



kontron

The Power of IoT

Kontron AIS GmbH

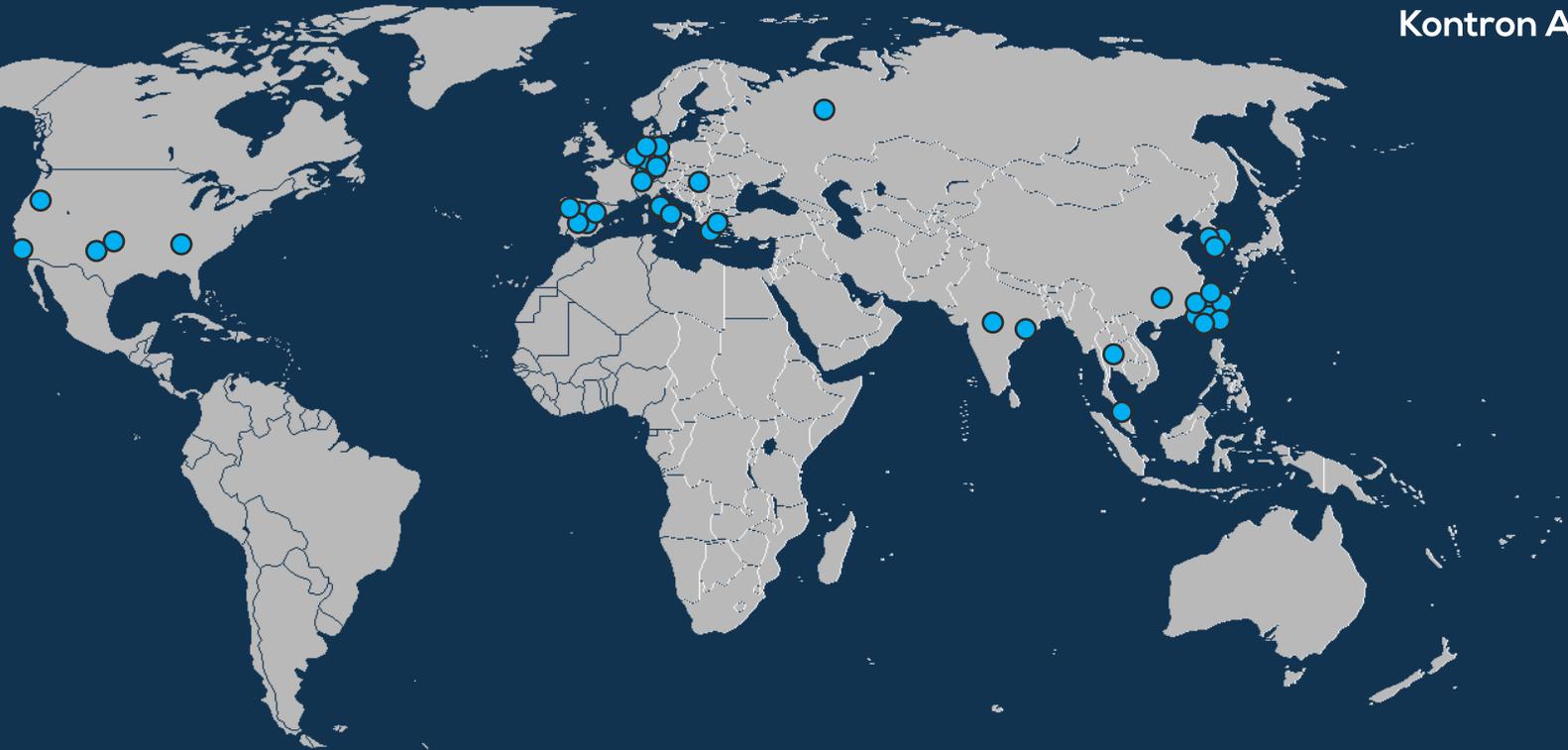
Scaling and Optimizing Module Production with MES and AI

Ensuring Quality & Cost-Effectiveness

Kontron AIS – PV Customers



FabEagle[®]MES



Crystallization
Growing
Wafering

10 x

Thin film
production

14 x

Silicon based cell
manufacturing

52 x

PV module
manufacturing

23 x

Solar receiver
production

2 x

Our Know-How

Kontron AIS GmbH – a Strong Partner

kontron

The Power of IoT

Kontron AIS GmbH



Crystal Growing

Ingot

Wafer

Solar Cell

Solar
Module

Solar Module Production with MES

- › PV Cells
- › Bussing
- › Flux

- › Glass
- › Back sheet
- › Encapsulant

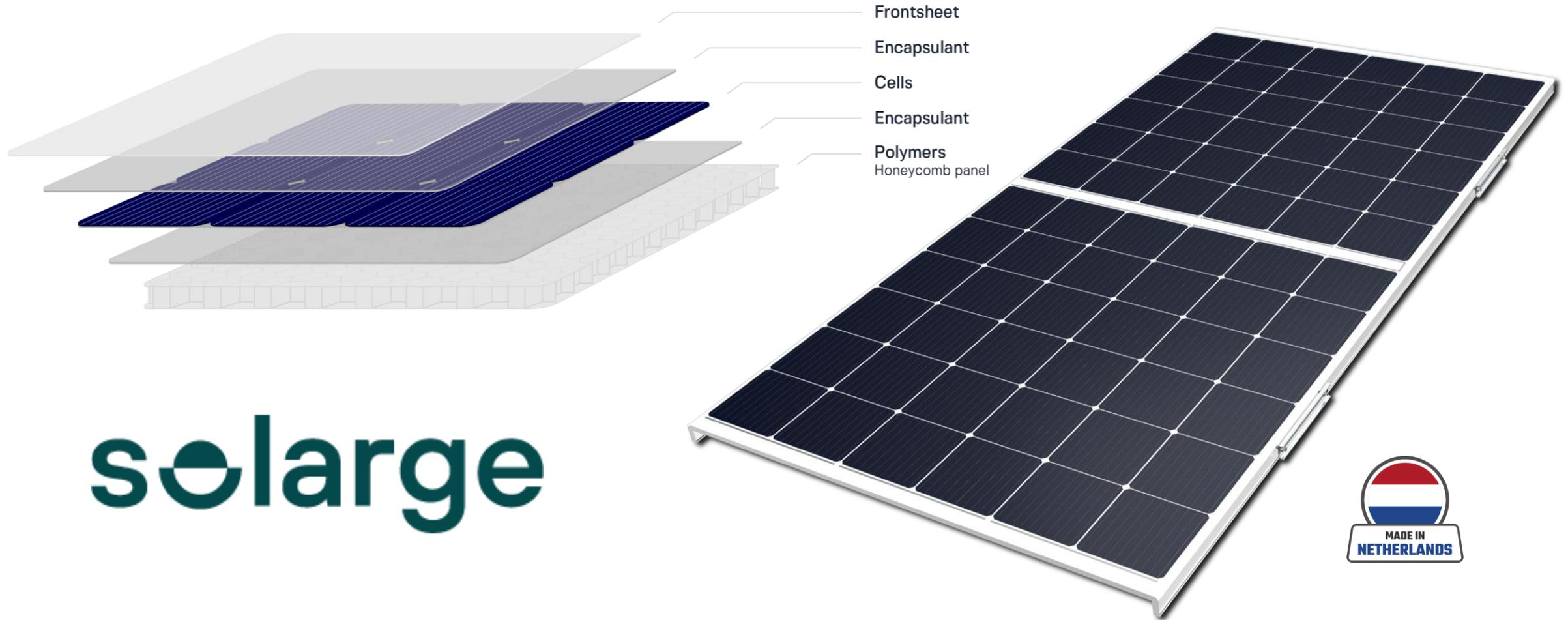
- › Frames
- › J-Box
- › Silicone



- › Material tracking and order management
- › Process and equipment data acquisition with Online-SPC
- › Support for BOM Tracking, Inspection, Rework, Grading, Sorting and Line Control
- › Real-time connection to ERP to track finished and semi-finished products
- › Monitoring of equipment performance

Reference – Solar Module MES at Solarge (Netherlands)

100% Zero Waste Modules at End of Lifecycle



solarge



Reference – Solar Cell MES at Suniva (US)

Success Story
Factory Automation

Kontron AIS GmbH **kontron**
The Power of IoT

Mastering Complexity: Suniva's Journey to a 2.5 GW Photovoltaic Cell Production Line with FabEagle®MES



"Even with a tight timeline, they not only delivered on schedule but exceeded our expectations. At Suniva, we often say that Kontron AIS is our favorite vendor – a sentiment that reflects their outstanding service and commitment."

Hawazin Abdullah,
MES Implementation Manager,
Suniva Inc.

Suniva

FabEagle®MES

Suniva Inc.
Norcross, Georgia, USA

Project:
FabEagle®MES for PV cell production line in the USA

Platform:
FabEagle®MES,
FabEagle®Connect

Kontron AIS services:
Consulting, project management, software implementation, equipment integration, on-site commissioning, 24/7 hotline support and maintenance

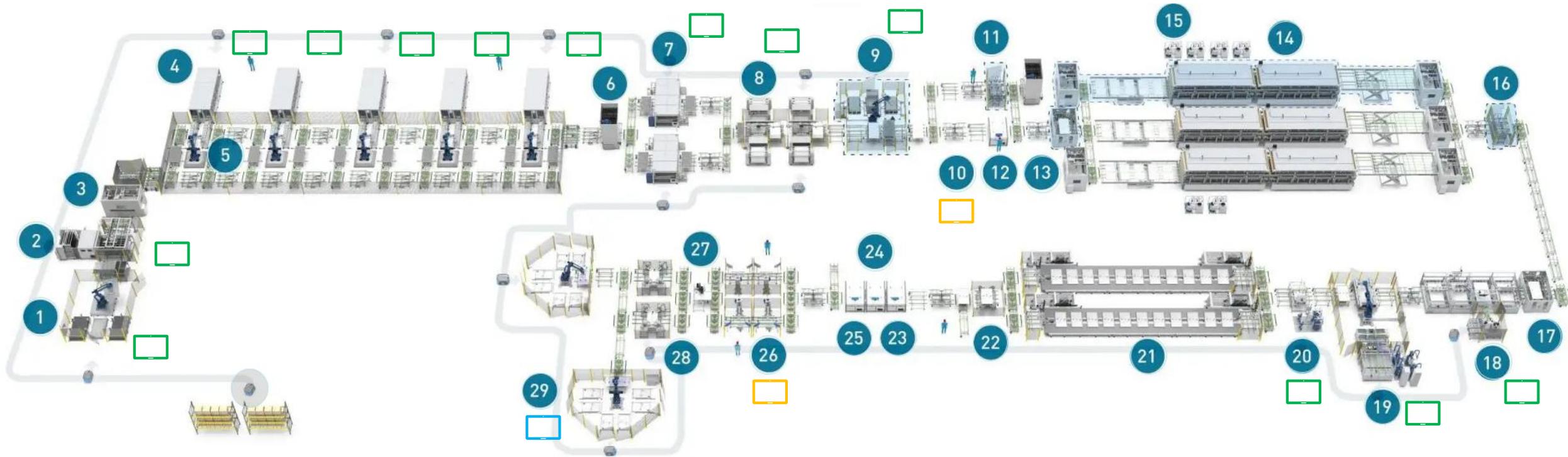
Challenge	Solution	Result
<ul style="list-style-type: none">› Short lead time to start of production (SOP)› Collect data on single wafer level to optimize quality› Integrate high-throughput equipment	<ul style="list-style-type: none">› High focus on project management by experienced Kontron team› Implementation of virtual single wafer tracking› Extensive collaboration with equipment vendors	<ul style="list-style-type: none">› Delivery on schedule and exceeding expectations› Single cell tracking to support ramp-up and optimizations› Reliable MES interfaces with high performance using SECS/GEM, OPC UA, TCP/IP-XML

- › **Process optimization by correlation of process data with final cell results**
- › Solved material tracking challenges:
 - › Long feedback loops
 - › More sophisticated cell structures
 - › Bigger factories and batch sizes
 - › Throughput optimized tools
- › Enabled Equipment Performance Tracking and ERP integration
- › **IMMENSE savings and fast payback time** as ramp-up is accelerated, and constant monitoring of production is possible

<https://kontron-ais.com/en/resources/customer-references/fabeagle-mes-photovoltaic-suniva>

Sample MES configuration for Module line

Ecoprogetti Turnkey line 1.2 GW

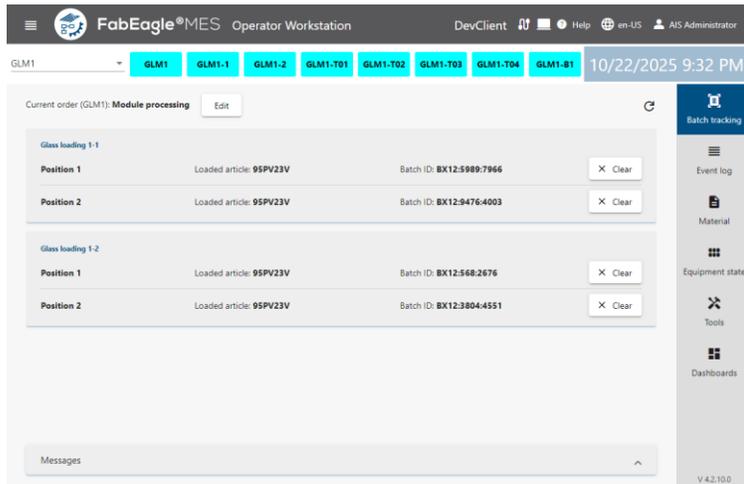


- › Scan stations for consumable material (glass, cells, foil, j-box, frame parts, silicone)
- › Visual inspection and rework stations with defect tracking for layups, laminates and modules
- › Packaging and sorting station

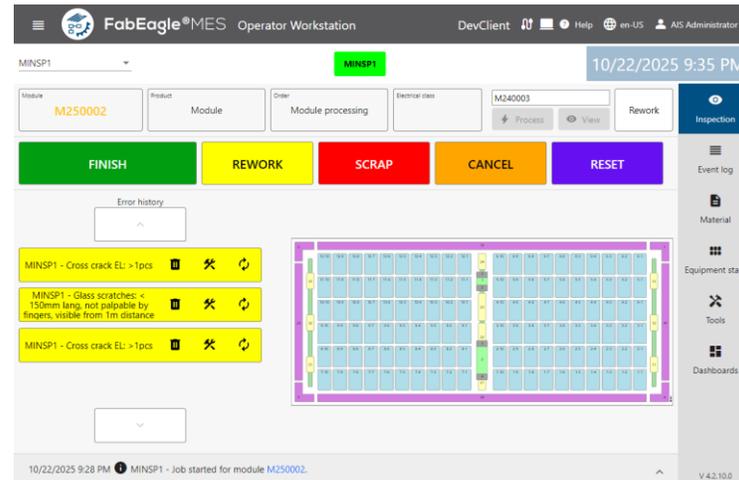
MES Shopfloor Clients in Module Production

Flexibility and Configuration

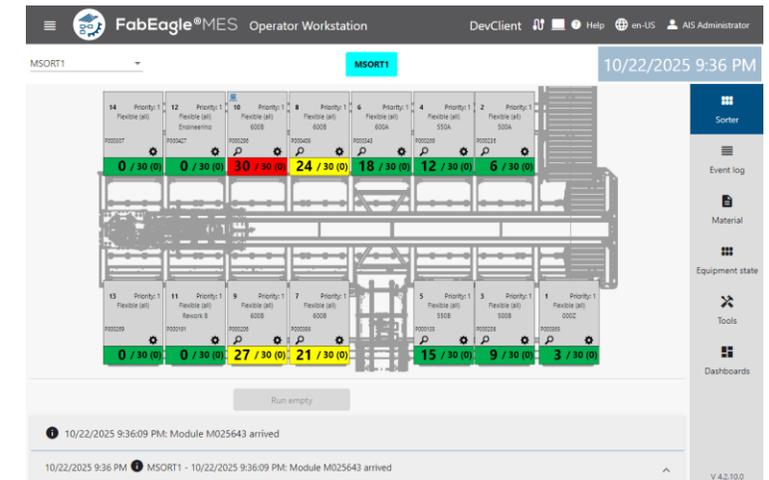
Scan stations



Visual inspection and rework



Packaging and sorting



- › **Scan stations** for consumable material (glass, cells, foil, j-box, frame parts, silicone)
- › **Visual inspection** and **rework** stations with defect tracking for layups, laminates and modules
- › **Packaging and sorting** station

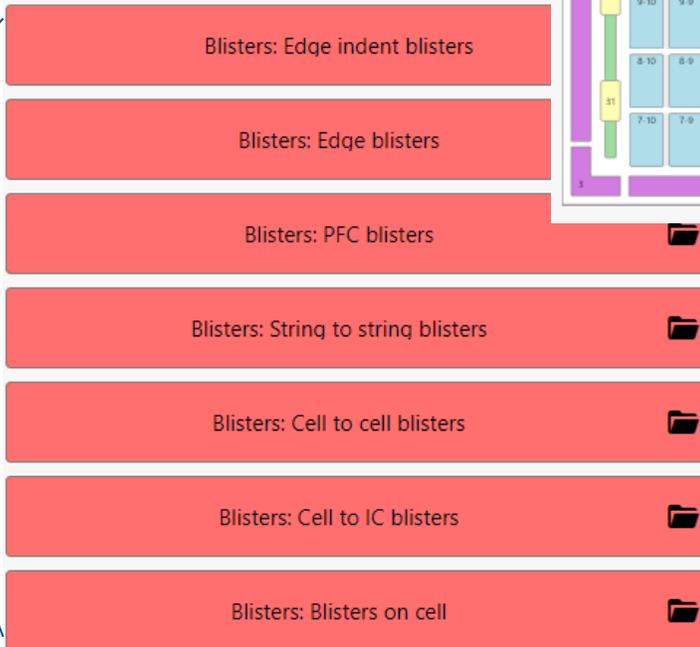
Defect Tracking

Configurable Inspection and Rework Station

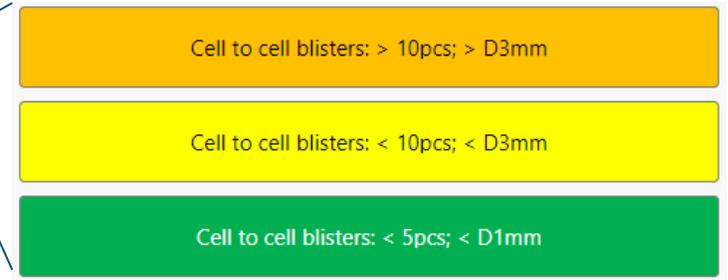
Component level

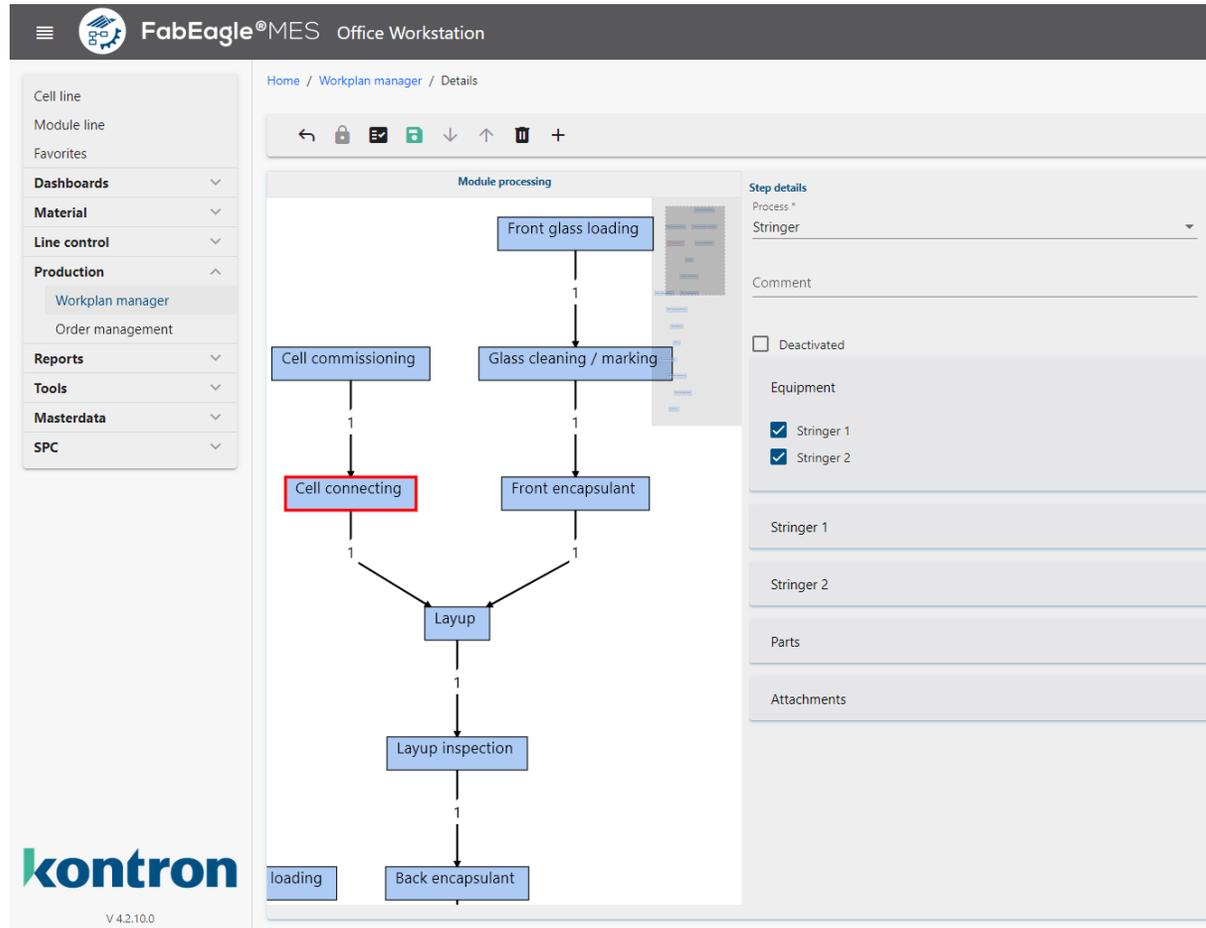


Defect group

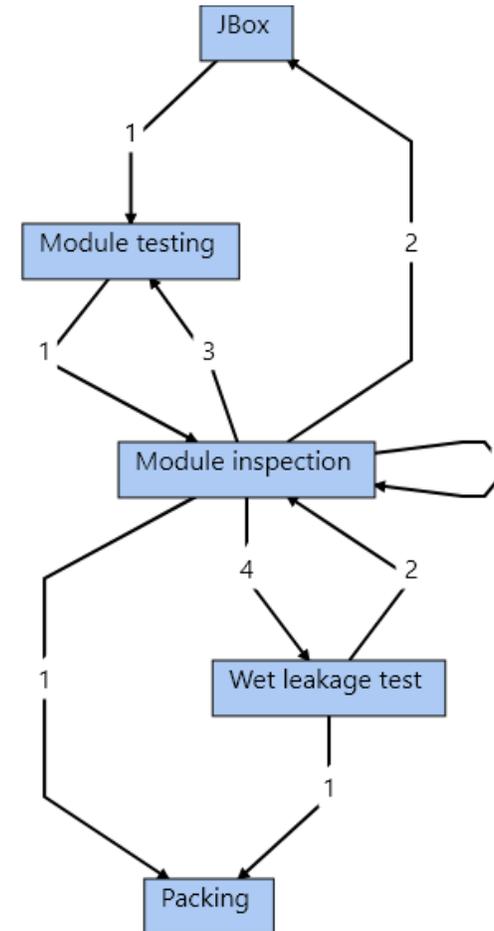
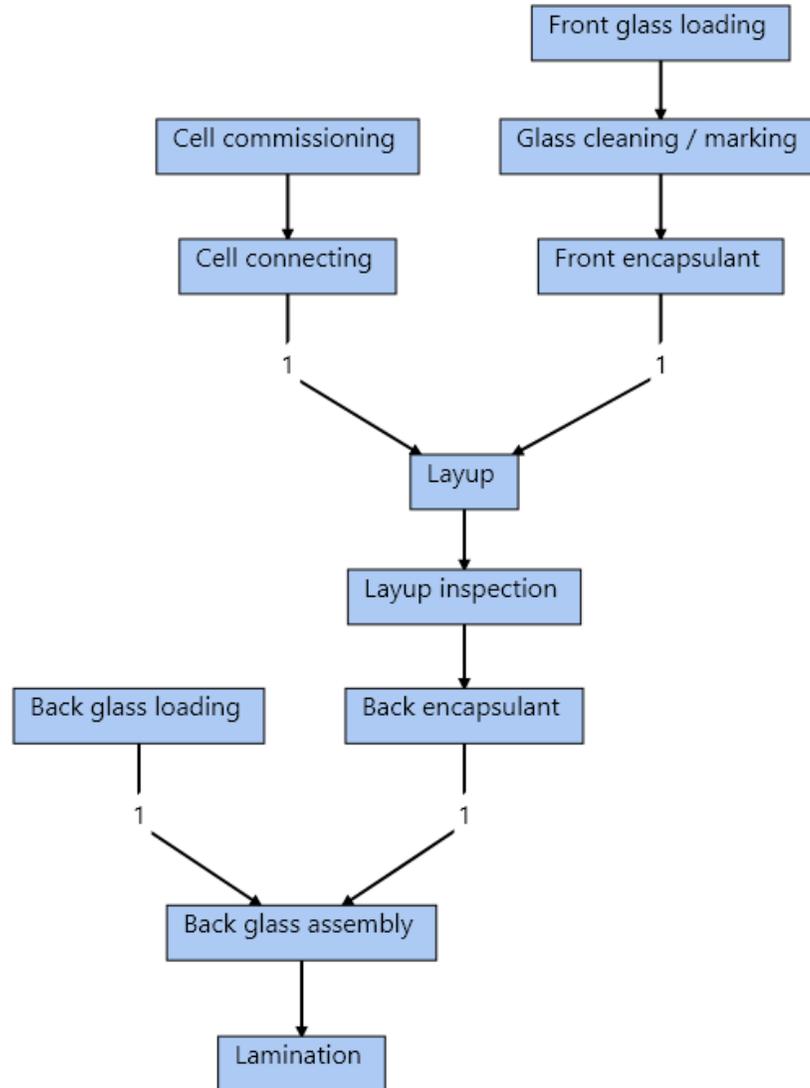


Defect code





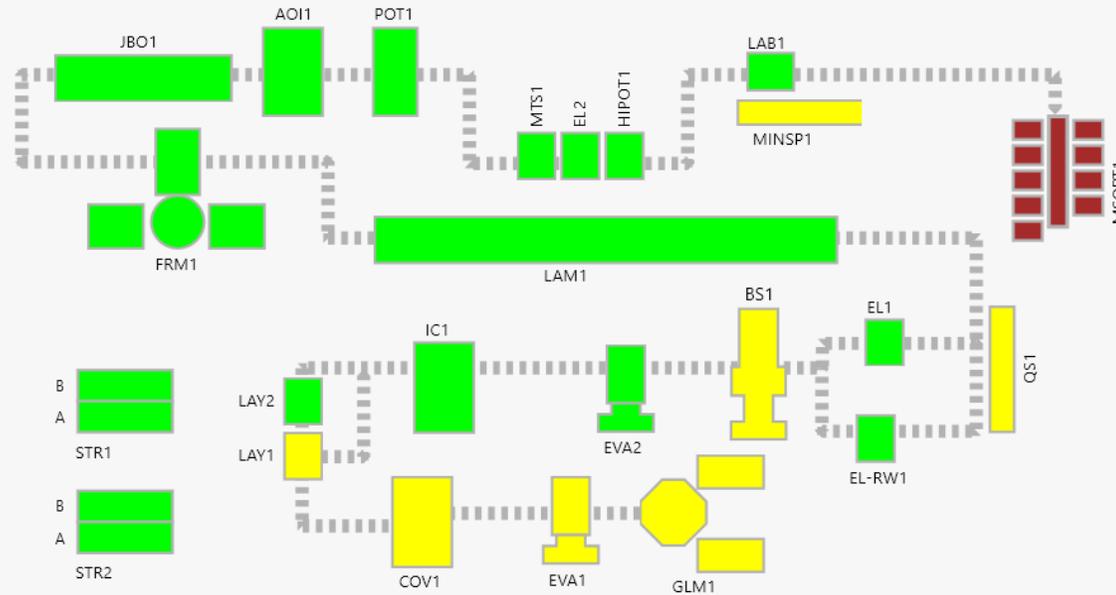
- › Configure your workflow graphically
- › Use it as a template for product variants
- › Setup bill of material (BOM)
- › Select recipes and equipment parameters
- › Setup alternative material routes based on state or process data of material
- › Configure rework loops to route material back to previous work steps



- › Branching
- › Merging
- › Rework Loops

- Cell line
- Module line
- Favorites
- Dashboards** ▾
- Material** ▾
- Line control** ▾
- Production** ▸
 - Workplan manager
 - Order management
- Reports** ▾
- Tools** ▾
- Masterdata** ▾
- SPC** ▾

Home / Module line



Machine states

- Productive
- Standby
- Engineering
- Scheduled Down
- Unscheduled Down
- Non Scheduled
- No Communication

+

Reset

-

Cyclotime [s] (updated 21:12)

	Frontend					Backend				
	GLM1	BS1	EVA1	LAY1	LAY2	FRM1	AOI1	MTS1	LAB1	MSORT1
Cycle time (target) [s]	20	20	20	20	20	20	20	20	20	20
Cycle time (current shift) [s]	19	20	18	21	18	19	18	21	19	18
Cycle time (last shift) [s]	18	21	19	18	18	18	18	18	20	21

Shift information

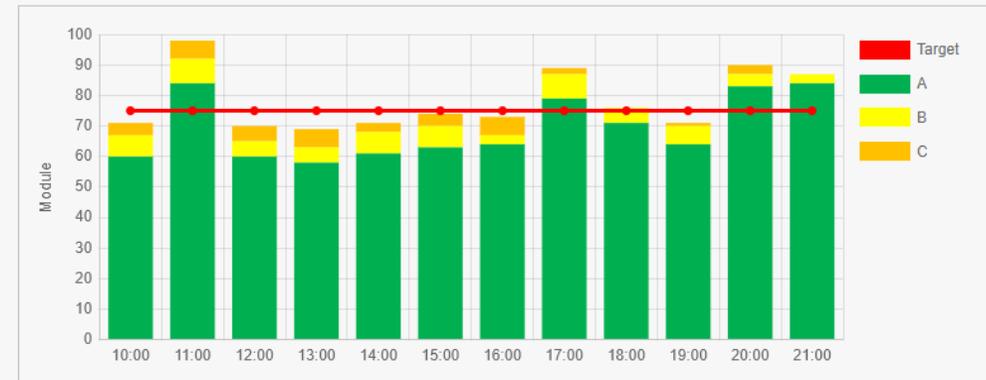
Current shift						
Target	600	Class	A	B	C	Scrap
Actual	432	Amount	346	72	12	2
Trend	610	[%]	80.01	16.05	0.03	0.01

Shift	Begin	End	Actual	Target
Morning shift	10/22/2025 6:00 AM	10/22/2025 2:00 PM	432	600
Night shift	10/21/2025 10:00 PM	10/21/2025 6:00 AM	605	600
Late shift	10/21/2025 2:00 PM	10/21/2025 10:00 PM	512	600

Active production orders

Production order	Plan	Remaining	Ratio	State
Module processing	100000	99940	1:2	OK

Produced modules within the last hours



Online Process Monitoring with Control Charts (SPC)

FabEagle®MES Office Workstation

Home / SPC / Rule charts overview

Name ↑	Chart type	Depends on product	Active	Process
Temperature actual value FF zone 1	XM-Karte	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Fast Firing
Temperature actual value FF zone 2	XM-Karte	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Temperature actual value FF zone 3	XM-Karte	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Temperature actual value FF zone 4	XM-Karte	<input type="checkbox"/>	<input checked="" type="checkbox"/>	

- › Configure charts
- › Monitor violations
- › Trigger actions

Edit spc chart 'Temperature actual value FF zone 1'

Chart type	Equipment	Process	Depends on product	Measurement value one	Measurement value two
XM-Karte	Horizontal Drying Oven - Fast Firing 1	Fast Firing	No	Temperature actual value FF zone 1 [°C]	Temperature actual value FF zone 1 [°C]

Basic data | Measurement values | Limits | **Rules** | Actions

Number	Description	Track XM
R1	1 value < lower limit 3 or one value > upper limit 3	RG1-XM
R2	2 of 3 consecutive values < lower limit 2 or > upper limit 2	RG2-XM
		RG3-XM
		RG4-XM
		<Off>

Cancel Submit

- › Chart types
 - › XM
 - › X/MR
 - › WWMA
 - › MOSUM
 - › CUSUM
 - › XM/S

Control chart	Equipment	Track	Rule 1	Rule 2	Rule 3	Rule 4
Temperature actual value FF zone 1	HTO-FF1	XM	✓	✓	✓	✓
Temperature actual value FF zone 2	HTO-FF1	XM	✓	✓	⚠	✓
Temperature actual value FF zone 3	HTO-FF1	XM	⚠	⚠	⚠	⚠
Temperature actual value FF zone 4	HTO-FF1	XM	✓	✓	⚠	⚠



- Cell line
- Module line
- Favorites
- Dashboards**
- Material**
 - Material
 - Transport container
 - Bin
 - Process container
 - Packaging lot

- Line control**
- Production**
 - Workplan manager
 - Order management

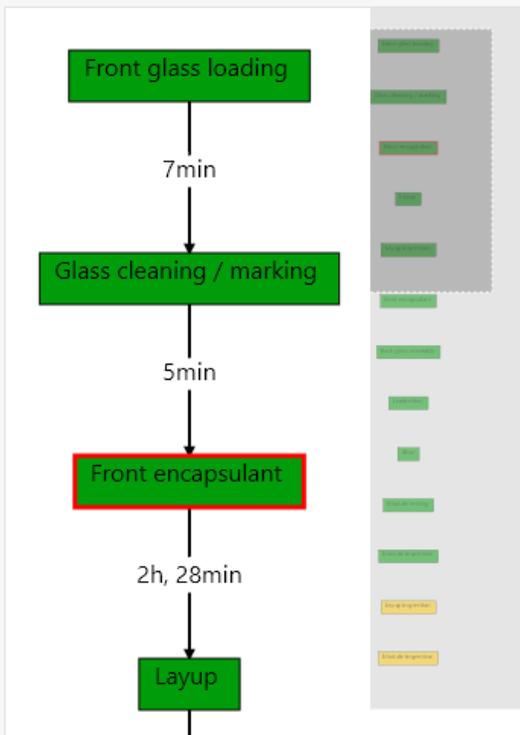
- Reports**
- Tools**
- Masterdata**
- SPC**

Home / Material / M250002

Masterdata

Material	M250002	Container	Product number	Module	Production order	Module processing
Work step	Module inspection	Slot	Product	Module	Work plan	Module processing

Material history



Material history

Show data for selected step
 Show all history entries of type process
 Show all history entries
 Data loaded at 10/22/2025 10:30:30 PM

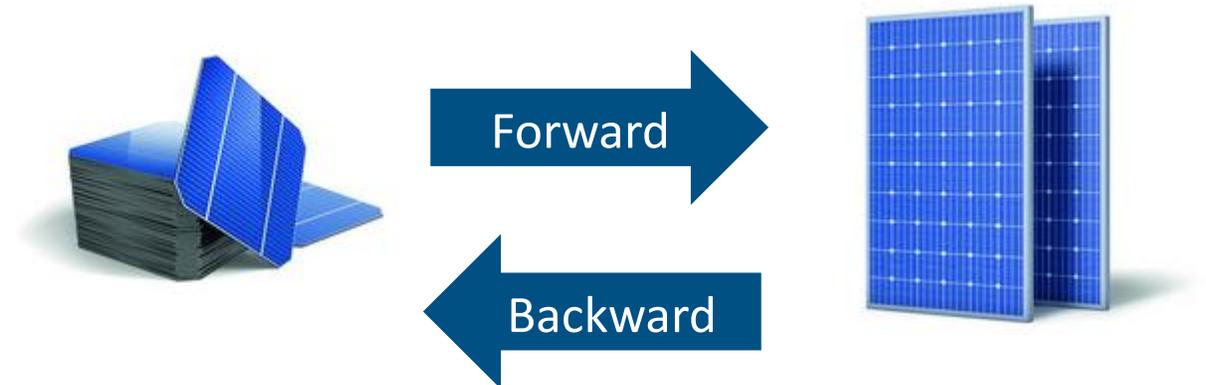
Process	EVA1 Layup	Production order	Module processing	Received	
Timestamp	7/21/2025 12:33:00 AM	Tracking type	Process	Load	
Operator		Work step	Front encapsulant	Process start	7/21/2025 12:31:00 AM
Position	EVA11	Product (Material)	Module	Process end	7/21/2025 12:33:00 AM
Container		Product (Production order)	Module	Unload	
Slot		Classification		Removed	
Comment					

Process	Matrix Layup	Production order	Module processing	Received	
Timestamp	7/21/2025 3:08:00 AM	Tracking type	Process	Load	
Operator		Work step	Layup	Process start	7/21/2025 3:01:00 AM
Position	LAY1	Product (Material)	Module	Process end	7/21/2025 3:08:00 AM
Container		Product (Production order)	Module	Unload	
Slot		Classification		Removed	

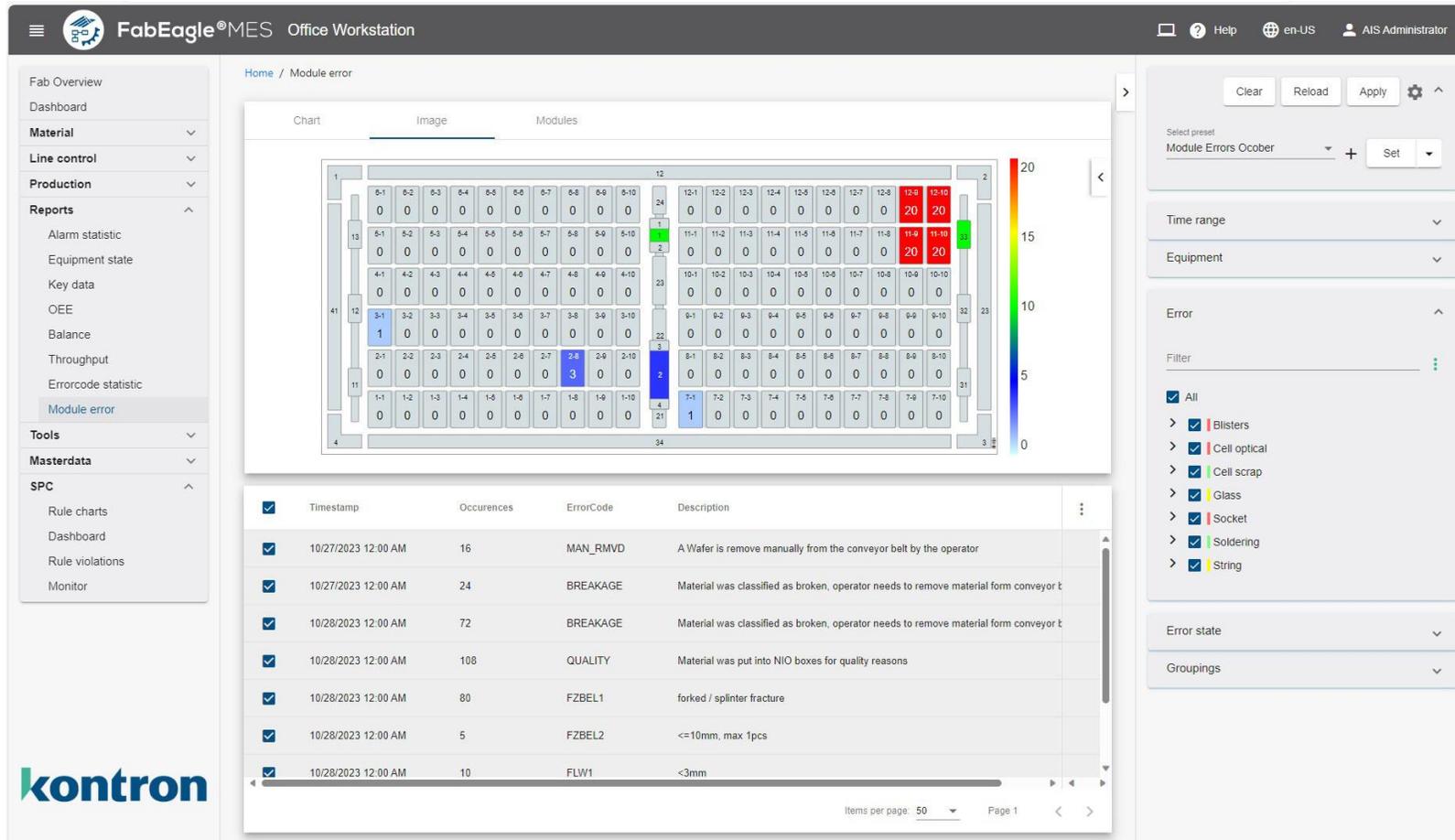


Material Genealogy – Forward and Backward

Children of material/charge	Parents of material/charge
Name M250003	Name LFH-B6W6-YVFD
<ul style="list-style-type: none">▼ M250003<ul style="list-style-type: none">> TJA-JZGL-ZG5B (EVAFoil1)> D4L-IMXQ-0P7K (Wire)MI9-90KD-96EB (EVAFoil2)> LFH-B6W6-YVFD (JBox)	<ul style="list-style-type: none">▼ LFH-B6W6-YVFD<ul style="list-style-type: none">> M250001 (Module)> M250002 (Module)> M250003 (Module)> M250004 (Module)> M250005 (Module)> M250006 (Module)> M250007 (Module)> M250008 (Module)> M250009 (Module)> M250010 (Module)> M250011 (Module)> M250012 (Module)> M250013 (Module)> M250014 (Module)> M250015 (Module)> M250016 (Module)> M250017 (Module)> M250018 (Module)> M250019 (Module)> M250020 (Module)
Details	
Material/Charge: MI9-90KD-96EB	
Article: EVAFoil 2	
Article number: EVAFoil2	
Article group: EVA foil 2	
Process: EVA2 Layup	
Timestamp: 21.7.2025, 08:02:00	
Position:	

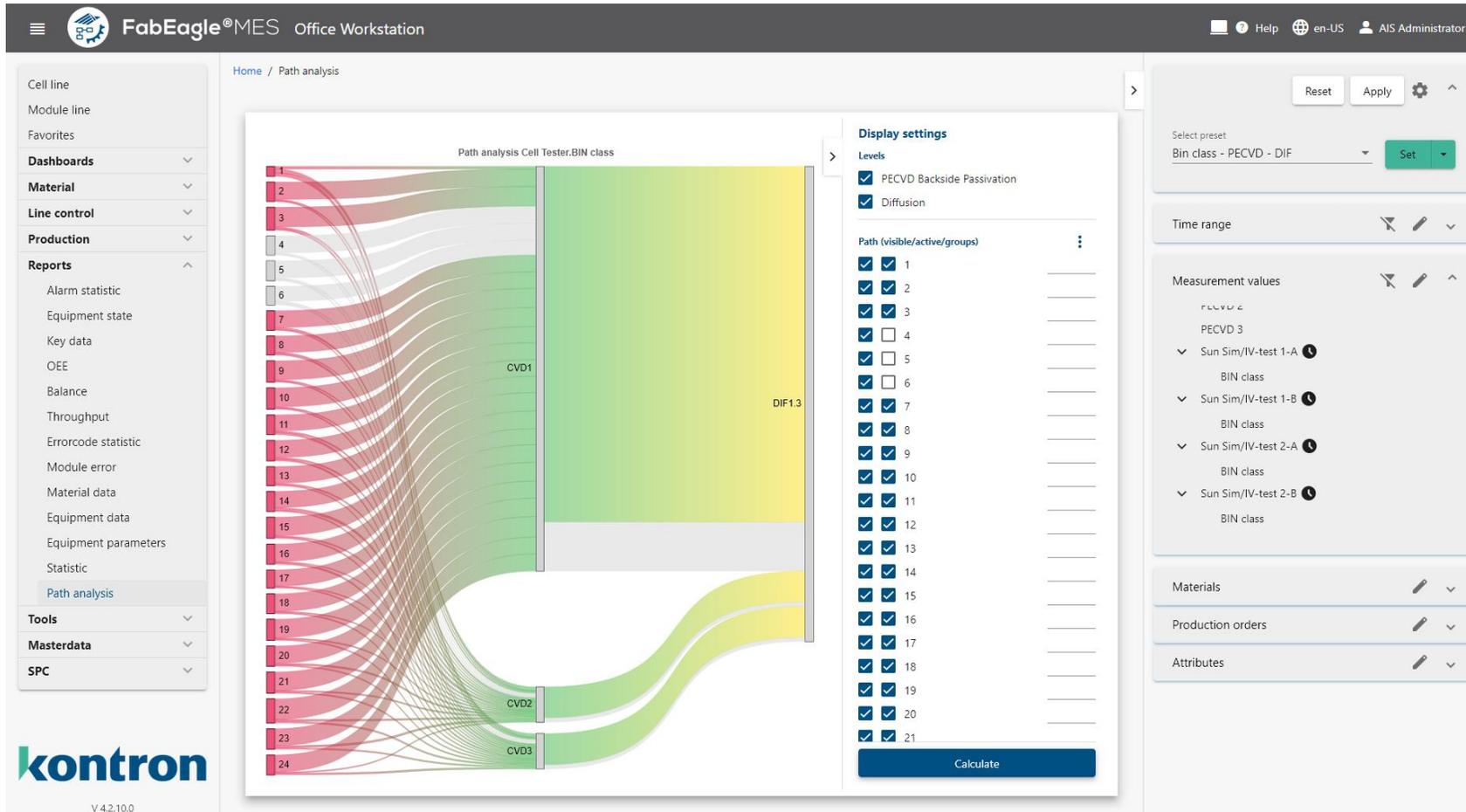


Module Defect Reporting



- › Defect reporting on cell and string level
- › Heat map reporting by location, defect code and number of occurrences

Path Analysis Based on Trace Data

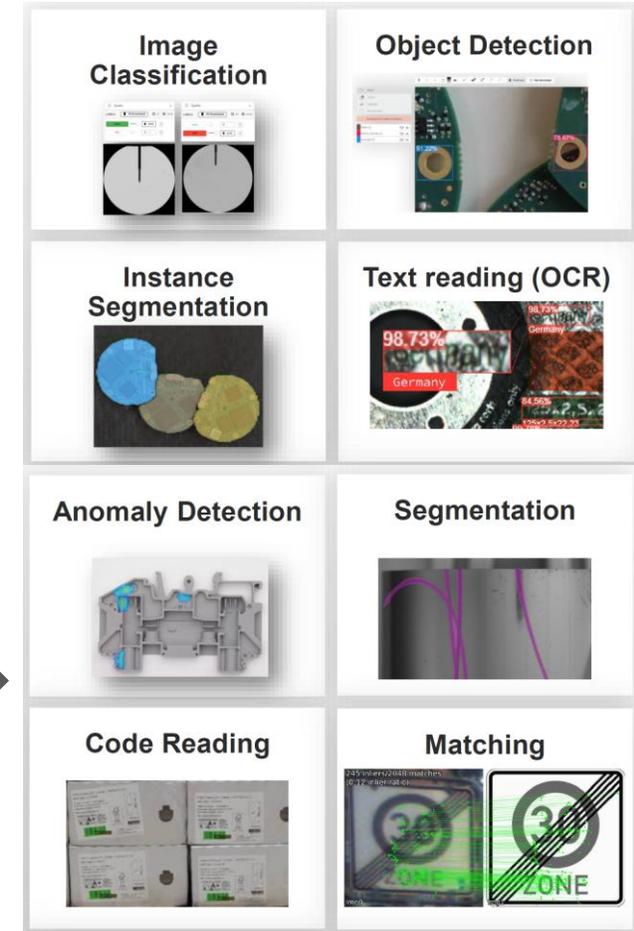
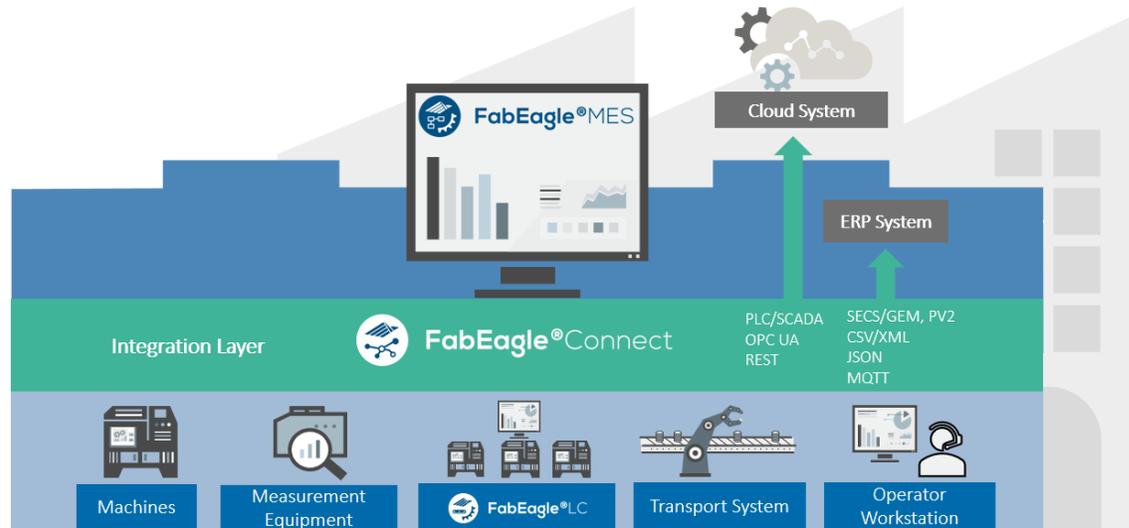


- › Configure path analysis for certain processes
- › Identify visually the source of defects

Vision AI integration

Embedding Artificial Intelligence (AI) capabilities into MES

- › Cameras are directly connected to MES
- › Image processing used as virtual (Software-) measurement device
- › Common data handling for process control and reporting within MES



Opportunities with Digital Twins

From Connected Fabs to Smart Fabrication

Empirical digital twin [1,2]

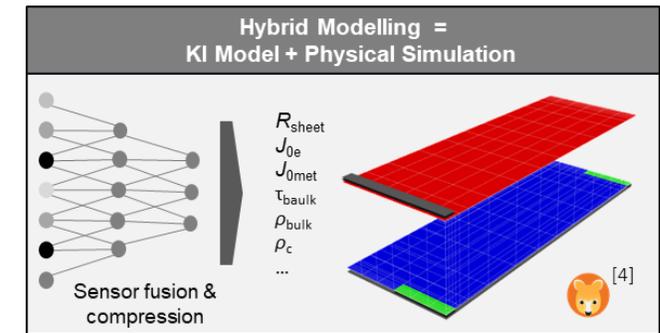
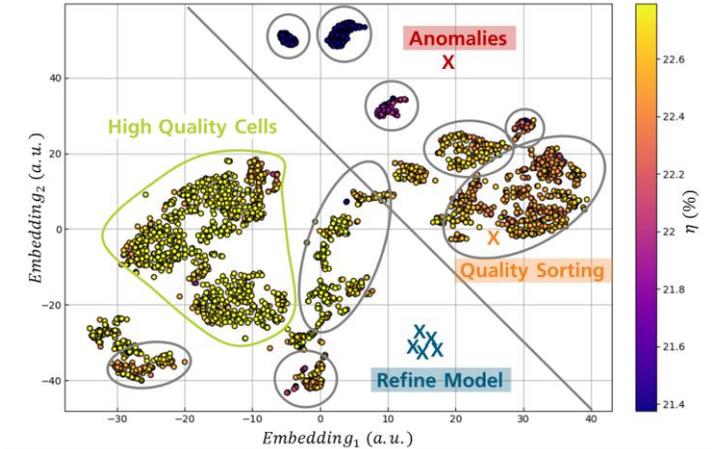
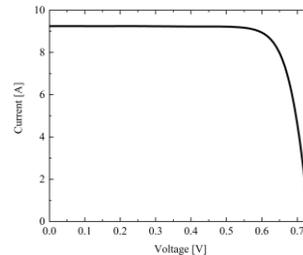
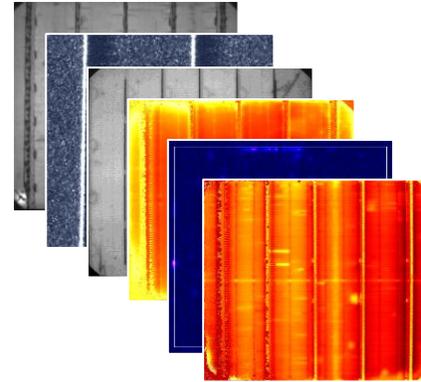
- › Trained with all inline and quality data
- › Describes the state of the solar cell
- › Quantifying defects and data patterns with impact to cell quality

→ For fast quality analysis

Physically interpretable digital twin [3]

- › Based on physics-informed deep learning
- › Predicts latent parameters, inaccessible by direct measurements
- › Fast loss analysis and potential analysis

→ For fast loss and potential analysis



Summary



FabEagle®MES

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Kontron AIS GmbH



Transparency

- › Online Process Visualization
- › Production Visualization
- › Trends and Reporting
- › Online-SPC



Traceability

- › Material and Carrier Tracking
- › Inspection and Rework
- › Quality Data Acquisition
- › Long-term Archiving



Production Control

- › Production Orders
- › Workflows
- › Event Management
- › Production Logistics

Your Questions

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