PDF / SOLUTIONS®

2025 Users Conference

Manufacturing Data Analytics

for Fab and Advanced Packaging

Jon Holt

December 4, 2025

AGENDA

- **PDF** – New Features & Roadmap for Fab and Advanced Pkg – Jon Holt
- **Intel** – Leveraging PDF Exensio for Intel Advanced Packaging and Test- Syed Baquar
- **onsemi** – Accelerating Analytics at onsemi - Tom Grein
- **UCSB** – Lab to Fab Solutions - Brian Thibeault
- **ams OSRAM** – Scaling Yield Intelligence - Ahmad Abdel Majeed
- **ALL** panel – ***Manufacturing Transformation Challenges***

01.

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New Features & Roadmap

For Fabs and Advanced Packaging

PDF Platform Objectives & Industry Needs

For Semiconductor Fabs and Advanced Packaging

Scalable solutions for AI growth, 3D & materials complexity, and collaboration

SCALE & PERFORMANCE

Real-time, clean, aligned manufacturing data for AI-driven transformation

DATA INTELLIGENCE

Connectivity, security, and collaboration via a neutral industry platform

SECURITY & TRUST

We are laser focused on these top priorities!

PDF/SOLUTIONS® Open Platform for Smart Manufacturing

Trust, Security, Scalability Across The Entire Platform

ModelOps and AI Applications

Align, Enrich, Integrate Data

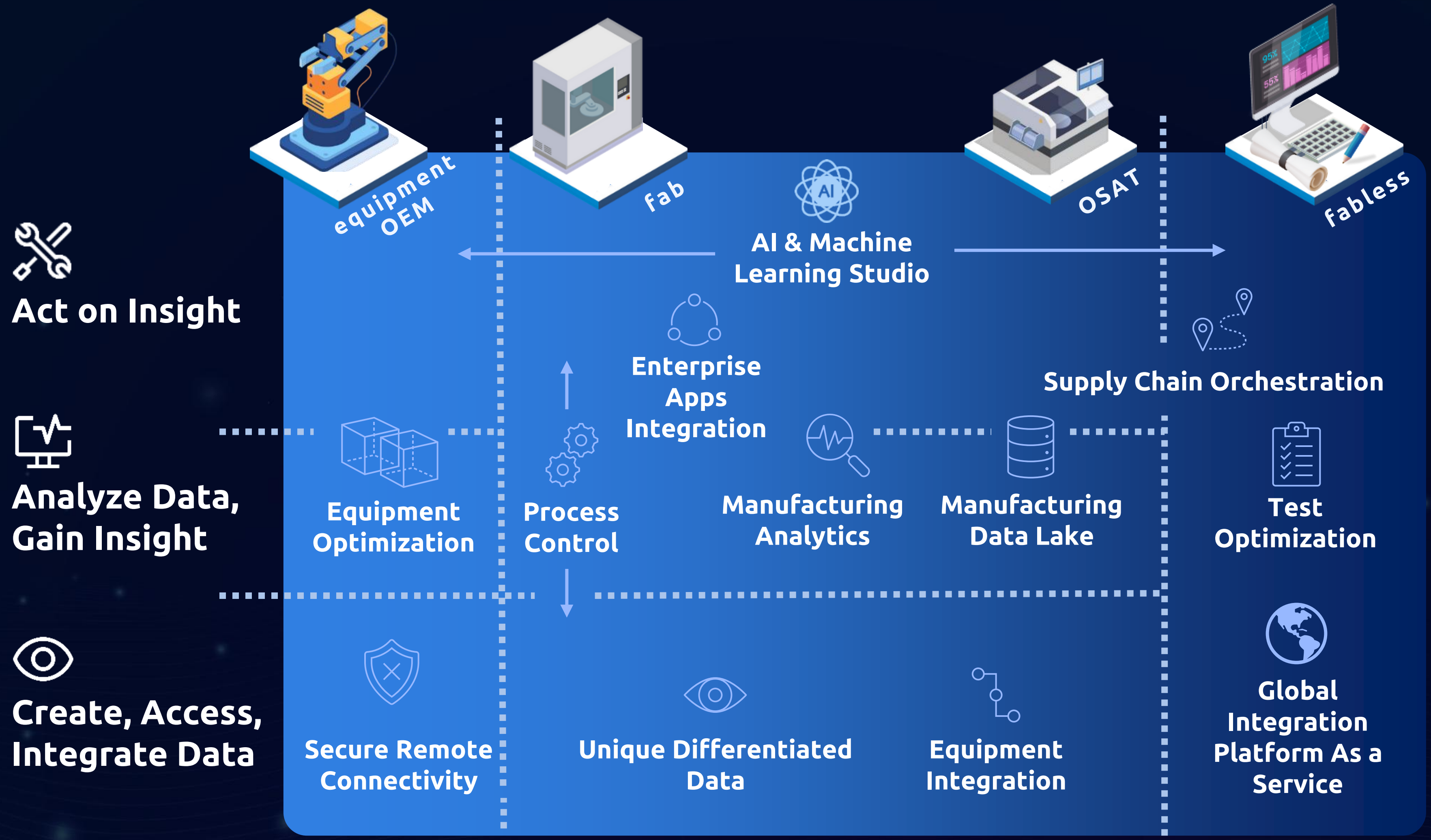
Monitor, Measure, Control, Execute

Create Unique Data

Integrate Across Equipment, Process and Supply Chain

- **Partner Integration and Apps**
- **Customer Apps**
- **Third Party Apps**

Mission Critical Analytics Platform for the Semi Industry



equipment OEM

fab

OSAT

fabless

Act on Insight

Analyze Data, Gain Insight

Create, Access, Integrate Data

AI & Machine Learning Studio

Enterprise Apps Integration

Supply Chain Orchestration

Equipment Optimization

Process Control

Manufacturing Analytics

Manufacturing Data Lake

Test Optimization

Secure Remote Connectivity

Unique Differentiated Data

Equipment Integration

Global Integration Platform As a Service

Single platform to ***Access*** *&* ***Analyze*** *data, and create* ***Insights-based Actions*** *across the entire semiconductor ecosystem*

New Products & Capabilities Released in 2025

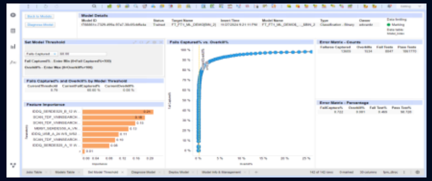
Highlights of KEY Features and Products for Fabs and Advanced Packaging

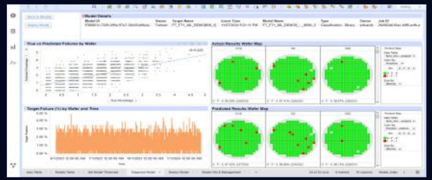
1. Sapience Supply Chain Solutions	Enterprise end to end data pipeline - connect anything to anything
2. Exensio ModelOPS	ML pipeline, Dynamic Compute, and predictive modeling (inference)
3. PDF & Partner AI Solutions	Lavorro: Maintenance Virtual Assist, Robovision: Exensio Vision Intelligence
4. Compound Semi (SiC) Solutions	Complex wafer-ID mapping and solutions
5. Big Data API	Kubernetes based, source & target (RW) capabilities, 3rd party app support
6. FDC Features & Products	Enhanced performance, multi source data acquisition (DAQ), Bulk Strategy Manager, and digital twin applications
7. Zero Trust Security	Fully encrypted end-to-end data, Zero CVE technical debt, automated SSO and RBAC integration, and secureWISE remote access

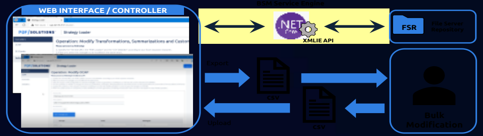
1 **Connect, transform, manage, & orchestrate** MES & Manufacturing/OSAT data

2 **NEW PRODUCT** - Communicate & control your supply chain through a **unified platform**

3 Achieve **data persistence** with built-in business/finance models, applications, and analytics solutions







LEAD WITH INDUSTRY STANDARDS

SEMI INDUSTRY
Eg, E187, 188, 190, 191
Chair 10 committees

CYBERSECURITY
SOC2
ISO27001
NIS2
CRA
SOX
end to end zero trust approach

ENTERPRISE READINESS

ENTERPRISE APPLICATIONS INTEGRATION
MES, PLM, ERP, SCM

Petabytes
of cloud-managed data
Exabytes
Ready data exchange

99.9%
uptime across all 8 regions

24/7
global support

Manufacturing & Supply Chain Solutions

🟢 New Product

🔵 Mature (multiple customers)

PDF provides a unified automated system to manage and monitor the communication & control of your end-to-end supply chain for logistics, engineering, cost, & quality improvement.

Multiple Supplier/Fab/OSAT MES's

MES 1 | MES 2 | MES 3

Factory 1 | Factory 2 | OSAT

1 connect, transform, manage data

secureWISE

PDF/SOLUTIONS

2 supplier alignment platform

secureWISE

3 connect, align, store, analyze data

PLM | ERP | YMS

Business & Finance Applications

1 **Connect, transform, manage, & orchestrate** MES & Manufacturing/OSAT data

- Integration framework supporting system-agnostic connectivity and ETL workflows
- Safe & secure data exchange pipeline
- Business Rules
- Orchestrations
- Data Governance

Sapience Manufacturing Hub

2 **NEW PRODUCT -** Communicate & control your supply chain through a **unified platform**

- Manufacturing & Test Governance
- Supplier Collaboration & Management
- WIP & Quality – Regular tracking & management
- Cross System Alignment (ERP, PLM, YMS)

sapience Supply Chain Hub

3 Achieve **data persistence** with built-in business/finance models, applications, and analytics solutions

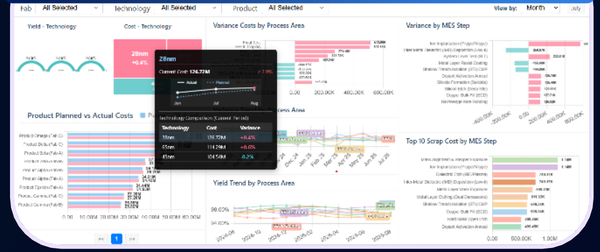
- ERP, PLM Applications
- YMS & AI Applications
- Business Rules
- Persistent manufacturing data source for data lakes
- MES to ERP mapping
- Lot movement alarm / rules & dashboards

exensio

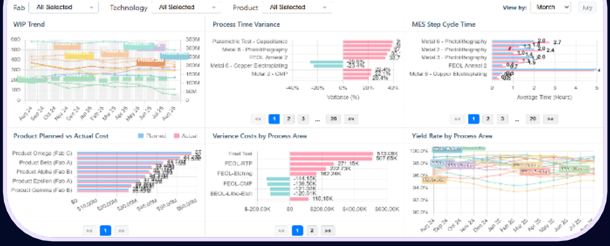
Sapience Manufacturing Hub Enterprise

Supply Chain Solutions – Operational Product Costing

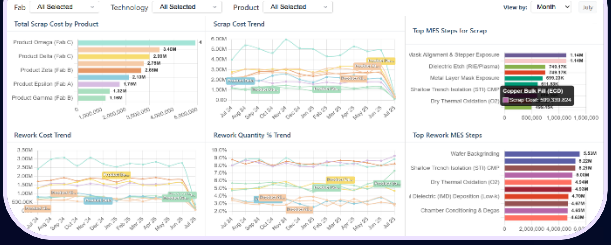
Enterprise Costs Overview



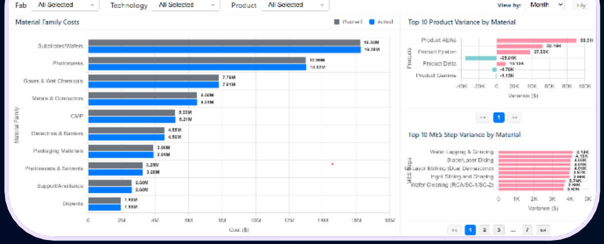
Manufacturing Costs



Quality Cost Impacts



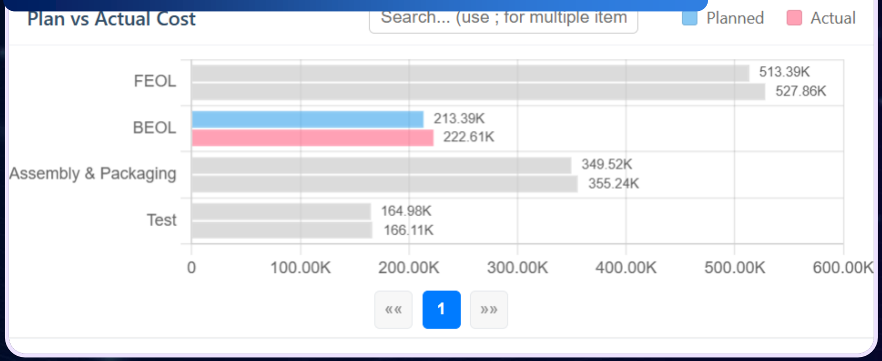
Material Cost Variances



- Gain enterprise-wide **cost visibility**
- **Trace** semiconductor-specific **cost variances**
- Target **high-impact changes** to optimize COGM
- Analyze **material-driven** cost deviations

Identify overestimated plan costs and adjust standard costs for more accurate Cost of Goods Manufactured (COGM)

Cost Segment Root Cause Analysis



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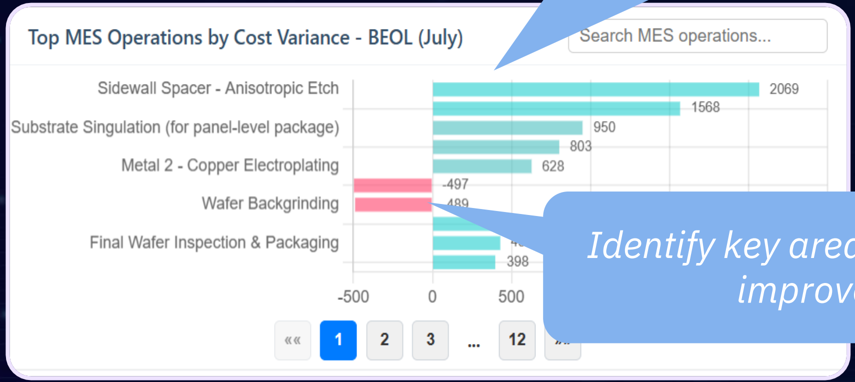
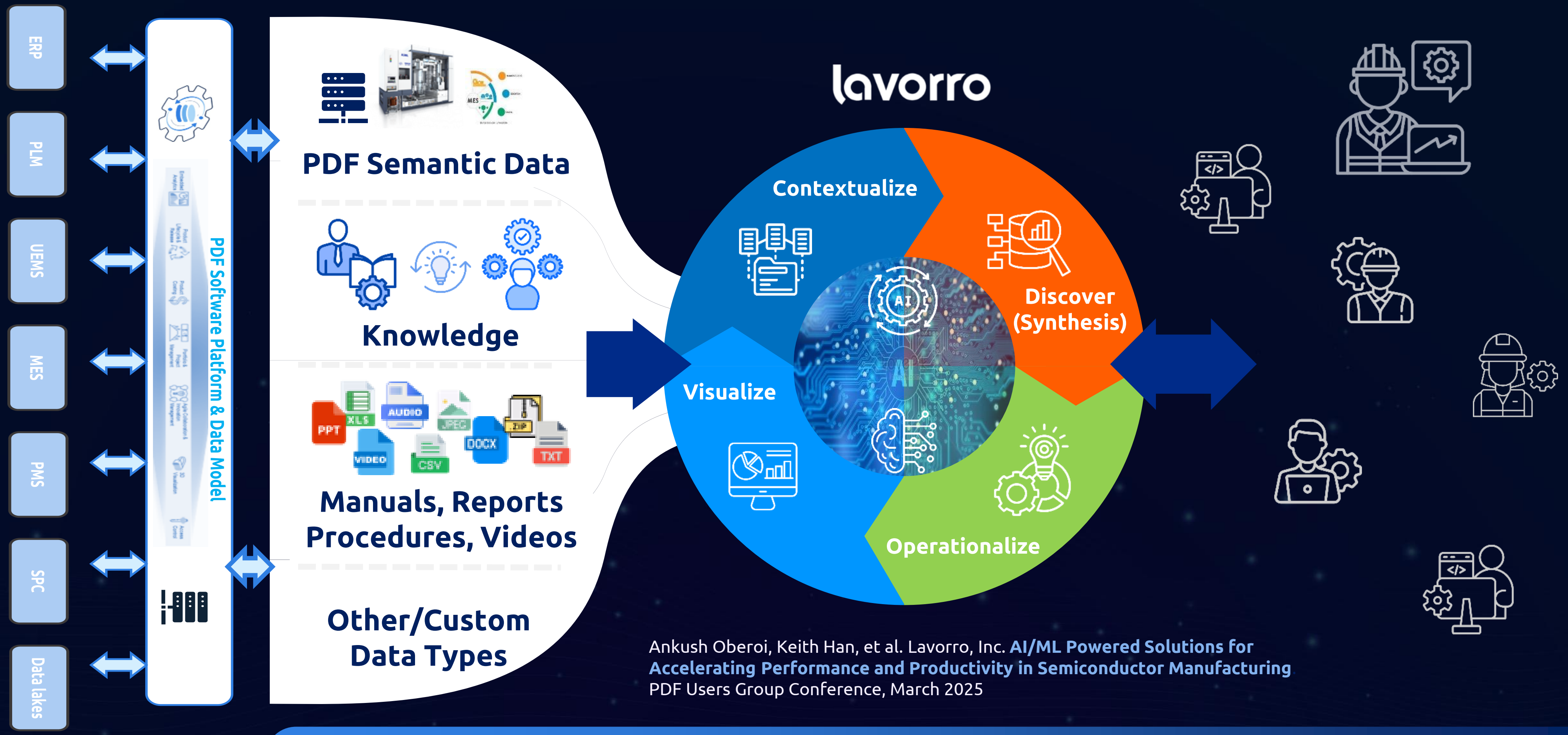


Identify key areas of operational improvements

PDF Platform & Lavorro Maintenance Virtual Assistant



ERP

PLM

UEMS

MES

PMS

SPC

Data lakes

PDF Software Platform & Data Model

PDF Semantic Data

Knowledge

Manuals, Reports Procedures, Videos

Other/Custom Data Types

lavorro

Contextualize

Discover (Synthesis)

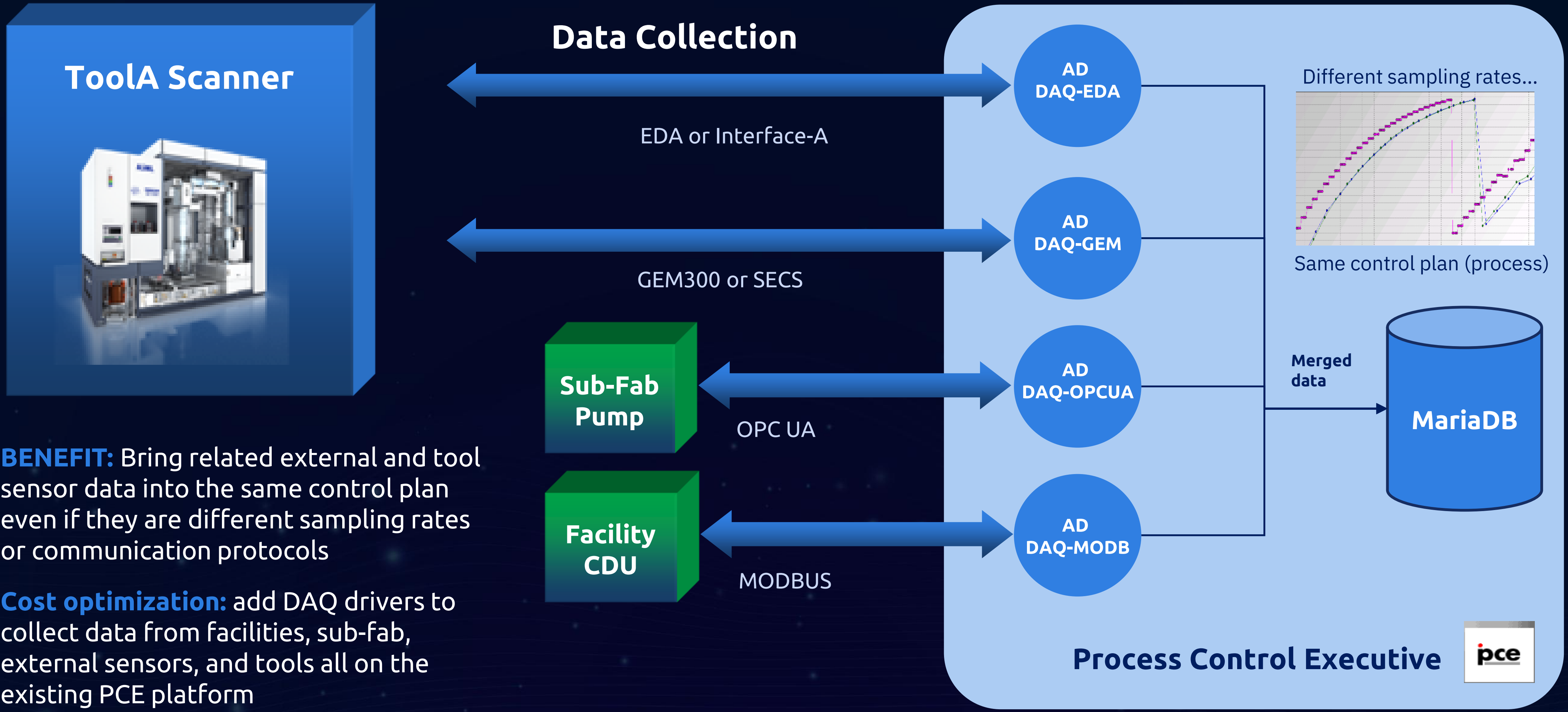
Visualize

Operationalize

Ankush Oberoi, Keith Han, et al. Lavorro, Inc. **AI/ML Powered Solutions for Accelerating Performance and Productivity in Semiconductor Manufacturing**
PDF Users Group Conference, March 2025

Focus your time on achieving results, not data integration and management

Multi-standard & Sensor FDC Data Acquisition (DAQ)



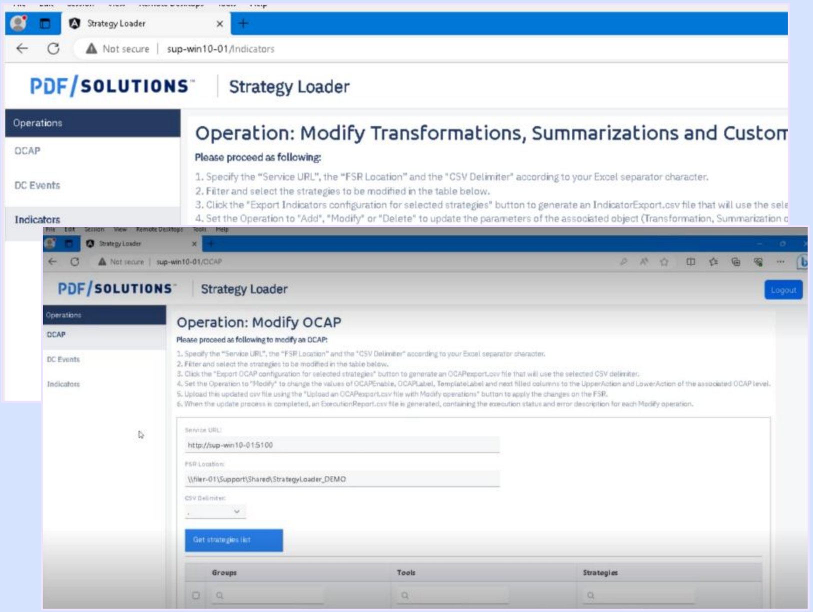
BENEFIT: Bring related external and tool sensor data into the same control plan even if they are different sampling rates or communication protocols

Cost optimization: add DAQ drivers to collect data from facilities, sub-fab, external sensors, and tools all on the existing PCE platform

Bulk Strategy Manager (BSM) Overview

What does it do? Allows bulk creation/copy/modify of FDC strategies which reduces maintenance and implementation time by up to **10X** for new and existing equipment, processes, and control plans

WEB INTERFACE / CONTROLLER



Operation: Modify Transformations, Summarizations and Custom

Please proceed as following:

1. Specify the "Service URL", the "FSR Location" and the "CSV Delimiter" according to your Excel separator character.
2. Filter and select the strategies to be modified in the table below.
3. Click the "Export Indicators configuration for selected strategies" button to generate an IndicatorExport.csv file that will use the sele
4. Set the Operation to "Add", "Modify" or "Delete" to update the parameters of the associated object (Transformation, Summarization c

Operation: Modify OCAP

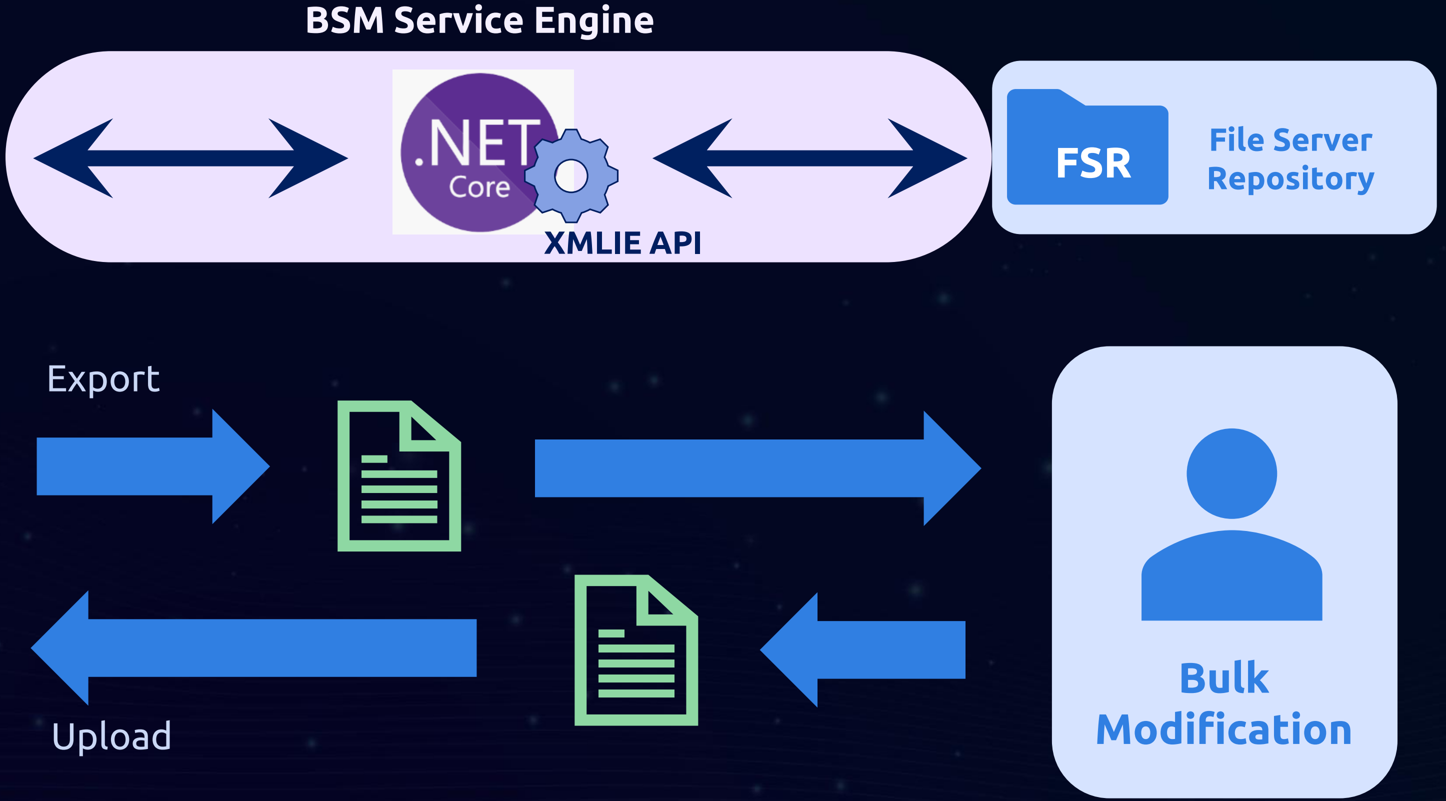
Please proceed as following to modify an OCAP:

1. Specify the "Service URL", the "FSR Location" and the "CSV Delimiter" according to your Excel separator character.
2. Filter and select the strategies to be modified in the table below.
3. Click the "Export OCAP configuration for selected strategies" button to generate an OCAPexport.csv file that will use the selected CSV delimiter.
4. Set the Operation to "Modify" to change the values of OCAPEnable, OCAPLabel, TemplateLabel and next filled columns to the UpperAction and LowerAction of the associated OCAP level.
5. Upload this updated csv file using the "Upload an OCAPexport.csv file with Modify operations" button to apply the changes on the FSR.
6. When the update process is completed, an ExecutionReport.csv file is generated, containing the execution status and error description for each Modify operation.

Service URL: http://sup-win10-01:5100

FSR Location: \\filer-01\Support\Shared\StrategyLoader_DEMO

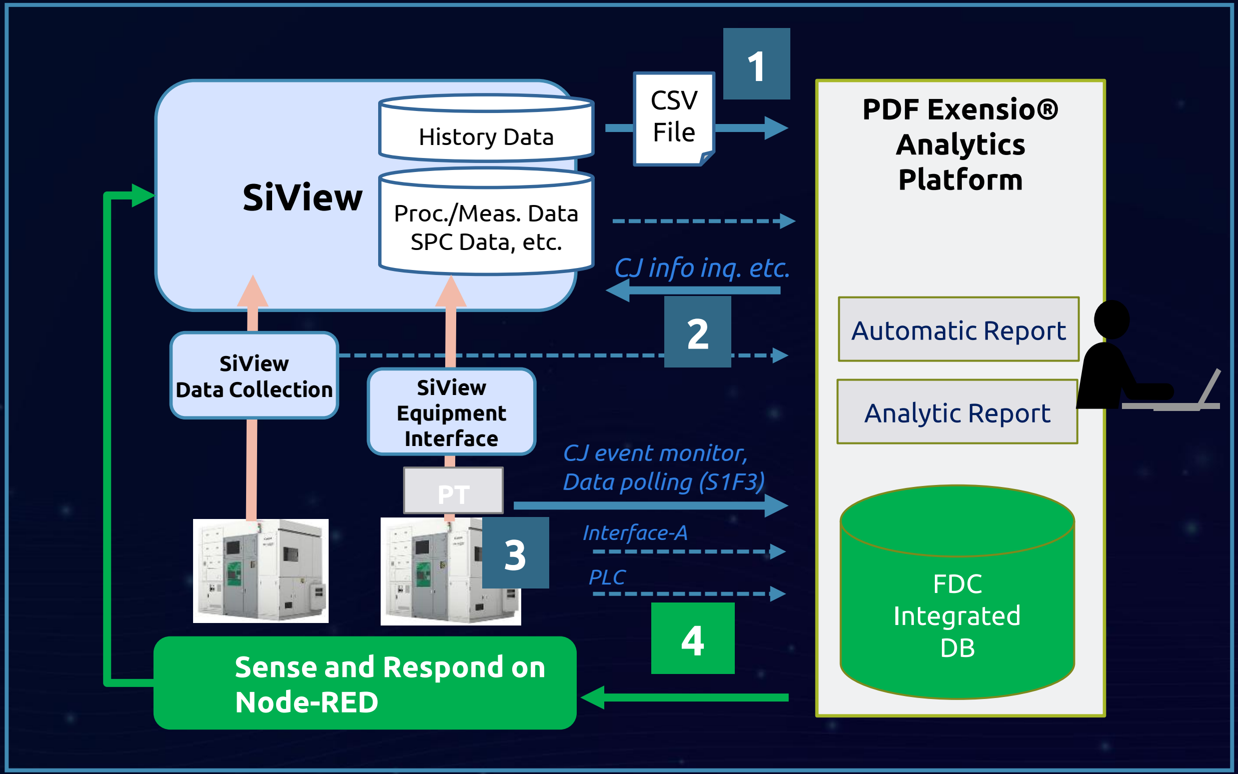
CSV Delimiter: ,



PDF Exensio & SiView integration with SaR

- SaR (Sense and Respond) is an IBM SiView solution for event-driven workflow automation for complicated scenarios
- Fab users can author workflows on SaR by themselves to meet their requirements
- IBM and PDF collaborated to develop the integration between SaR and Exensio as out-of-box

Integration Architecture



1 **Provide SiView History**
- Lot Operation, Wafer-Chamber in tools
- Export as CSV files

2 **Access to SiView MM API**
- PDF calls SiView MM API (REST/SOAP) for online data

3 **FDC data capture**
- Deploy PDF's Path-Through (PT) module in SiView Equipment Interface server for system availability and maintainability

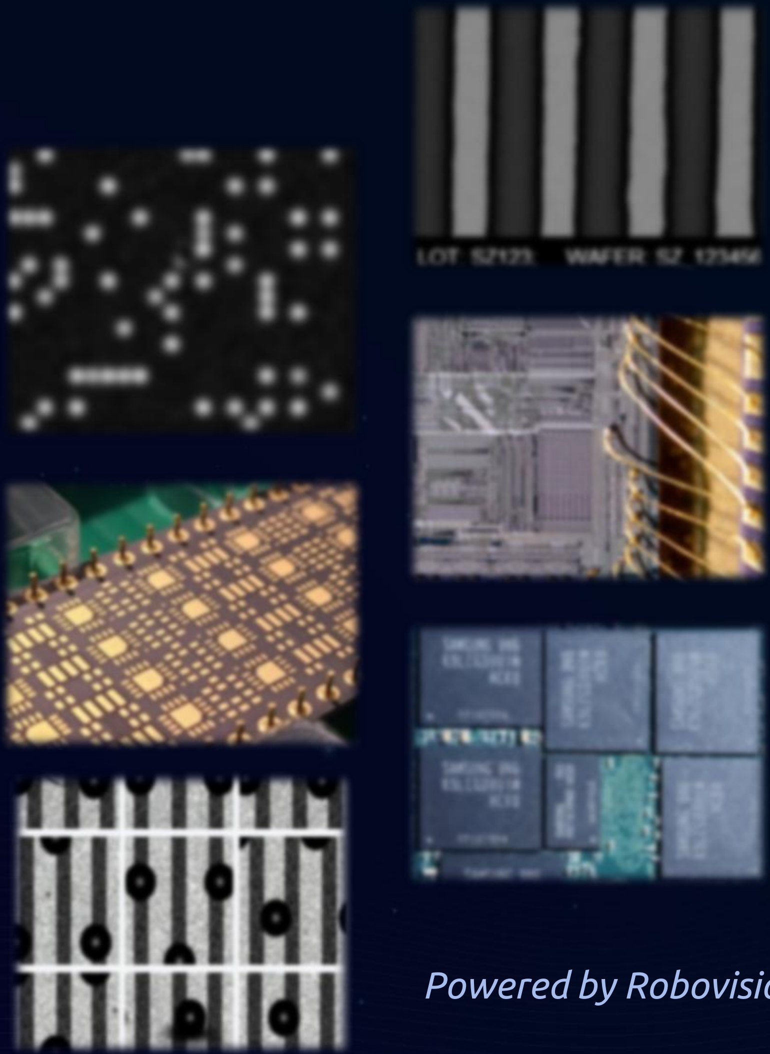
4 **Business Event Source for SaR**
- Business Event (e.g. Warning or Violation of monitored index, etc)

Exensio® Vision Intelligence (E-VI)* Summary

Problem: Semiconductor manufacturers face growing complexity in defect detection and quality control. Legacy systems: rule-based vision, ADR, ADC & AOI tools, and manual inspection—fail to scale across tools, SKUs, and defect variability.

Solution:

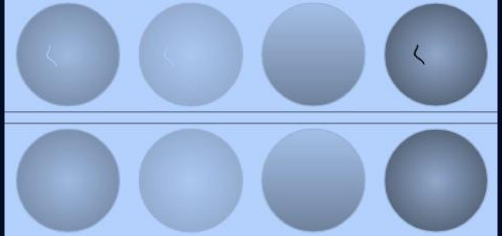
- ✓ Vision AI promises rapid, consistent, scalable cost-efficient inspection of substrates, wafers, die, modules - far beyond human vision.
- ✓ Exensio® Vision Intelligence (E-VI)* augments the established Manufacturing Analytics platform by combining image data across all operations with any other data end-to-end.
- ✓ Adopting the platform enables cost reduction, reduces revenue lost through equipment downtime reduction, provides higher yield predictability and high yield learning ramp up.

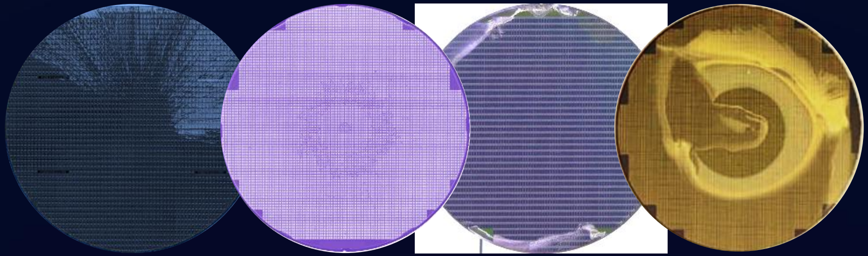


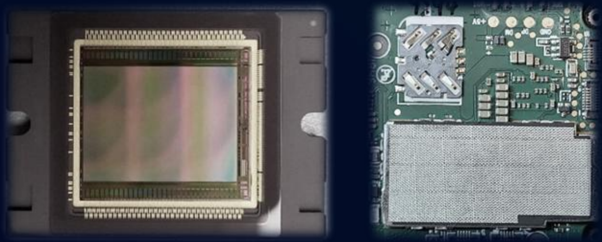
Powered by Robovision

Single Platform for Enterprise-Wide Deployment

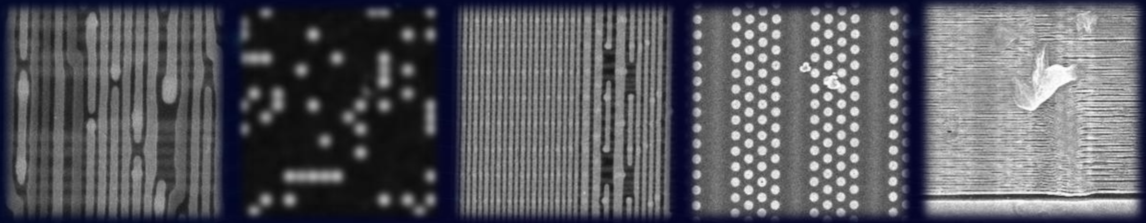
Vision Intelligence across all areas of manufacturing

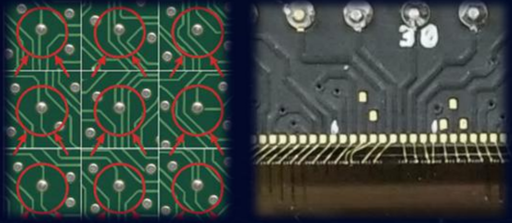




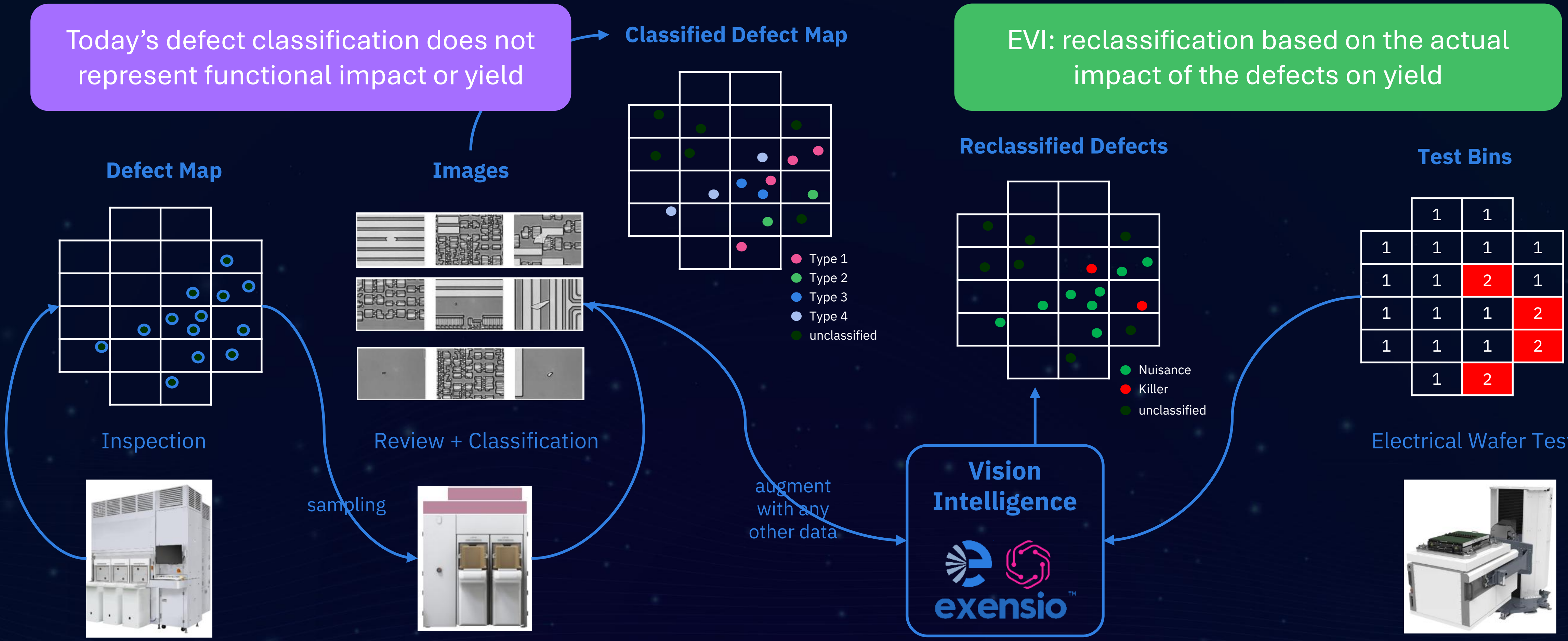


- incoming material inspection
- fab inline inspection and review
- dicing, Assembly & Test: AOI
- module assembly, test and final inspection





Example: Inline Inspection ADC (Auto Defect Classification)



Today's defect classification does not represent functional impact or yield

Classified Defect Map

- ● Type 1
- ● Type 2
- ● Type 3
- ● Type 4
- ● unclassified

Defect Map

Images

Inspection

sampling

Review + Classification

augment with any other data

EVI: reclassification based on the actual impact of the defects on yield

Reclassified Defects

- ● Nuisance
- ● Killer
- ● unclassified

Vision Intelligence

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Test Bins

	1	1	
1	1	1	1
1	1	2	1
1	1	1	2
1	1	1	2
	1	2	

Electrical Wafer Test

Efficient end-to-end AI workflow

Data Import

Data Annotation

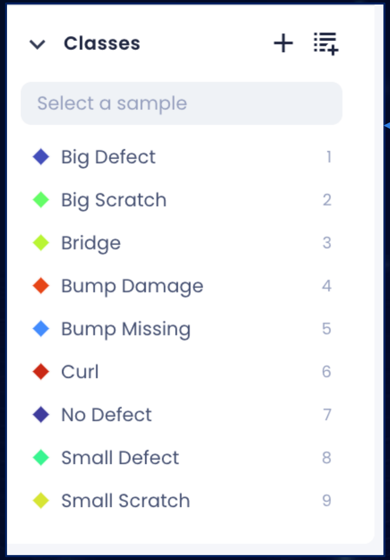
Data Curation

Model Training

Model testing

Model Optimisation

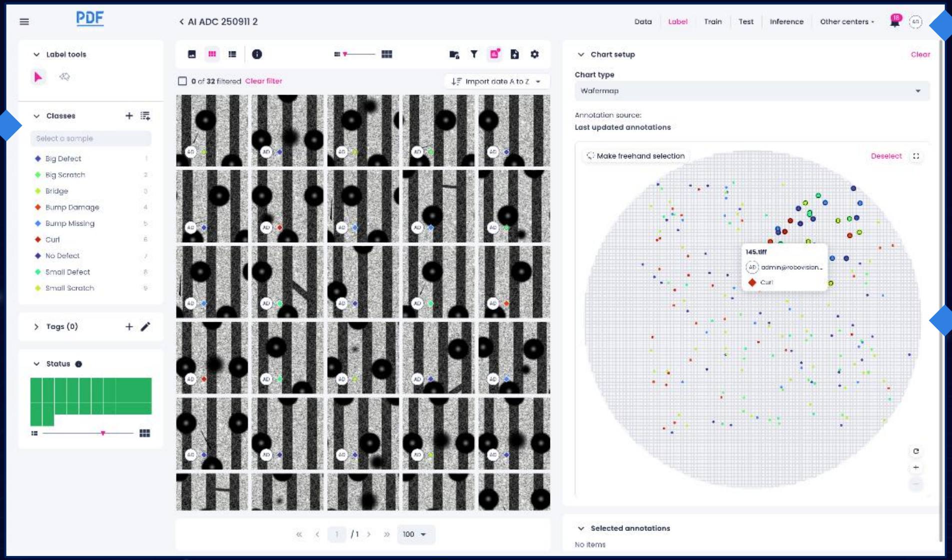
Model Deployment



Classes

Select a sample

◆ Big Defect	1
◆ Big Scratch	2
◆ Bridge	3
◆ Bump Damage	4
◆ Bump Missing	5
◆ Curl	6
◆ No Defect	7
◆ Small Defect	8
◆ Small Scratch	9



< AI ADC 250911 2

0 of 32 filtered Clear filter

Import date A to Z

Chart setup

Chart type: Wafermap

Annotation source: Last updated annotations

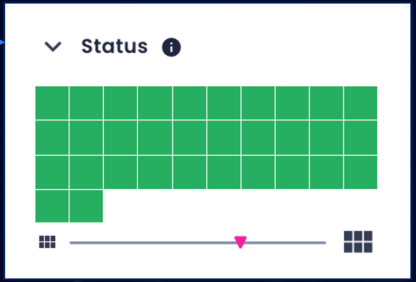
145.tiff

admin@robovision...

Curl

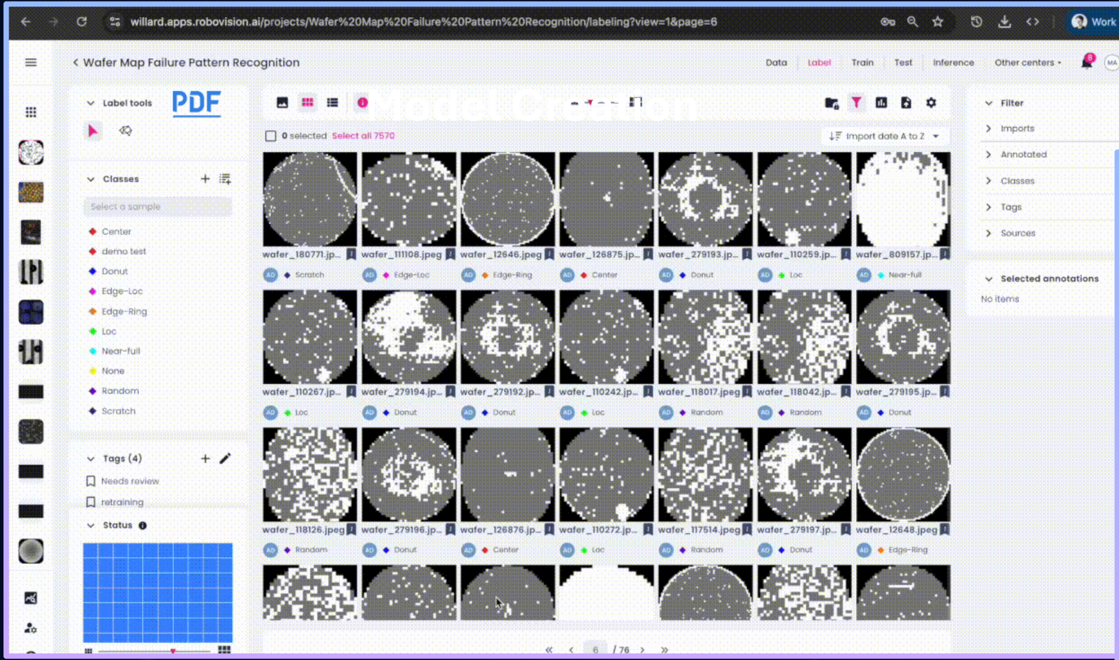
Selected annotations

No items

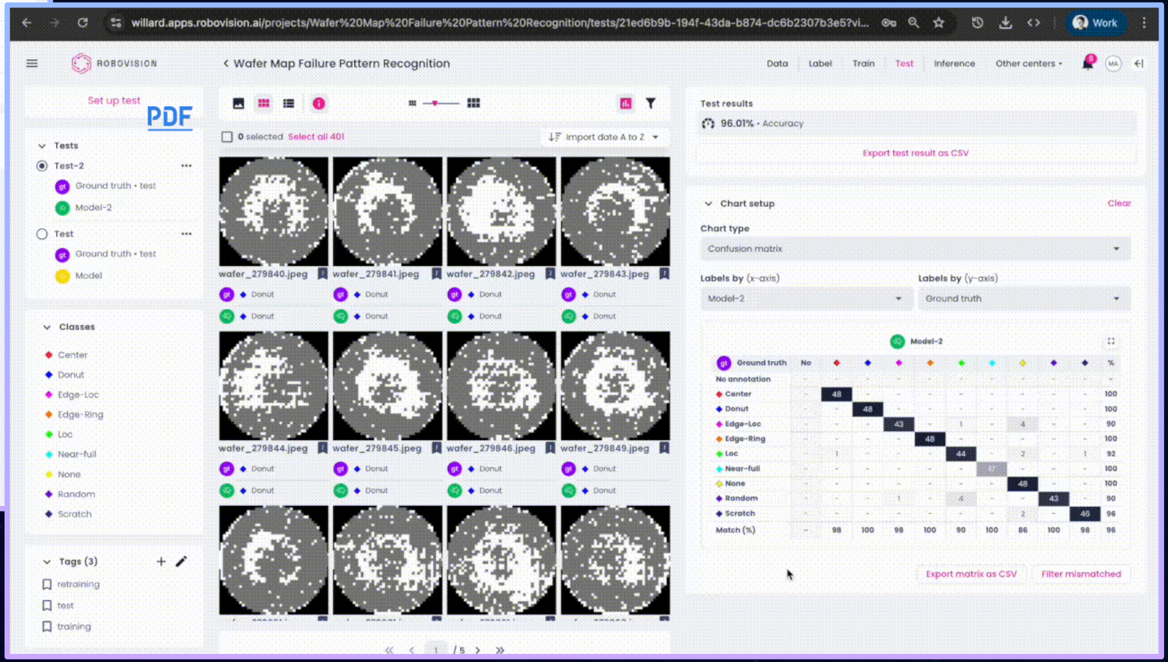


Example: Spatial Wafer Classification

Using images bin maps from electrical test for AI image-based wafer classification

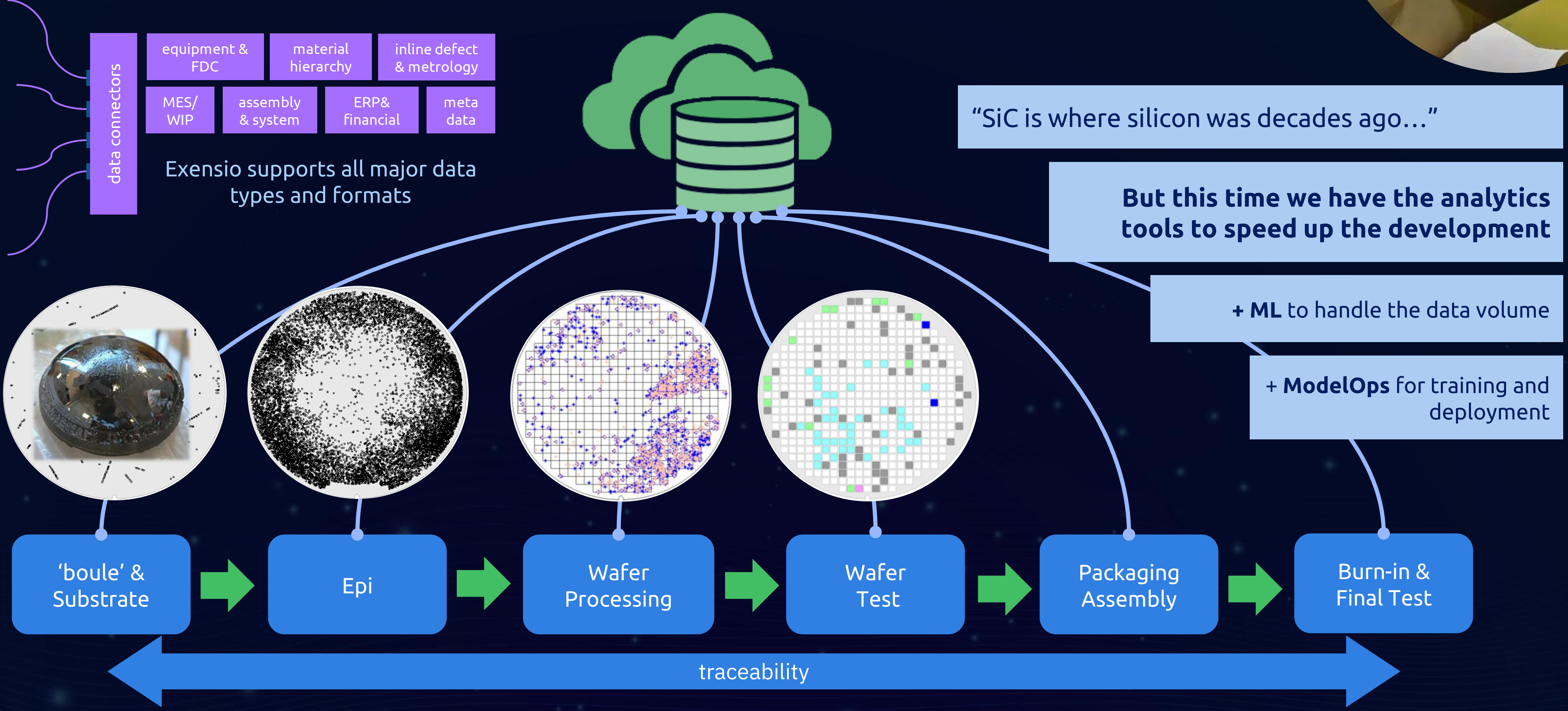


Model Testing



early identification of systematic issues | cross-fab & cross-supplier benchmarking | smart disposition

SiC End-to-End Manufacturing Analytics



Exensio supports all major data types and formats

"SiC is where silicon was decades ago…"

But this time we have the analytics tools to speed up the development

+ **ML** to handle the data volume

+ **ModelOps** for training and deployment

Roadmap: Manufacturing Analytics

Products/Features Released last 12-mo

Analytics

Exensio Platform

Deep Learning and Machine Learning & Performance Enhancements

N-2
- Fab Reader Big Data
- Metrology Big Data
- NPI – New Product Intro
- Wafer Genealogy
- Sapience Manufacturing Hub

N-1
- Guided Analytics AI/ML
- Guided Analytics Exec View
- SEMI E142 Beta Release
- Predictive Burn-In
- Sapience Supply Chain Hub

NOW
- Standard OS (RHeL/Alma8)
- Spotfire12
- ModelOps (PCM/CP/FT)
- Dynamic ML Training Pipeline
- Predictive Binning
- Data Feed Forward
- Studio AI

Included in next LTS

N+1
- Multi-threaded compute
- LLM JDP
- Full Exensio SEMI E142
- Configurable GA
- Defect Big Data
- StudioAI Integration
- New Data Retrieval
- Spotfire14

N+2
- Adaptive Spatial Diagnostics
- Image based classification
- StudioAI (All Big Data types)
- Defect Image Classification
- LLM Phase2
- Scalable Analytics*

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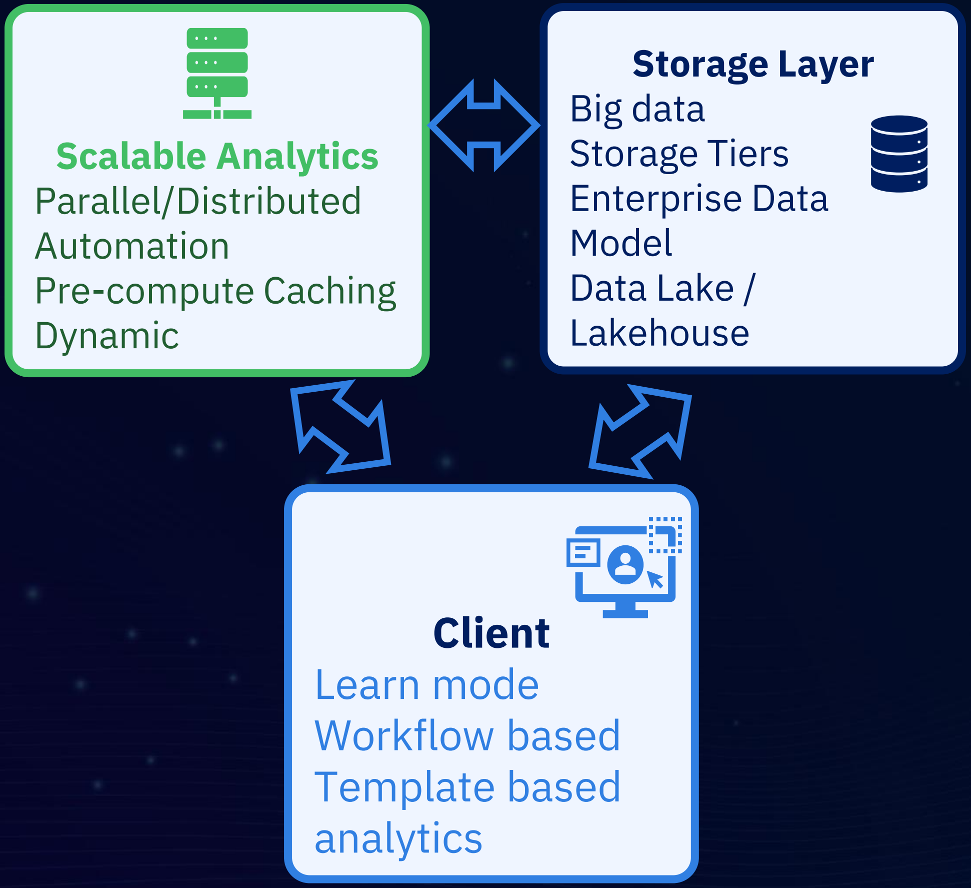
Scalable Analytics - Roadmap

Available in Exensio in 2026

- Raw Data never brought to client, just what client needs for visualizations - **FAST**
- Charts & Visualizations driven from Scalable Analytics and leverage parallel processing - **PERFORMACE**
- Dynamically Scalable based on current need – **COST mgmt**
- Caching in data layer for even faster access - **EFFICIENT**
- Pre-computed analytics through automation / autonomous agents looking at all the data all the time - **AUTOMATED**



Scalable Analytics
Parallel/Distributed
Automation
Pre-compute Caching
Dynamic

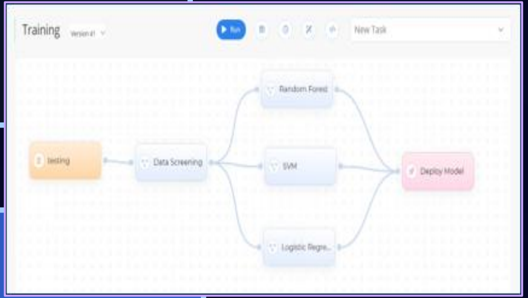
Storage Layer
Big data
Storage Tiers
Enterprise Data Model
Data Lake / Lakehouse

Client
Learn mode
Workflow based
Template based analytics

AI/ML at Scale – MLOps (Studio AI)

Exensio ModelOps:

- Built for semiconductor data
- Highly integrated within Exensio
- Facilitates semiconductor-oriented solutions and edge inference
- Production-proven



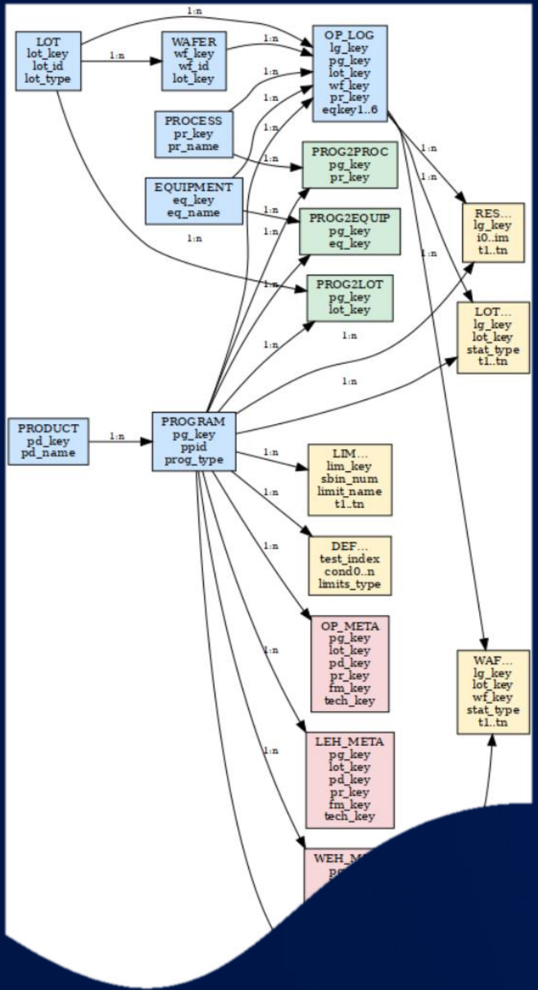
Tiber AI Studio:

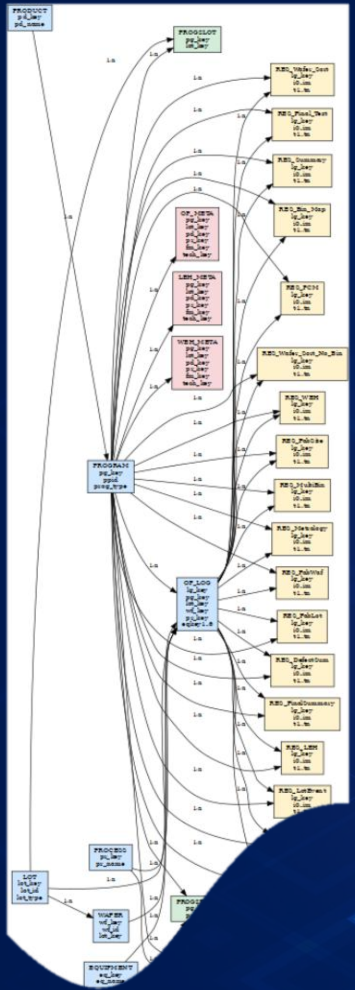
- Built to empower data-scientists
- From code to production - Bring your own algorithm
- Highly Scalable
- Production-proven

exensio™

Studio AI

Extended Semiconductor Semantic Data Model



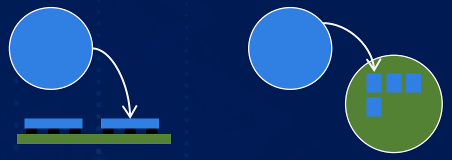


enhanced

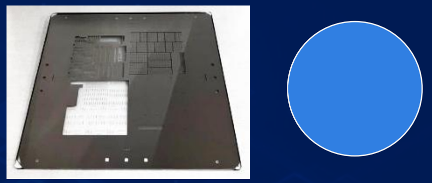
data model

to support more use cases in manufacturing

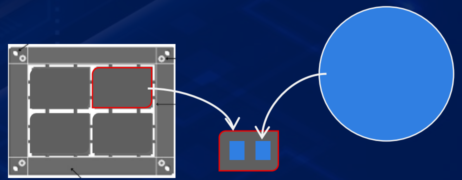
new relationships for traceability



reticle-wafer mapping



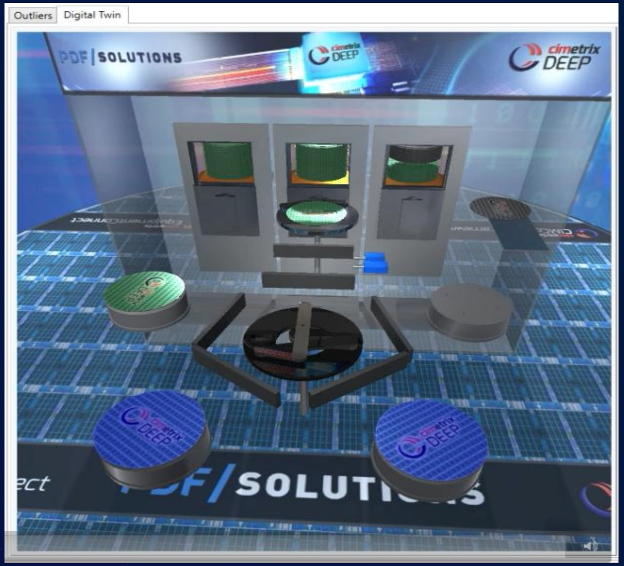
substrates and Panels

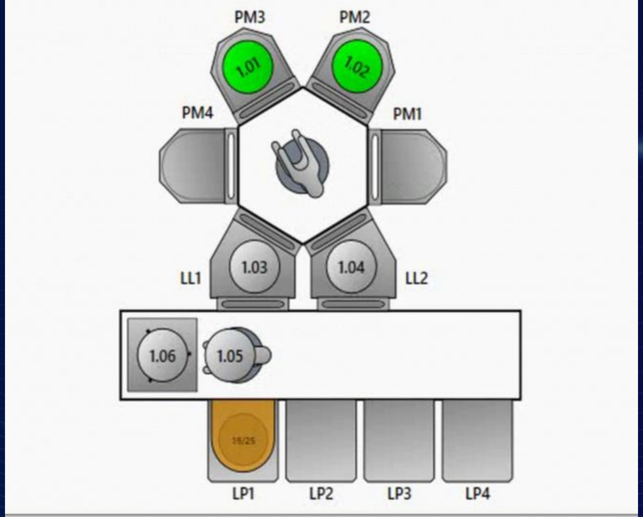


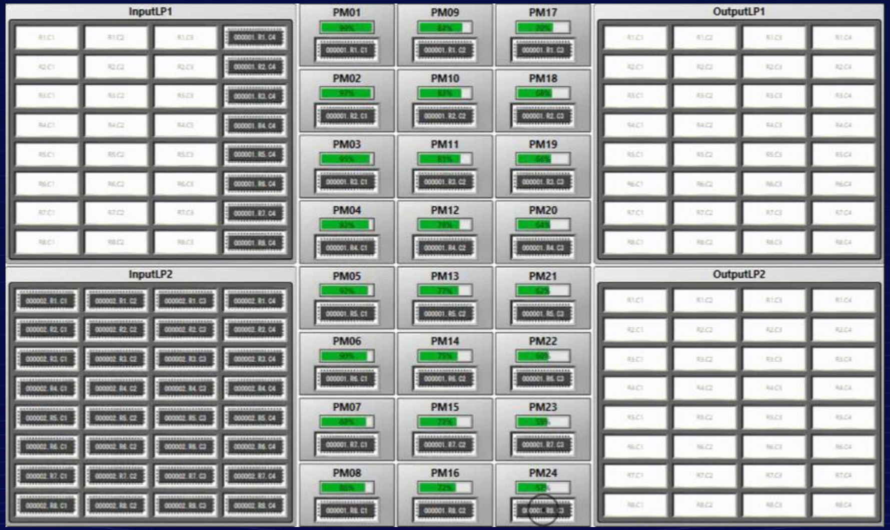
32 new data types & schemas added in 2025 and many more (>90 being added in 2026 and beyond)

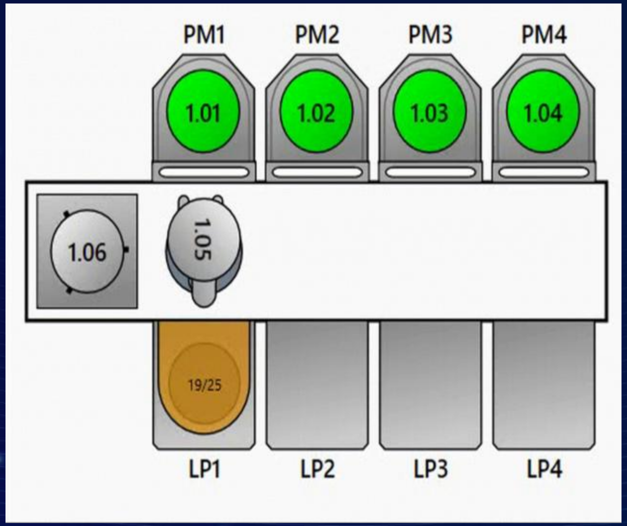
Equipment & Fab Twins – Realtime Control

- Beta release available now
- Digital representation of the equipment and factory floor connecting the physical & digital worlds
- Monitor and optimize manufacturing, resources, efficiency, and health of the equipment.
- Digital Twins are the AI foundation for Smart Manufacturing and Enterprise Control systems




Vacuum Cluster


Continuous Flow


Atmospheric Cluster

PDF Solutions Platform Differentiation

Mission Critical Data & Analytics platform, integrated with enterprise applications, enabling key business processes & cross-company collaboration

Industry and Domain Expertise

ABILITY TO

Create, Integrate, Align, Analyze, and Act on Data

Fully Integrated Solution Architecture

PLATFORM FOR

Cross Industry Collaboration and Execution

PDF is evolving its data analytics and visualization platform to enable next generation AI

“This evolution is set to **transform data analytics**” with a platform that is user-centric, highly customizable, and exceptionally flexible.

Featuring **advanced capabilities**, seamless integration, and industry-specific solutions, the data analytics and visualization is being tailored specifically **for the semiconductor industry.**

Our **vision** is to drive **innovation** and **efficiency** by empowering organizations with better **AI through superior data quality**.”

06.

Panel

Jon Holt
PDF

Syed Baquar
INTEL

Tom Grein
ONSEMI

Brian Thibeault
UCSB

Ahmad Abdel Majeed
AMS OSRAM

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Manufacturing Data analytics for fab and advanced packaging

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