocking advancement.	Waiting time versus active operation time.
Predictable output	Actual takt adherence is linked to completed production cycles.	Hourly, shift and batch output trends.
Standardized execution	Operations and completion conditions are defined by product and station.	Consistent workflow status and recorded completion.
Faster process changes	Station assignments and process definitions can be reconfigured.	Controlled comparison before and after process changes.
Continuous improvement	Production data is retained according to the agreed implementation.	Recurring delays, variability and performance trends.

Configurable platform and custom development



SAL is not limited to a fixed set of functions or a predefined production-line configuration. It can be delivered as a custom-engineered solution based on the client’s products, equipment, process rules, data requirements and system landscape.

Configuration	Development
Configuration within the SAL platform – Workstation count, order and active positions – Products, variants and production recipes – Operations, instructions and planned takt times – Line-filling and line-emptying behavior – User roles, permissions and language – Dashboards, reports and displayed indicators	Client-specific software development – Custom operator and supervisor interfaces – Custom workflow, quality and rework logic – PLC, equipment and smart-tool interfaces – ERP, MES, WMS and REST API integrations – Traceability and product-history functions – Custom alarms, analytics and escalation rules

Examples of custom functional modules



Process and product logic

Mixed-model production, product-specific sequences, conditional operations and controlled process revisions.

Quality and traceability

Serial-number history, quality gates, inspection results, rework, non-conformities and component-batch records.

Tools and equipment

Torque tools, scanners, RFID, test stations, inspection equipment, printers and other production devices.

Management reporting

Client-defined KPIs, shift reports, production summaries, alarms, escalation rules and historical analysis.

Enterprise integration

Production-order import, inventory signals, ERP, MES, WMS, databases and client-specific REST APIs.

User experience

Role-specific screens, multilingual interfaces, visual work instructions and workflows adapted to local procedures.

Custom functions are included only after technical definition, scope approval and validation of the required interfaces.

Possible implementation variants



01 — Production monitoring	02 — Workstation coordination	03 — Integrated production control
– Cycle and takt-time monitoring – Workstation and line status – Production output – Bottleneck identification – Historical reports when required	– Operator task presentation – Completion confirmation – Dynamic workstation activation – Filling, running and emptying logic – Controlled line-advance requests	– PLC and machine communication – Production-order integration – Product identification and traceability – Quality and equipment data – ERP, MES or WMS integration

Integration and industrial control boundaries



SAL requests and coordinates production actions; the PLC validates and executes physical movement under the applicable safety conditions.

Production indicators supported by SAL



Takt-time adherence Planned versus actual cycle	Cycle time by station Duration and variability	Output Hour, shift and batch	Production plan Planned versus actual
Bottleneck frequency Repeated blocking stations	Waiting time Finished but blocked	Interruption time Recorded production stops	Changeover time Model or batch transitions
Work in progress Products currently on line	Rework When quality module is included	First-pass completion When quality data is available	OEE When required equipment signals exist

The final KPI set depends on the selected modules, available machine signals and agreed data-retention scope.

Implementation approach



STEP	PHASE	CONTENT
01	Process analysis	Map products, stations, operations, line states and responsibilities.
02	Functional specification	Define core scope, custom functions, interfaces, data and acceptance criteria.
03	Configuration and development	Configure SAL and implement the approved client-specific modules.
04	Integration	Connect PLCs, production equipment and enterprise systems included in scope.
05	Validation	Test representative filling, running, emptying, fault and recovery scenarios.
06	Launch and improvement	Train users, support production start and refine the process using measured data.

The final system architecture, implementation schedule and commercial scope are established after a technical assessment of the client’s production line and integration requirements.

SAL solution definition



SAL — Smart Aerial Line is a configurable and custom-developable production orchestration, process monitoring and takt-time management solution for overhead bicycle assembly lines.

Scope

The core platform provides structured process definition, workstation coordination and production visibility.

Additional traceability, quality, reporting, equipment and enterprise-integration functions are developed according to the approved client-specific scope.

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