2023 PDF Users Conference:

PDF Analytics Platform

Location:
Santa Clara Marriott - 2700 Mission College Boulevard Santa Clara, California 95054 USA

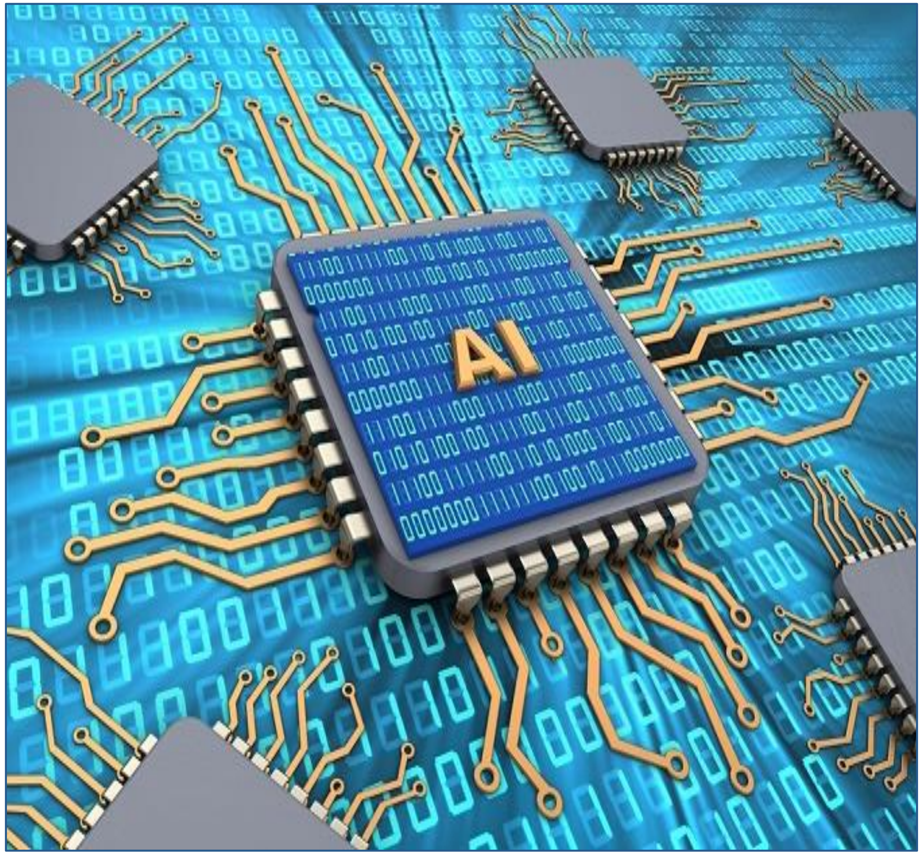
PDF Solutions - Platform for Semiconductor Analytics

Our Vision and Strategy

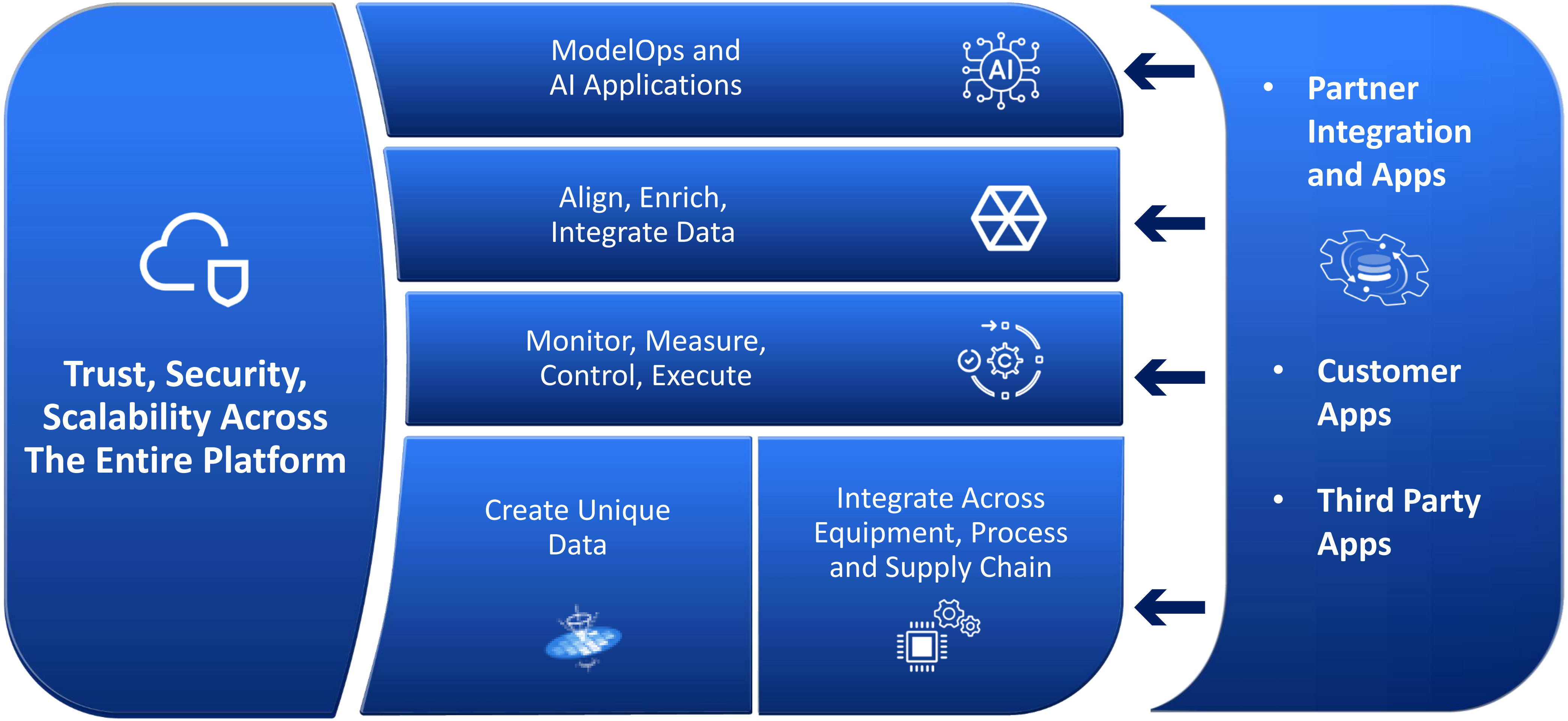
October 25th 2023

Agenda

- PDF's Platform for Semiconductor Analytics
- PDF Platform – Positioning in "Hybrid" Ecosystem
- PDF Platform – Key Capabilities and Differentiation
- PDF Solutions – "The Analytics Platform for Semi"
- PDF Platform – Looking Forward



PDF's End-to-End Platform for Semiconductor Analytics



Trust, Security, Scalability Across The Entire Platform

ModelOps and AI Applications

Align, Enrich, Integrate Data

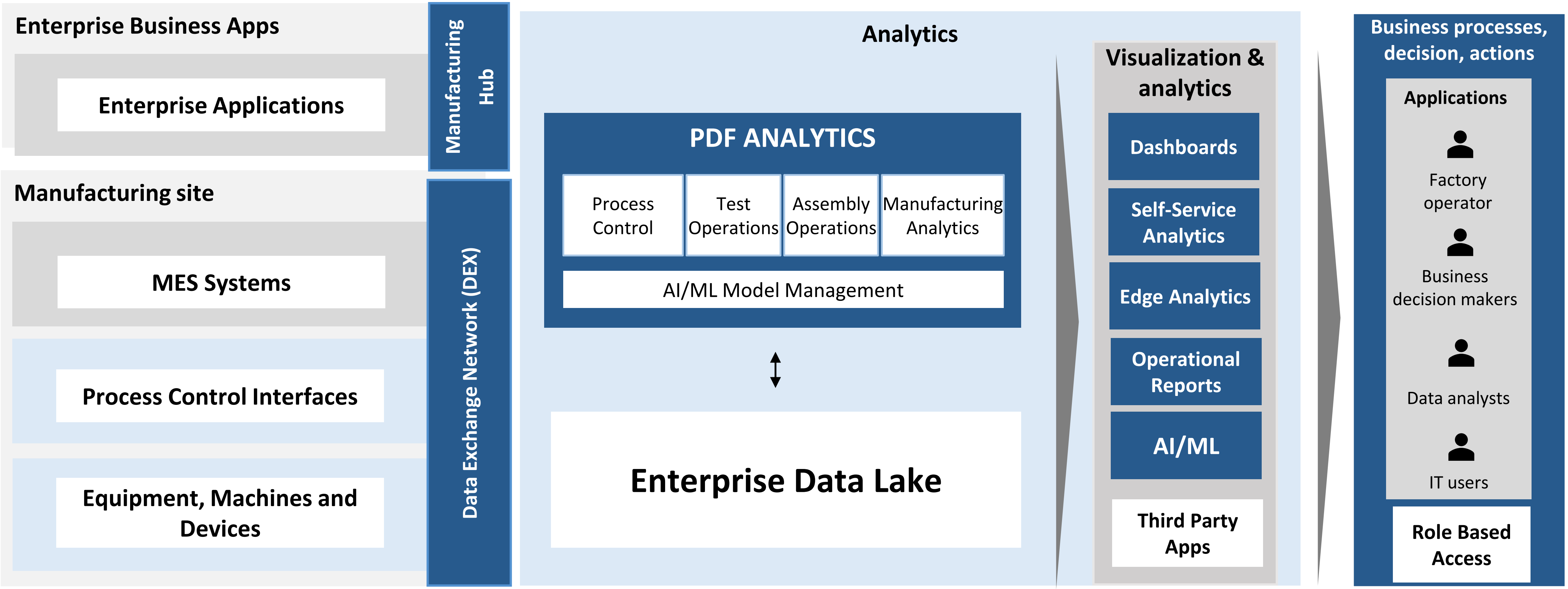
Monitor, Measure, Control, Execute

Create Unique Data

Integrate Across Equipment, Process and Supply Chain

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

PDF Platform – A Hybrid Enterprise Architecture View



Enterprise Business Apps

Enterprise Applications

Manufacturing Hub

Manufacturing site

MES Systems

Process Control Interfaces

Equipment, Machines and Devices

Data Exchange Network (DEX)

Analytics

PDF ANALYTICS

Process Control

Test Operations

Assembly Operations

Manufacturing Analytics

AI/ML Model Management

Enterprise Data Lake

Visualization & analytics

Dashboards

Self-Service Analytics

Edge Analytics

Operational Reports

AI/ML

Third Party Apps

Business processes, decision, actions

Applications

Factory operator

Business decision makers

Data analysts

IT users

Role Based Access

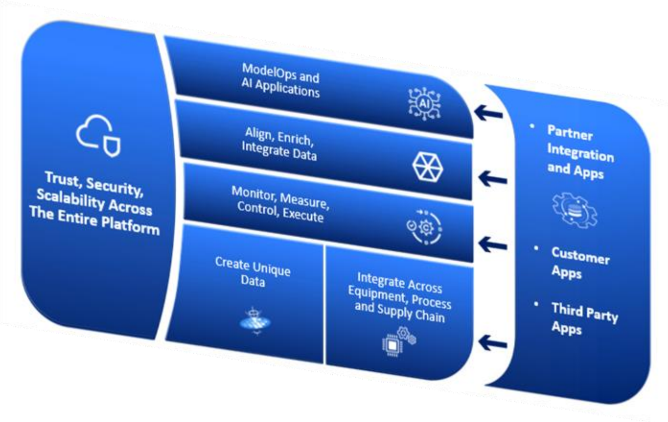
PDF Platform can integrate with existing enterprise cloud or on-prem architecture

Key Capabilities of a Platform for Semiconductor Analytics

The necessary….

- Scalability
- Cloud Support
- Data Management
- Risk and Compliance
- BI and Visualization
- AI/ML at Scale
- Generative AI
- Data Security & Governance

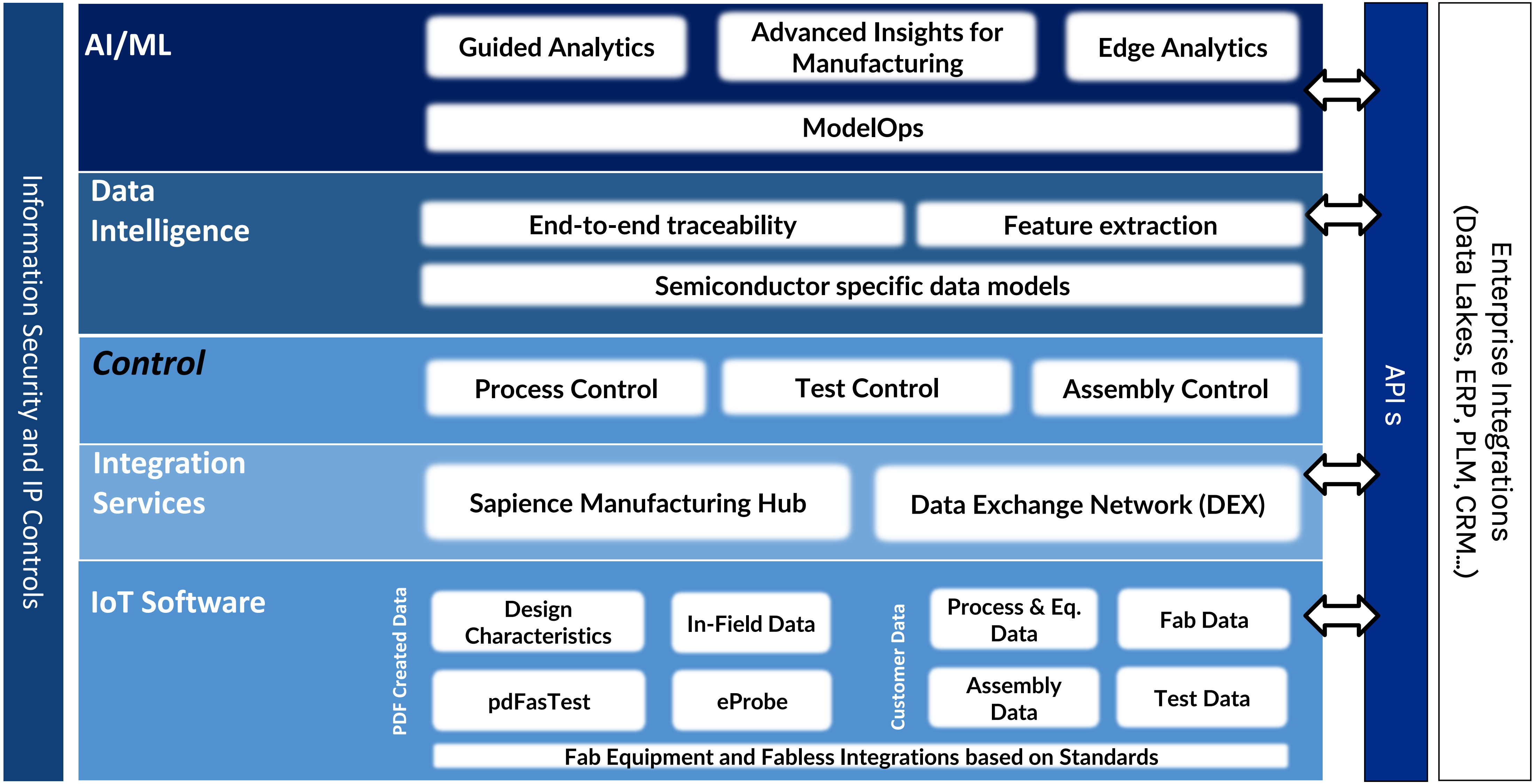
and



…. The sufficient

- Integrated platform
- Industry specific data / semantic models
- Differentiated data
- Domain knowledge enriched analytics
- End-to-end security from internal/external manufacturing facilities to central deployment
- Semiconductor specific ML pipelines, ModelOps, generative AI and ML solutions
- Manufacturing control and edge deployment
- Industry partnerships
- Out of the box support for industry tool types, standards and data formats

End-to-end Integrated Platform for Semiconductor Analytics



Information Security and IP Controls

AI/ML
- Guided Analytics
- Advanced Insights for Manufacturing
- Edge Analytics
- ModelOps

Data Intelligence
- End-to-end traceability
- Feature extraction
- Semiconductor specific data models

Control
- Process Control
- Test Control
- Assembly Control

Integration Services
- Sapience Manufacturing Hub
- Data Exchange Network (DEX)

IoT Software
- PDF Created Data
  - Design Characteristics
  - In-Field Data
  - pdFasTest
  - eProbe
- Customer Data
  - Process & Eq. Data
  - Fab Data
  - Assembly Data
  - Test Data
- Fab Equipment and Fabless Integrations based on Standards

API s

Enterprise Integrations
(Data Lakes, ERP, PLM, CRM…)

PDF/SOLUTIONS™

Industry Specific Data / Semantic models

IC Design **Fab** **Sort** **Assembly** **Test** **System**

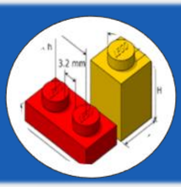
Material Descriptions In Hierarchy	Meta Data	MES/ WIP Equipment History	Fault Detection and Control (FDC)	Defect & Metrology	Equipment and Non-Lot	Product	Assembly / System	ERP / Business / Financial	Data Sources & Connectors
Technology Family Process Product Source Lot Lot Wafer # Die Layout	Equipment Operator Program Recipe Date/Time Process Flow Stages Steps SEMI E142 Traceability	Equipment TrackIn/Out Recipe Operator Chamber QueueTime CycleTime Wfr Counts Rework Reticle	Indicators Summaries Trace Charts Model prediction & Management Real time data collection Sub-fab FDC	Parametric Categorical Lot / Wafer Summaries Defect Summary Kill Ratio Defect Images	Equipment SPC Fab chemical delivery Equipment counter data Equipment Event / PM Consumables	Test chip (CV) PCM / WAT Wafer Sort Bin Map Multi-Bin Final Test Module Data MCM Chiplets WLA	Die traceability Location of reel/tube Solder paste batch, vendor Equipment parameters Operator logs	Production Order Product Costing Consumables Parts Alarms / Events Split / Merge Scrap / Unscrap Financial EBOM	Other 3rd party Apps & databases … Data Lake connectivity BDAPI … Sapience Manufacturing HUB

Data / Semantic models for analysis readiness

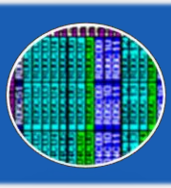
Differentiated Data

Technology Development

Regular layout



CV test chip characterization



Design genetics pattern family

Mass Production

PDF Generated

CV Core sensor

DFI eProbe

xScribe CV

Feature Extracted

Existing & new data

Equipment Connectivity

PDF Leads Standards for Analytics & Equipment Data Collection

- SEMI NA Regional Standards Committee Assistant Co-Chair
- SEMI NA Information & Control Committee Co-Chair
- SEMI NA GEM 300 Task Force Leader
- SEMI NA DDA Task Force Leader
- SEMI NA Advanced Backend Factory Integration (ABFI) Task Force Leader
- SEMI NA GUI Task Force Leader
- SEMI NA Fab & Equipment Computer and Device Security (CDS) Task Force Leader
- SEMI Japan F-GEM Task Force Leader
- NEMI Board of Directors
- Task Group Leader of IPC Connected Factor Initiative Subcommittee
- Co-Chair of the Smart Manufacturing Technical Working Group of iNEMI
- SEMI NA Traceability Committee Co-Chair
- SEMI NA Advanced Backend Factory Integration (ABFI) Task Force Leader
- SEMI NA Single Device Tracking (SDT) TF Leader
- GSA TIES SWG-07 Liaison Team Leader
- GSA TIES SWG-07 M345 Working Group Co-Leader

Domain Knowledge Enriched Analytics

IC Design | Fab | Sort | Assembly | Test | System

Quality & Reliability Protection

Design / Manufacturing Co-Optimization

Accelerated Product Qualification

Accelerated Yield Ramp

Smart Factory Enablement

Overall Equipment Effectiveness

Shop Floor to Top Floor Connectivity

20%
Improved Efficiency

10%
Improved Utilization

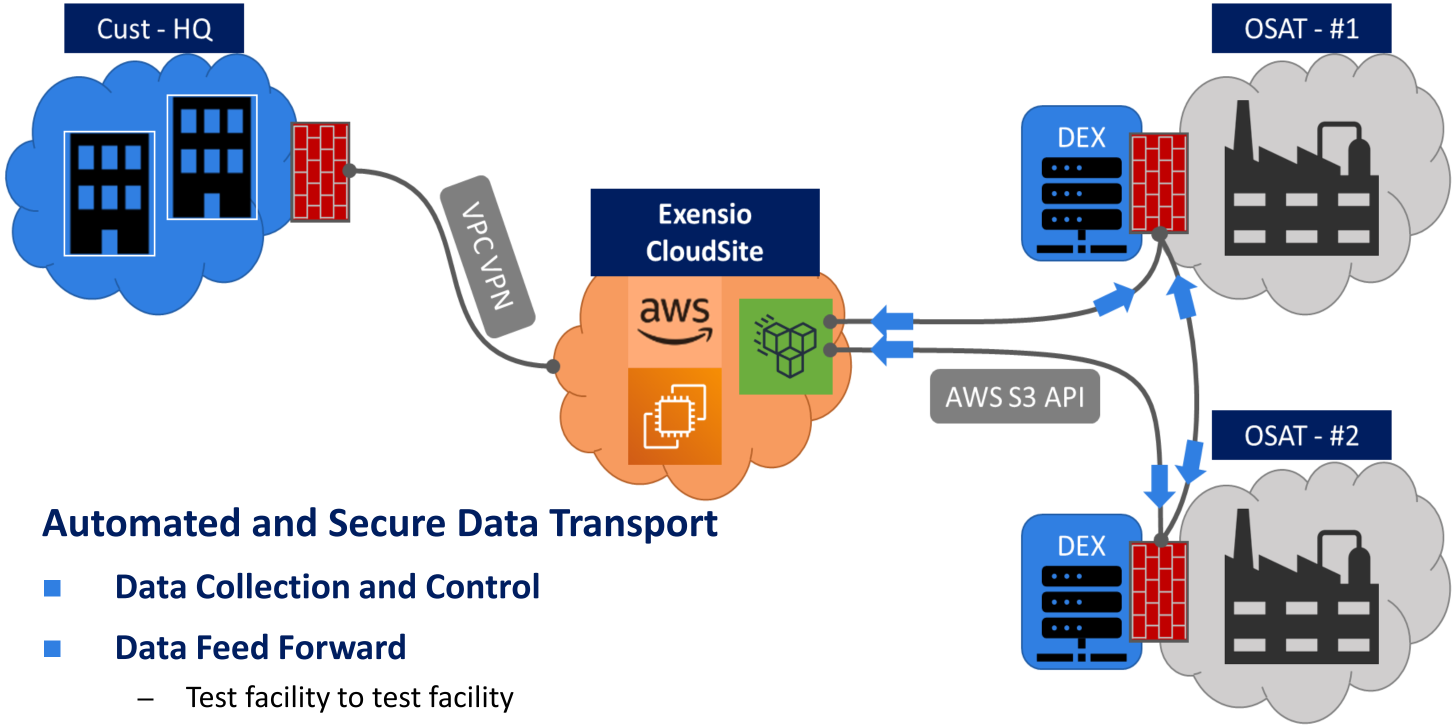
6-month faster
Time to Value

30%
Improved Quality

2X
Faster time to Revenue

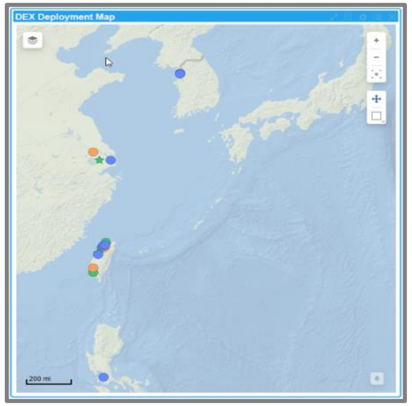
30%
Reduced Cost

End-to-end Edge Deployment and Security



Automated and Secure Data Transport

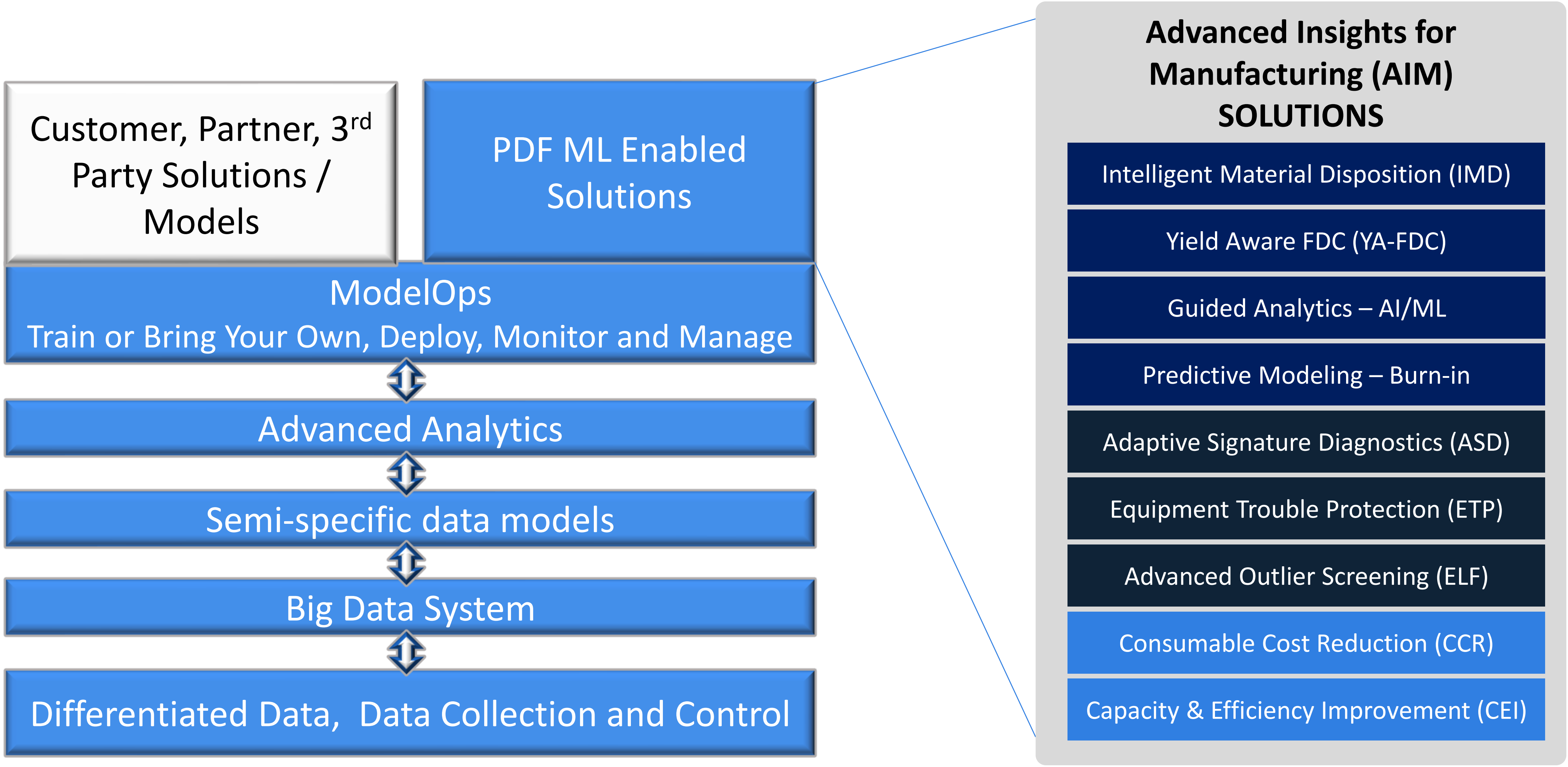
- **Data Collection and Control**
- **Data Feed Forward**
  - Test facility to test facility
  - Server to test program / model
  - Test facility to customer instance
- **Security**
  - Strong Encryption: data-in-transit & data-at-rest
  - Zero-trust, Identity-based Access Controls
  - Regular Independent Assessments
    - Annual 3rd party PEN testing
    - Annual SOC 2 Type 2 audit (Exensio Cloud)
    - Continuous scanning of all external-facing services



DEX Network – Q3-2023

Site Name	Site Name
Amkor China	JCET Singapore
Amkor Korea	JCET China
Amkor Philippines	KYEC ZhuNan
Amkor Taiwan	Siguard Hsinchu
ASE Chungli	SPIL Chung Shan
ASE Kaohsiung	SPIL Hsinchu
Carsem Malaysia S-Site	SPIL SuZhou
Foxconn Taiwan/Ingrasys	SPIL Zhong Ke
Giga Taiwan	UTAC Singapore
JCET Korea	UTAC Thailand
Winstek	

ModelOps and AIM Solutions



Customer, Partner, 3rd Party Solutions / Models

PDF ML Enabled Solutions

ModelOps
Train or Bring Your Own, Deploy, Monitor and Manage

Advanced Analytics

Semi-specific data models

Big Data System

Differentiated Data, Data Collection and Control

Advanced Insights for Manufacturing (AIM) SOLUTIONS

- Intelligent Material Disposition (IMD)
- Yield Aware FDC (YA-FDC)
- Guided Analytics – AI/ML
- Predictive Modeling – Burn-in
- Adaptive Signature Diagnostics (ASD)
- Equipment Trouble Protection (ETP)
- Advanced Outlier Screening (ELF)
- Consumable Cost Reduction (CCR)
- Capacity & Efficiency Improvement (CEI)

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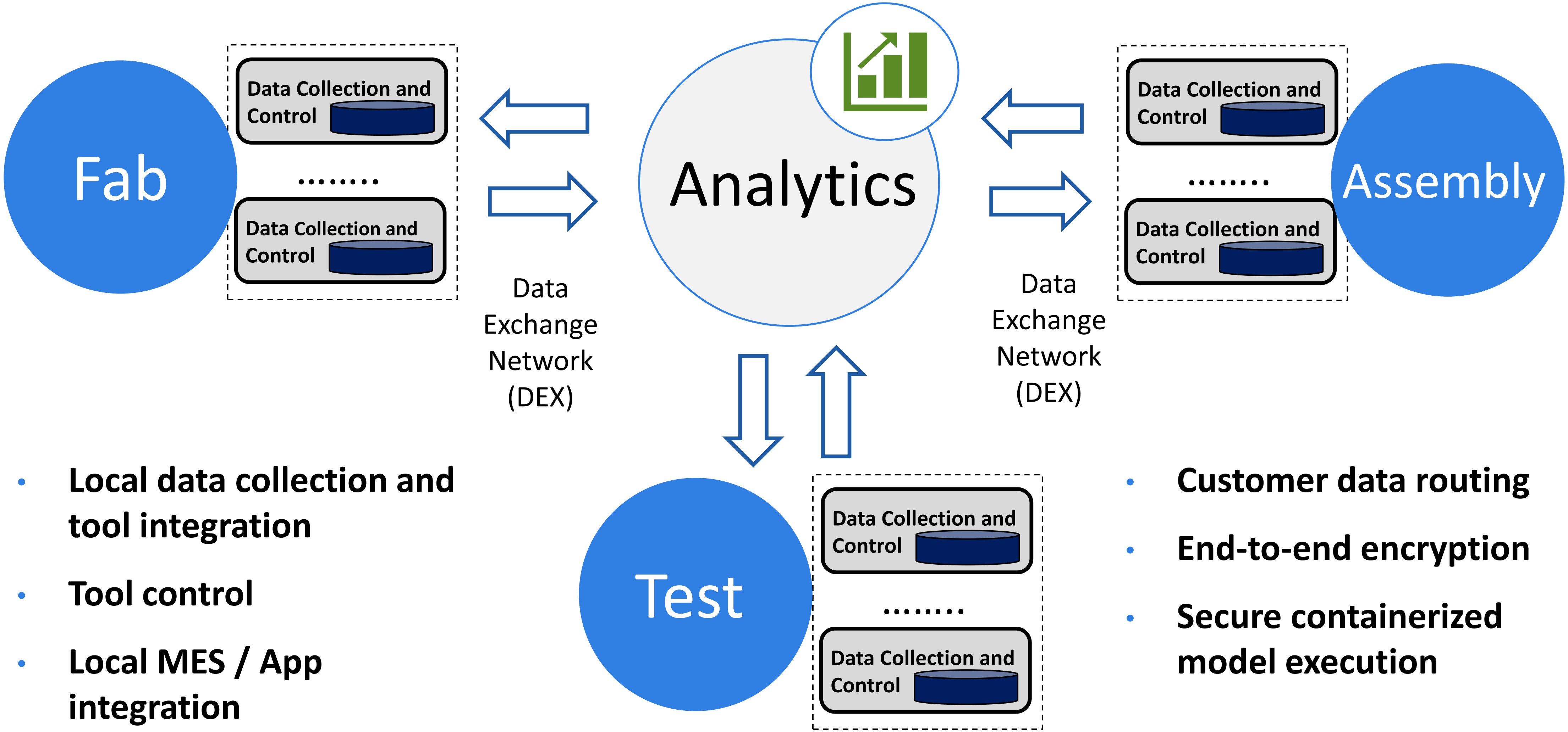
Manufacturing Control and Edge Deployment



- **Local data collection and tool integration**
- **Tool control**
- **Local MES / App integration**

- **Customer data routing**
- **End-to-end encryption**
- **Secure containerized model execution**

PDF Partnerships for an Expanded End-to-End

SAP

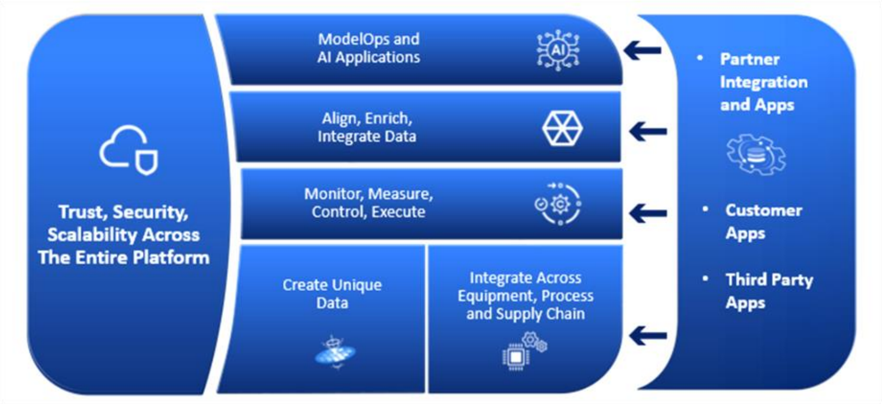
Financial: Links business & supply chain data with E2E manufacturing data for automation/analysis of quality & cost

SIEMENS

Design: E2E manufacturing data integration with Test Pattern layout & design

ADVANTEST

Test: Differentiated data and enhanced solutions for Test



proteanTecs

Collaboration with pT agents: and monitors integrated for Rapid Diagnosis of Chip Product Health

aws Microsoft

Cloud platform: analytics partner for Semiconductor supply chain solutions – over 78 products cloud ready.

Kulicke & Soffa

Assembly: Differentiated data and enhanced solutions for Assembly

IBM

MES: Integrated offering with PDF Analytics

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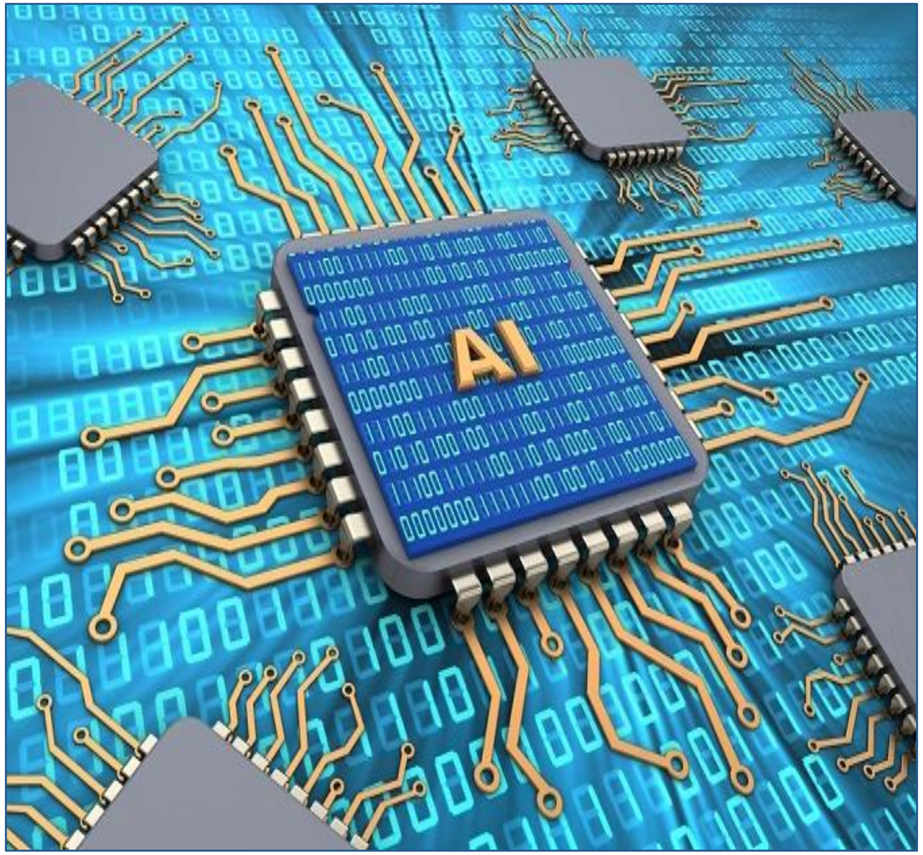
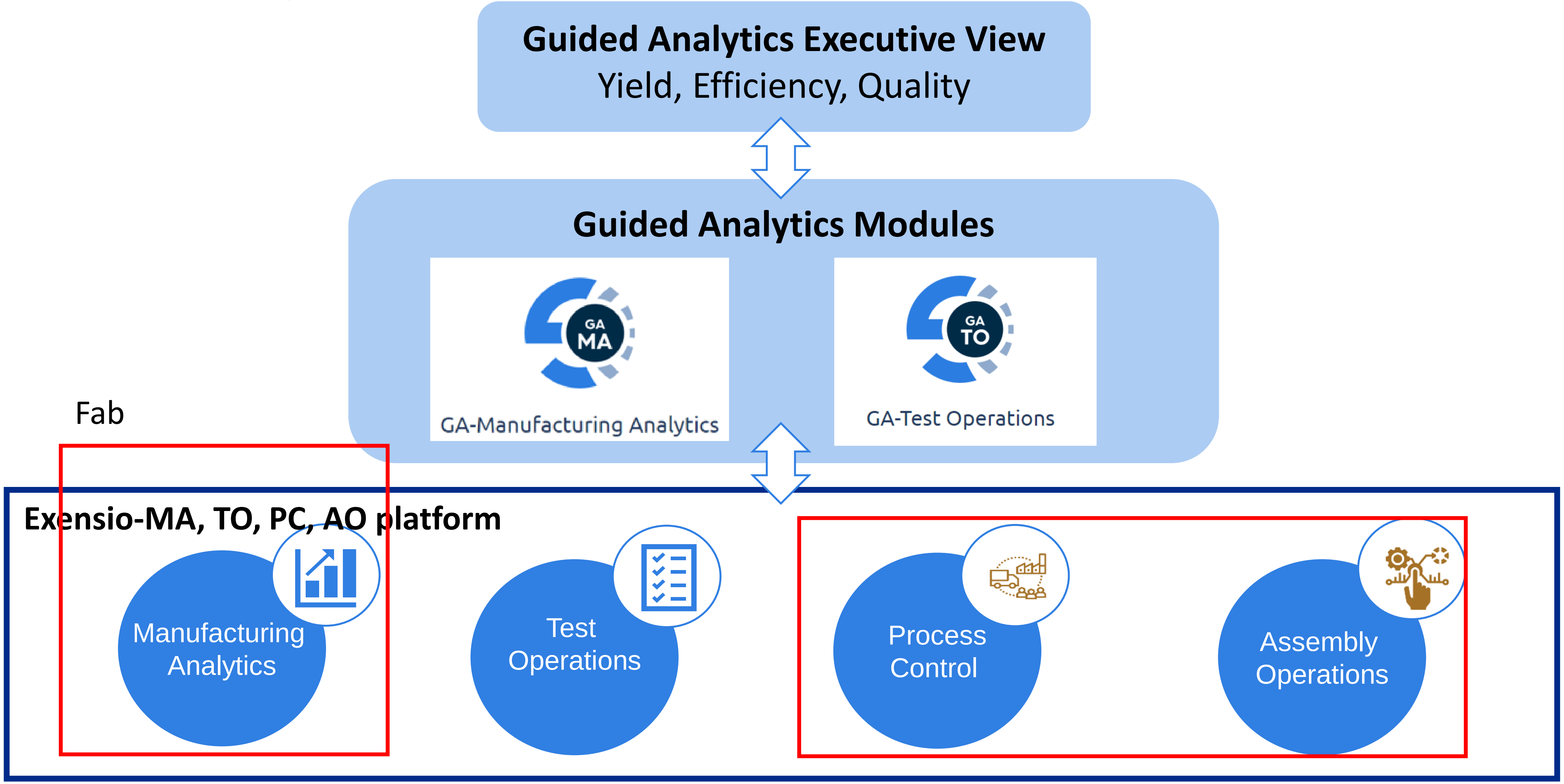
- **PDF Platform – Looking Forward**



Guided Analytics



Guided Analytics Executive View
Yield, Efficiency, Quality

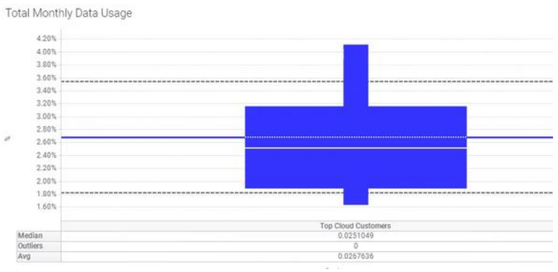
Guided Analytics Modules

Fab

Exensio-MA, TO, PC, AO platform

Guided Analytics: Continuous Data Mining on 100% of data

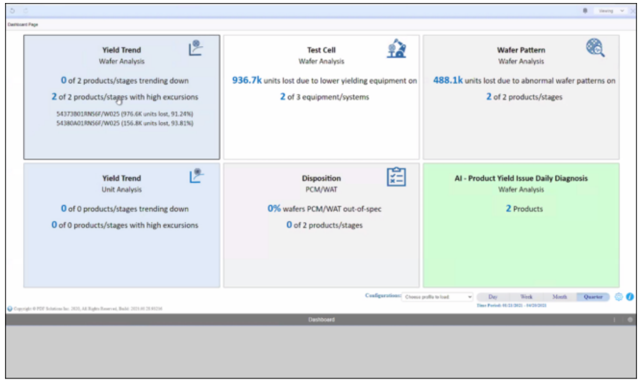
- **Manual analysis typically evaluates monthly 3-5% of the data**
  - Significant time spent aligning data types
  - Focus on obvious excursions and low yields
  - Harder to analyze wafer patterns, correlations across dat

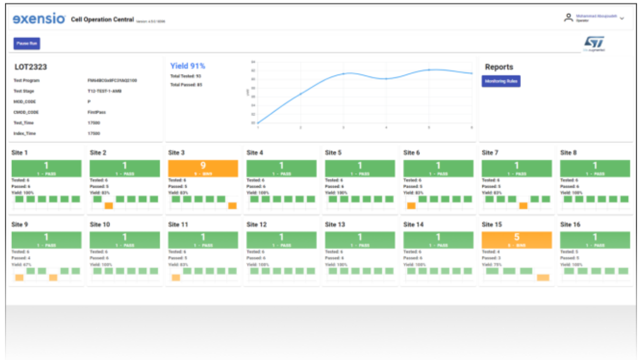


- **Guided Analytics systematically analyzes 100% of the aligned data* and highlights issues**
  - Single database with aligned data allows for consistent results and more sophisticated analysis
  - Structured GA flow provides consistency in analysis across the organization

**Data types: Yield, Hard/Soft Bins, failing test parameters, PCM/WAT, test equipment, UPH*

TOTAL (User, Customer, Multi, Employee) Experience



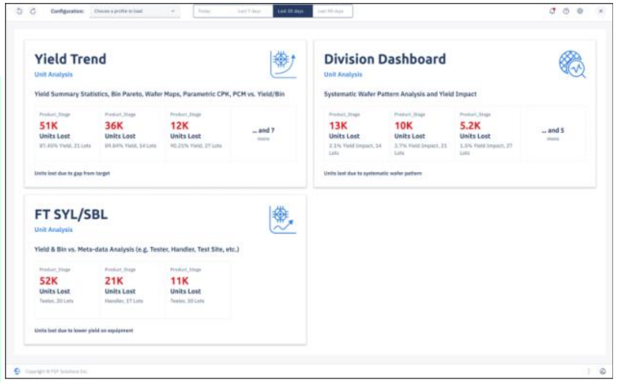


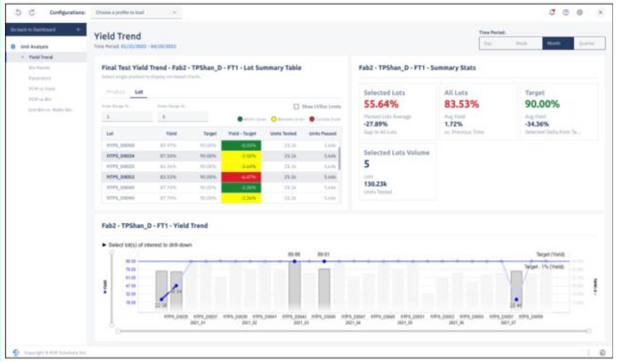
Before

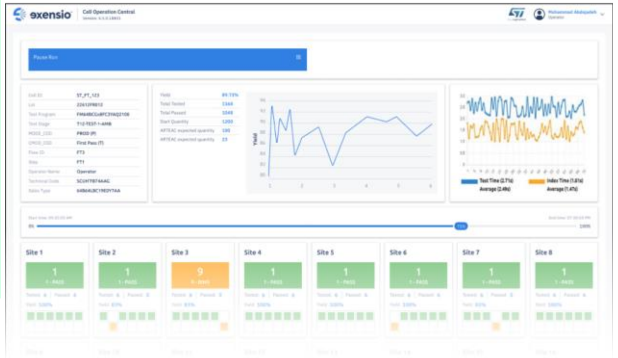
- UI: 45%
- UX: 59%
- Usability: 65%
- Interactive 32%
- Responsive 41%
- Accessibility 39%

After

- ✓ UI: 90%
- ✓ UX: 85%
- ✓ Usability: 88%
- ✓ Interactive 91%
- ✓ Responsive 90%
- ✓ Accessibility 93%







User

Optimizing usability, accessibility and overall adoption rates.

Customer

Optimizing for the customer as the end-user.

Multi

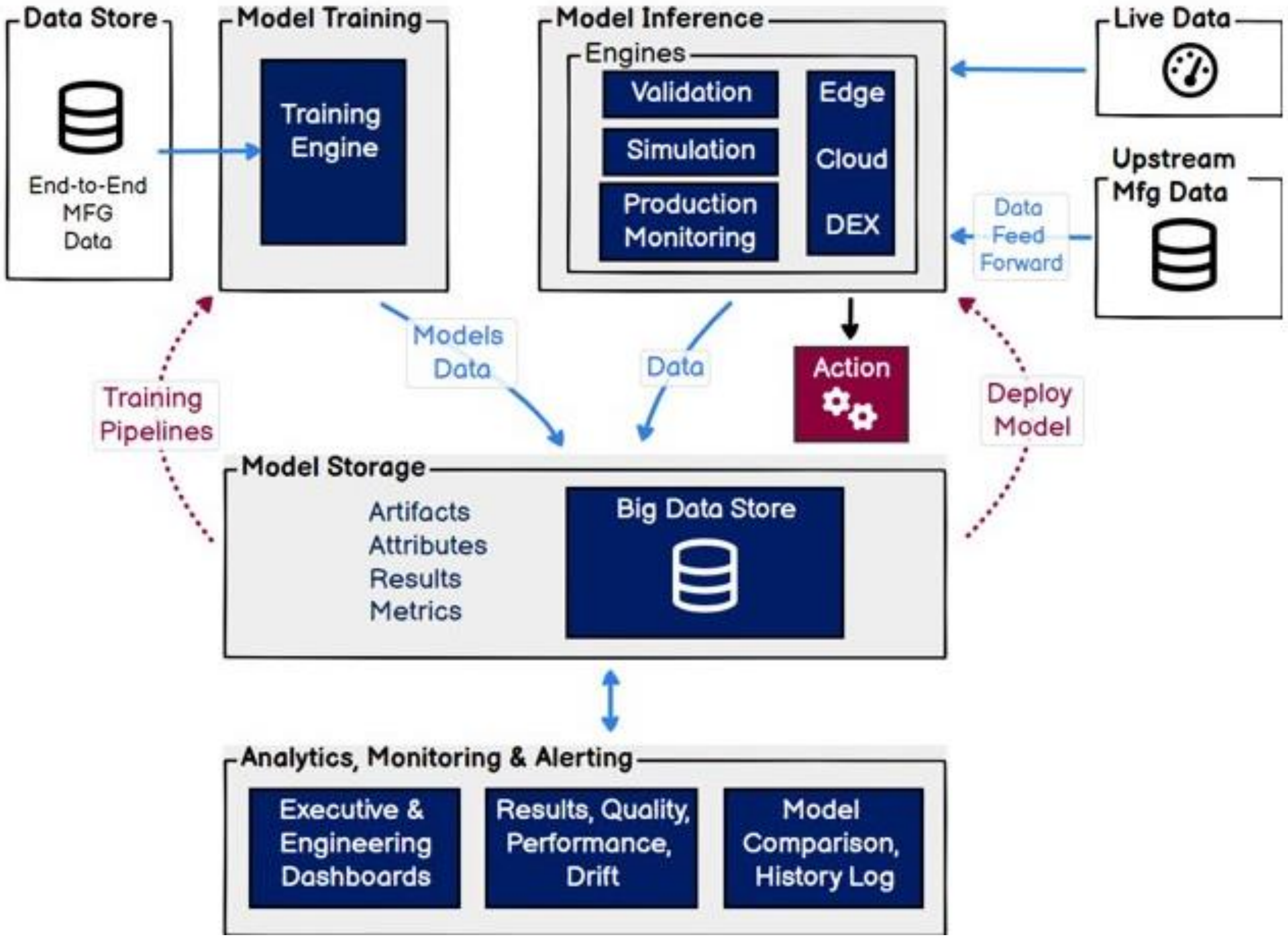
Optimizing every device for the best possible experience.

Employee

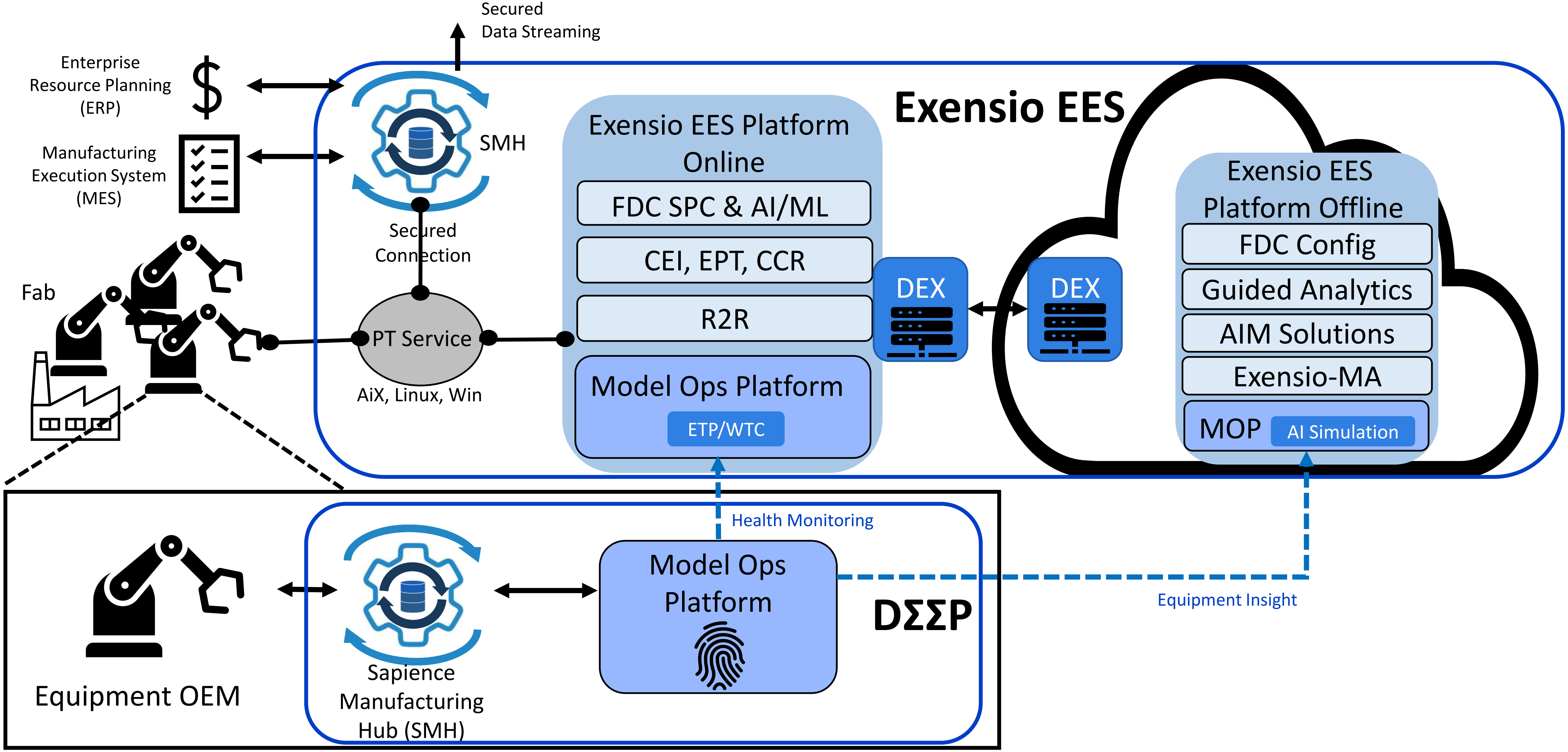
Optimizing for the employee as the end-user.

PDF Platform Model Ops Enables Scaling & Performance

- Integrated with the Exensio platform to leverage semi data access, analytics and control
- Central Model Storage System
- Dynamically Scalable Big Data model training infrastructure
- Deploys to Cloud & real-time Edge Inference Engines
- Bring-your-own Algorithm / Model / Inference Engine



Exensio Equipment Engineering System Platform



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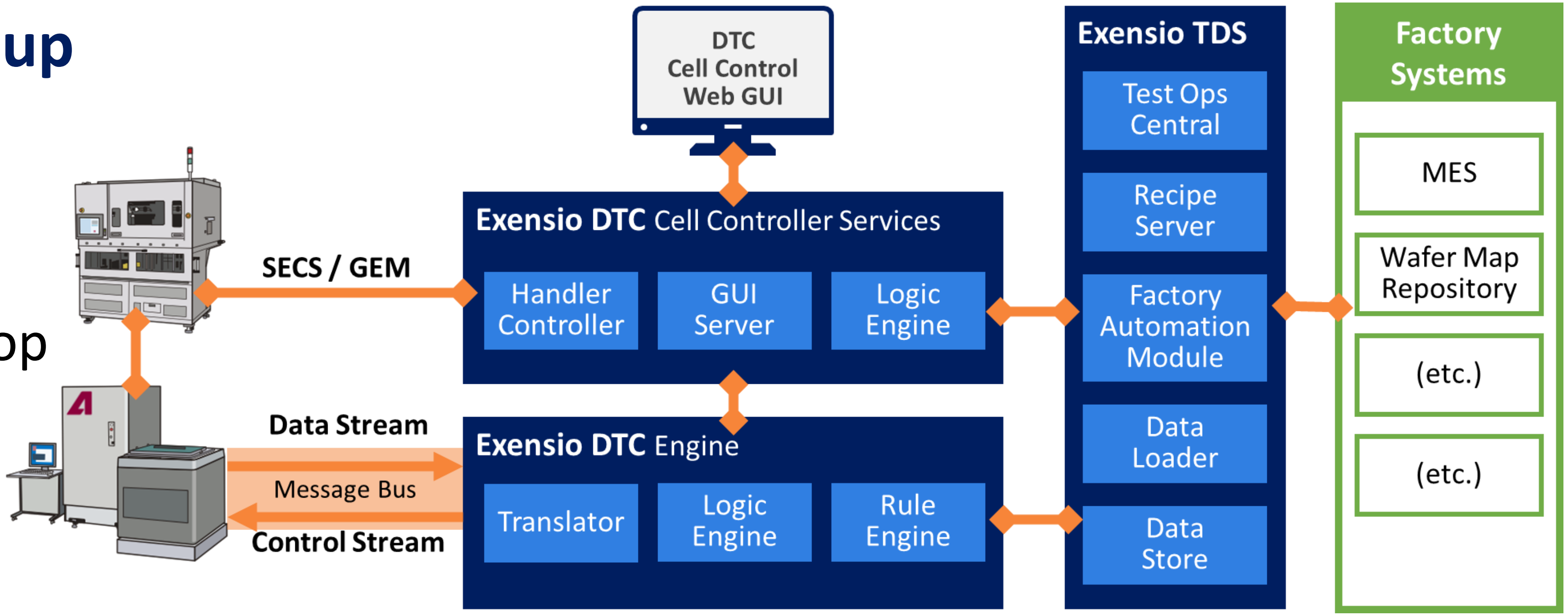
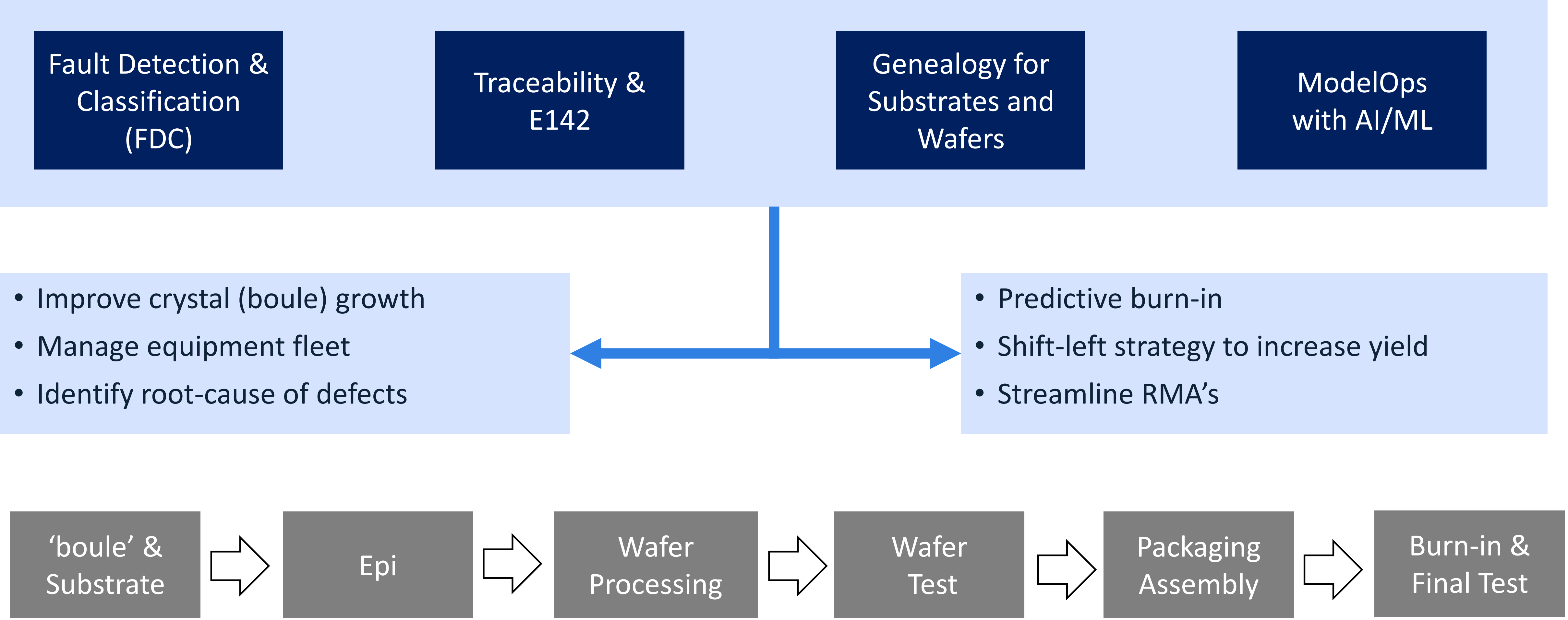
DTC+ Software Cell Controller

- **Tester & Handler Setup**
  - – Master data driven
- **Tester Control**
  - – TOS, TP load, start, stop
- **Handler Control**
  - – Start, stop, sites
- **Message Bus**
  - – RITdb data, RITdb commands



Next generation of DTC test cell integration leveraging modern equipment interfaces and stream protocols (SECS-GEM, MQTT, etc.)

SiC Package for Fabs and IDM’s



Fault Detection & Classification (FDC)

Traceability & E142

Genealogy for Substrates and Wafers

ModelOps with AI/ML

- Improve crystal (boule) growth
- Manage equipment fleet
- Identify root-cause of defects

- Predictive burn-in
- Shift-left strategy to increase yield
- Streamline RMA’s

‘boule’ & Substrate → Epi → Wafer Processing → Wafer Test → Packaging Assembly → Burn-in & Final Test

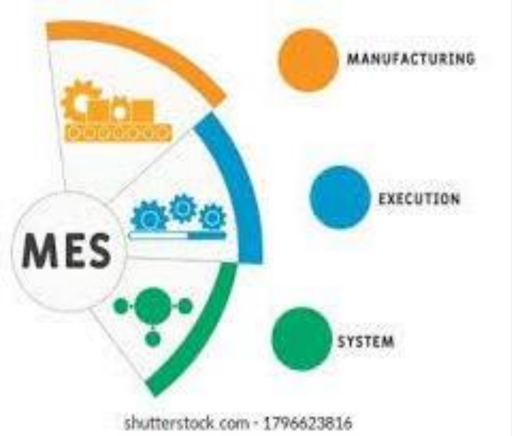
DΣΣP, Diagnostically Σnhanced Σquipment Protection

- Provides a Higher Level of Equipment Reliability and Deeper Visibility into Equipment Performance
  - Ability to Check Overall Equipment Health
    - Overall Equipment Health & Characterization
    - Monitor Critical Equipment Sub-Component’s Health
    - Create Golden Fingerprints for Each Sub-Component
  - Predict Failures Before They Happen
    - AI/ML Monitors and Identifies When Component Health Starts to Deteriorate Over Time
    - Prevents Costly Unscheduled Tool Downtime

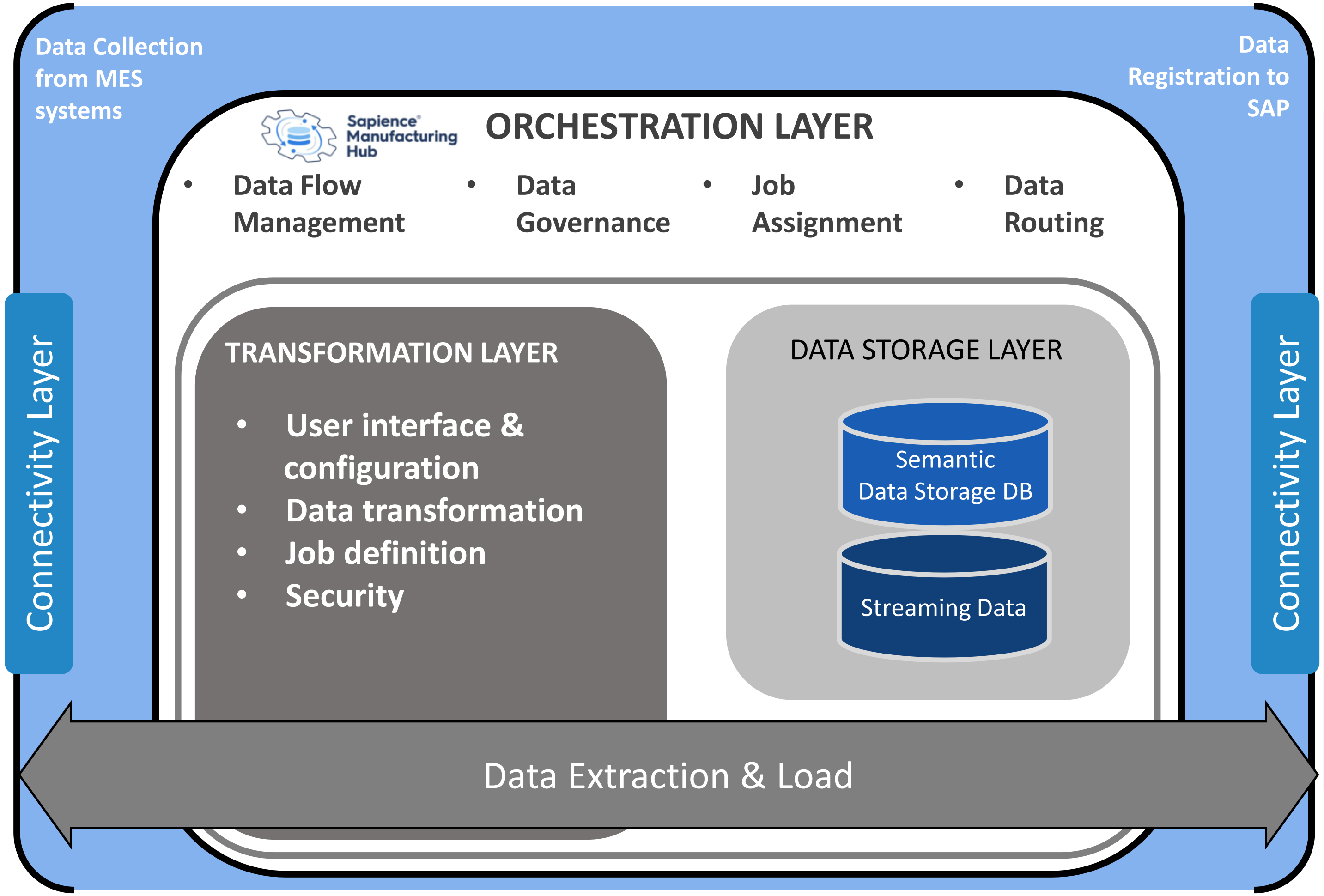
- Enables a new flow of recurring revenue from services contracts

Sapience Manufacturing HUB Connecting the Siloes

SOURCE LAYER



- Factory Applications
- Process & Metrology Tools
- Custom Applications
- Data Warehouses
- Devices
- 3rd Party Systems
- CRM



Data Collection from MES systems

Data Registration to SAP

Sapience Manufacturing Hub

ORCHESTRATION LAYER

- Data Flow Management
- Data Governance
- Job Assignment
- Data Routing

TRANSFORMATION LAYER

- User interface & configuration
- Data transformation
- Job definition
- Security

DATA STORAGE LAYER

Semantic Data Storage DB

Streaming Data

Data Extraction & Load

APPLICATIONS LAYER

- ERP & Business Intelligence
- Transactional Applications
- Machine Learning Applications
- Custom & 3rd Party Applications
- Enterprise Data Warehouse

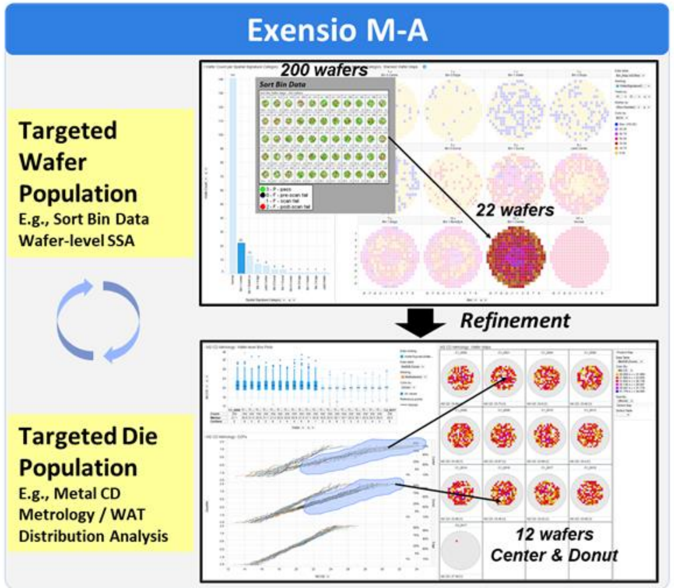
The "Sapience Manufacturing HUB" is an Enterprise Application Integration (EAI) platform

NPI & FA Diagnostics with Siemens Tessent + Exensio

Locate & Identify Root Cause of Logic Failures

Locate and Identify Root Cause of Memory Failures

Exensio M-A: Home in on target population for biggest impact



Exensio M-A

Targeted Wafer Population
E.g., Sort Bin Data
Wafer-level SSA

200 wafers

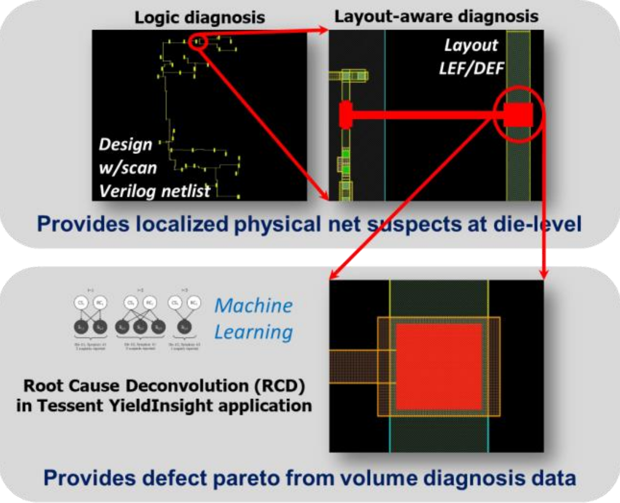
22 wafers

Refinement

Targeted Die Population
E.g., Metal CD
Metrology / WAT
Distribution Analysis

12 wafers
Center & Donut

Tessent YieldInsight: Localize defects for more effective logic PFA



Logic diagnosis

Layout-aware diagnosis

Design w/scan Verilog netlist

Layout LEF/DEF

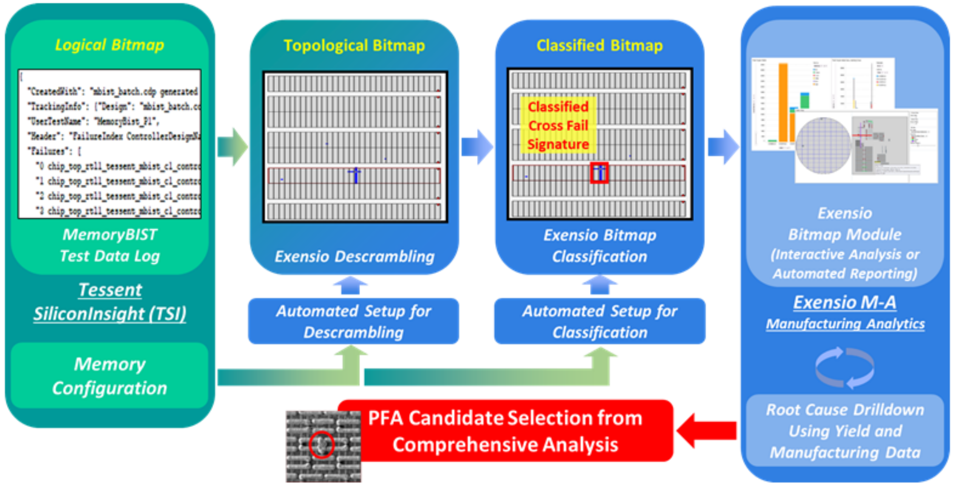
Provides localized physical net suspects at die-level

Machine Learning

Root Cause Deconvolution (RCD) in Tessent YieldInsight application

Provides defect pareto from volume diagnosis data

Tessent SiliconInsight and Exensio M-A: Simplify and routinize effective memory bitmap



Logical Bitmap

MemoryBIST Test Data Log

Tessent SiliconInsight (TSI)

Memory Configuration

Topological Bitmap

Exensio Descrambling

Automated Setup for Descrambling

Classified Bitmap

Classified Cross Fail Signature

Exensio Bitmap Classification

Automated Setup for Classification

Exensio Bitmap Module (Interactive Analysis or Automated Reporting)

Exensio M-A Manufacturing Analytics

Root Cause Drilldown Using Yield and Manufacturing Data

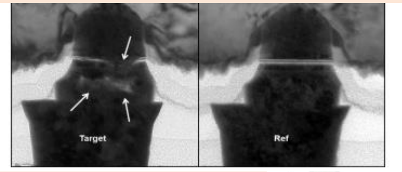
PFA Candidate Selection from Comprehensive Analysis

Product Ramp : Conventional vs. DirectScan Learning Cycle

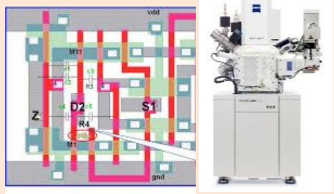
Conventional Yield Learning Cycle

Learning Cycle Time →

(resulting in 1 fail site of data)



(3-5 weeks including logistics) EFA / PFA



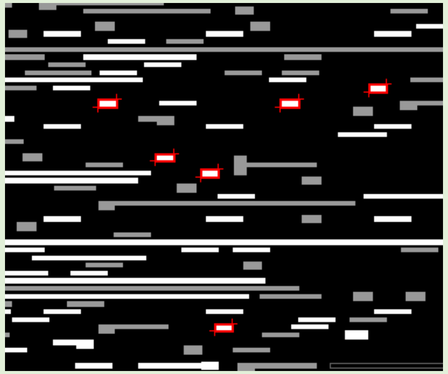
(2-4 weeks w/ logistics) Wafer Sort Test

(4-6 weeks) BEOL processing

(1-2 weeks) MOL processing

(1-2 weeks) FEOL processing

DirectScan Accelerated Learning Cycle



- eProbe inline Point scanning
- Inspect **full wafer within days of process split** (CIP, OPC, or DFM).
- Inspect >200B patterns per day
- "Short flow" learning mode possible (skip unrelated FEOL & MOL processing) to further accelerate learning cycle

The result of over 20 years of Innovation

1997 Integrated Yield Ramp

2003 Yield Analysis

2006 FDC

2008 Big Data YA-FDC

2015 Test

2017 Assembly, Traceability

2019 AI / ML Cloud

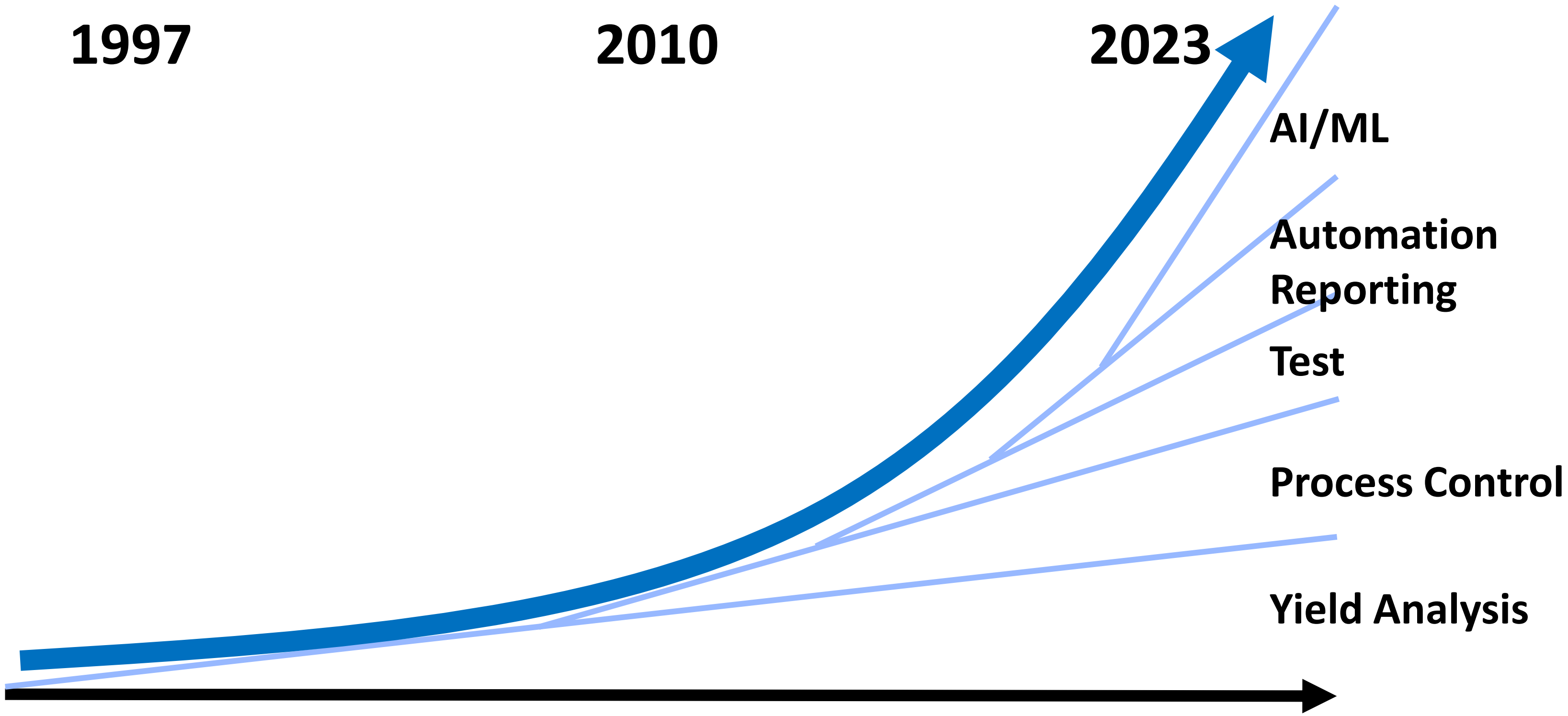
2020 Equipment Analytics

2022 eProbe DirectScan

Enhancing Yield Ramp → *Semi Supply Chain Analytics*

PDF/SOLUTIONS™

A stable platform built on latest available IT



AI/ML

Automation

Reporting

Test

Process Control

Yield Analysis

1997	2010	2023
On Premise	On Premise	Hybrid Cloud
RDB	RDB & NRDB	NRDB
Unix	Linux	Linux
Thick Client	Windows Client	Multi Client & Mobile

- The functionality delivered by the platform has rapidly increased
- The platform continuously evolves to take advantage of the latest IT innovation
- As the IT stack evolves, we maintain full compatibility of the customer workloads, control and test plans

PDF/SOLUTIONS™

PDF Solutions is your proven partner for the future of Semiconductor Technology Development and Manufacturing

Process Technology

3D Complexity

Global Supply Chain

AI and Platform

Thank You

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