This presentation contains forward-looking statements regarding PDF Solutions' future products and business prospects that involve risk and uncertainty. Actual results could differ materially from those discussed. You should review PDF Solutions' SEC filings, including its annual report on Form 10-K and quarterly reports on Form 10-Q, for more information on these risks and uncertainties. PDF Solutions does not undertake an obligation to update any such statements.
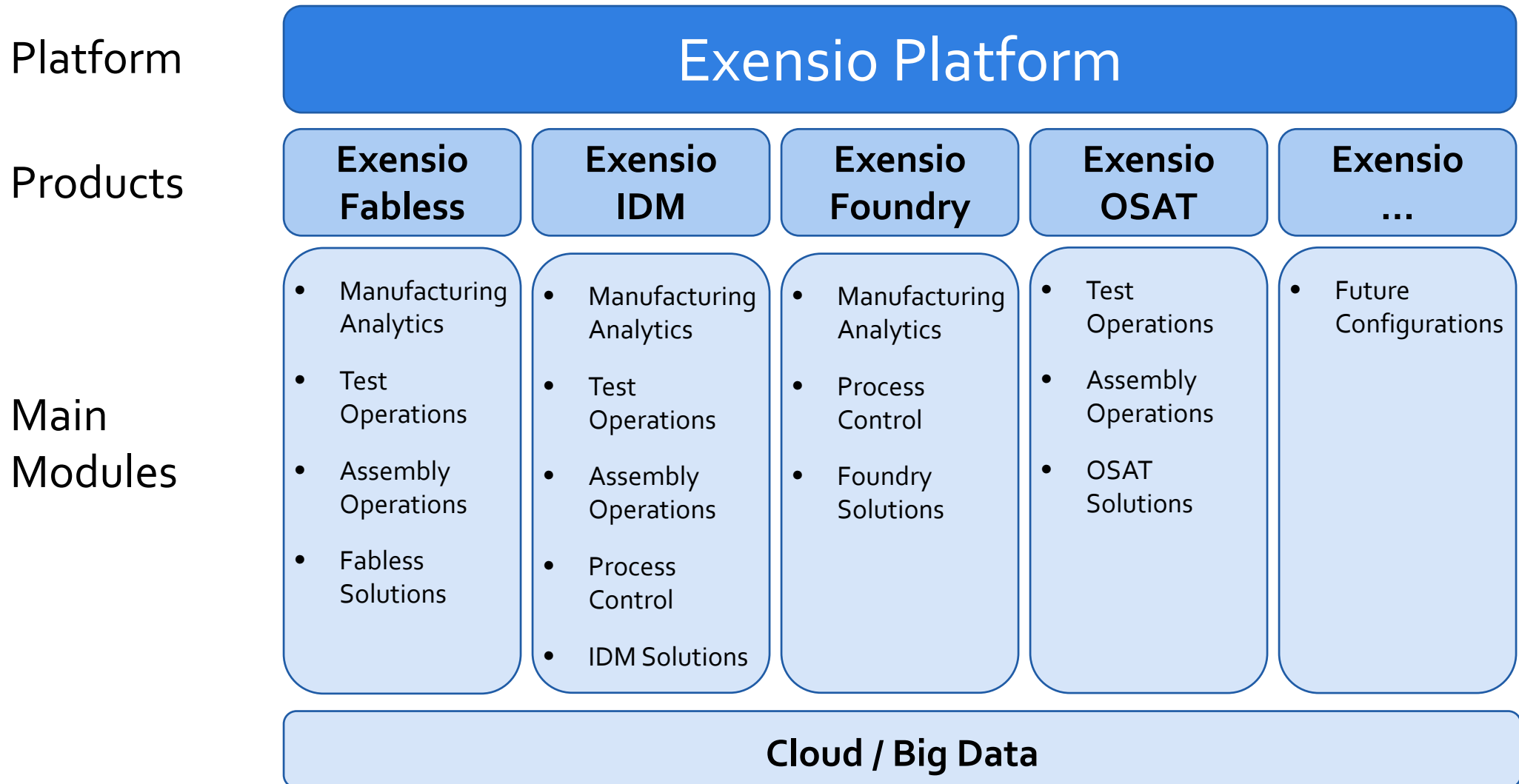
Exensio Platform: Big Data Analytics and Control for Semiconductors

Process Control
Detect and identify process or tool problems in manufacturing in real time

Test Operations
OEE optimization, escape prevention, and yield recovery

Manufacturing Analytics
Higher manufacturing yields via integration of all front-end and back-end data

Assembly Operations
Traceability of wafers, die, and multichip modules through assembly & packaging

Process Characterization
Analytics that support the DFI System and CV Core System

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Exensio as a Platform

Platform	Exensio Platform				
Products	**Exensio Fabless**	**Exensio IDM**	**Exensio Foundry**	**Exensio OSAT**	**Exensio ...**
Main Modules	• Manufacturing Analytics • Test Operations • Assembly Operations • Fabless Solutions	• Manufacturing Analytics • Test Operations • Assembly Operations • Process Control • IDM Solutions	• Manufacturing Analytics • Process Control • Foundry Solutions	• Test Operations • Assembly Operations • OSAT Solutions	• Future Configurations
	Cloud / Big Data				

Motivation – Fabless Example

Exensio Fabless

Manufacturing Analytics
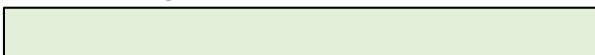
Advanced Capabilities

Monitoring

Test Operations

Advanced Capabilities

Monitoring

Data collection / Control

Assembly Operations

Advanced Capabilities

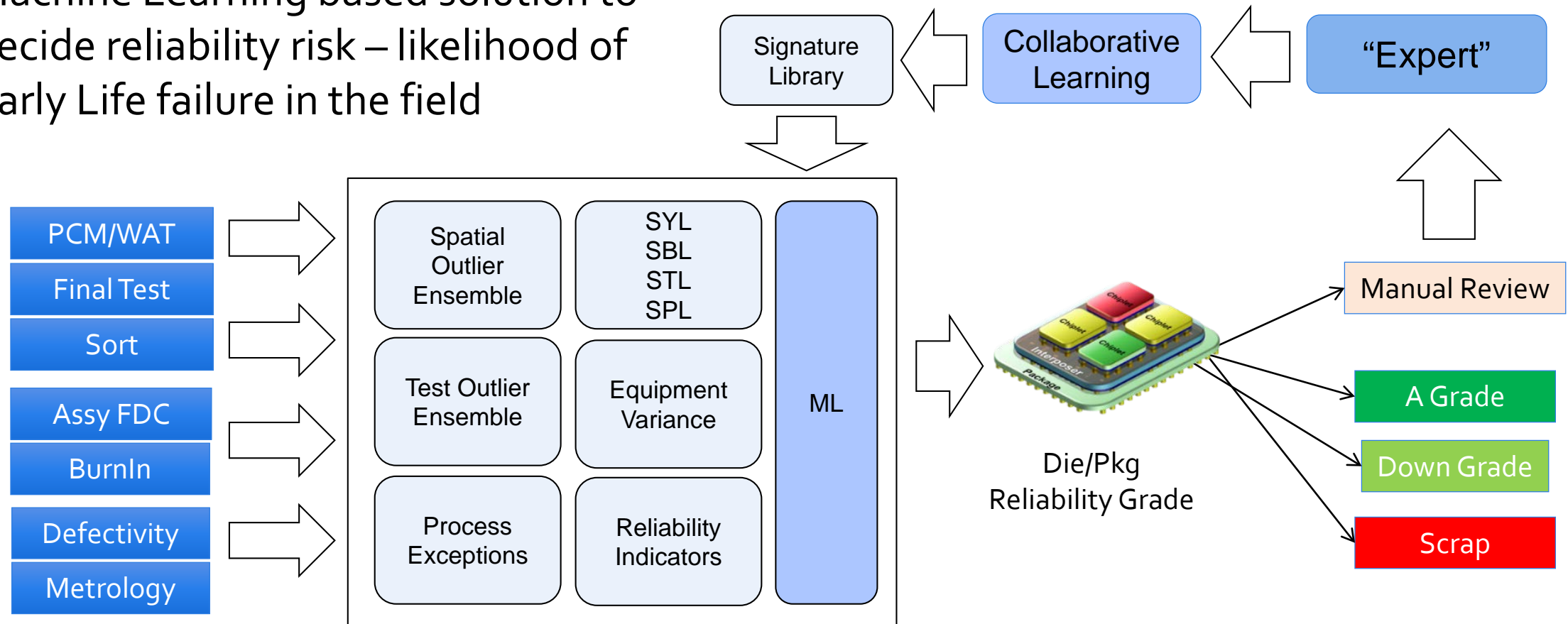Monitoring

Data collection / Control

Fabless Solutions
Reporting
Big Data

Targeted configuration - Core capability – Consistent sub-modules – One business model – Lite versions – Big Data across the modules –Reporting and automation across the modules – Fabless Solutions

Early Life Failure Detection (ELF)

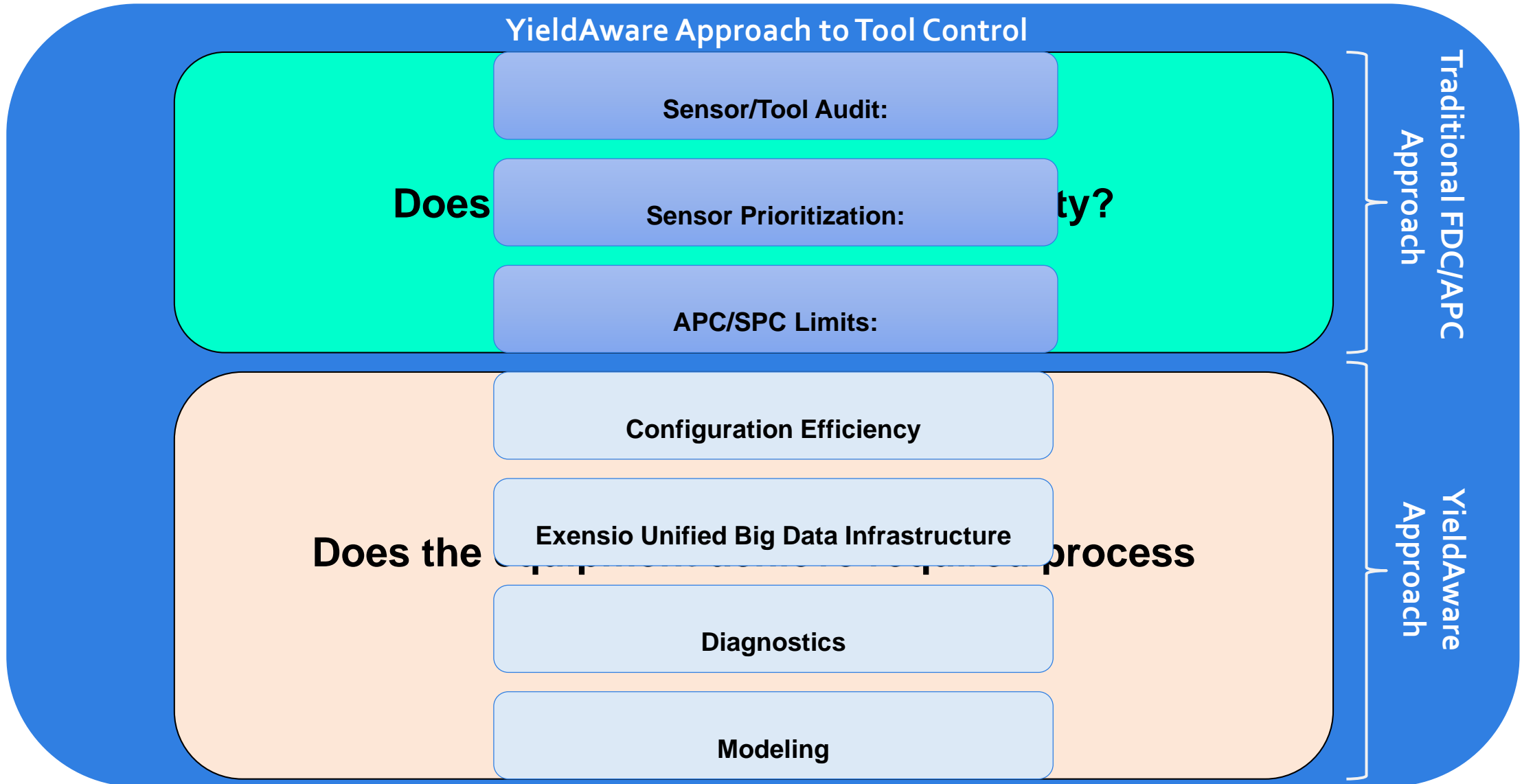Machine Learning based solution to decide reliability risk – likelihood of Early Life failure in the field

Signature Library

Collaborative Learning

"Expert"

PCM/WAT
Final Test
Sort

Assy FDC
BurnIn

Defectivity
Metrology

Spatial Outlier Ensemble

SYL
SBL
STL
SPL

Test Outlier Ensemble

Equipment Variance

ML

Process Exceptions

Reliability Indicators

Die/Pkg Reliability Grade

Manual Review

A Grade

Down Grade

Scrap

Multiple data types, Multiple algorithms, Machine Learning, Potentially large data sets, Collaborative Learning, …

Point Solutions not Sufficient
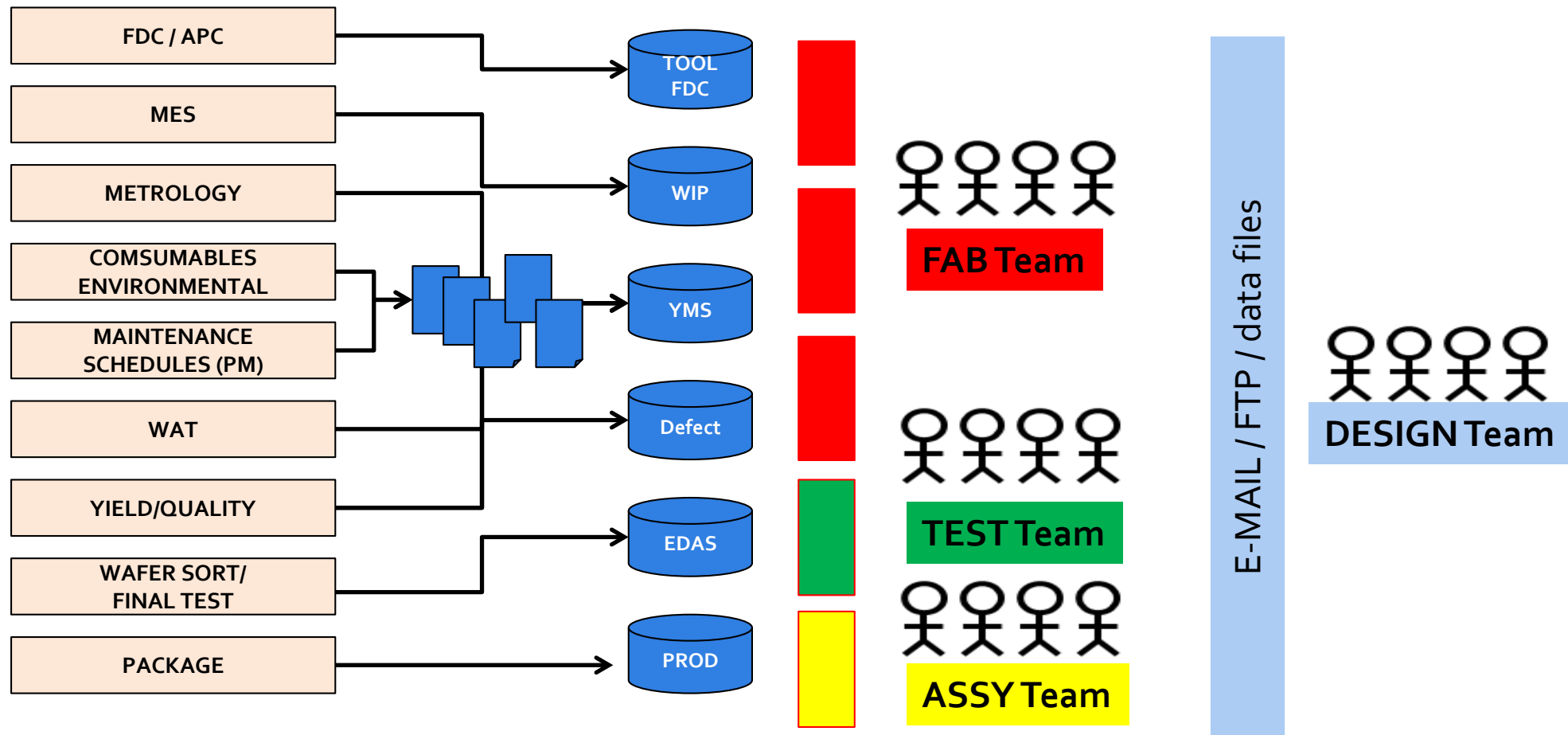
Multiple Databases – Multiple User Interfaces - Custom integrations - Silos with only part of the picture available to each team – Local optimization – Many data types/formats

7

Point Solutions not Sufficient – Tool Vs. Process Optimization

YieldAware Approach to Tool Control

Does ... **ty?**

Sensor/Tool Audit:

Sensor Prioritization:

APC/SPC Limits:

Does the ... **process**

Configuration Efficiency

Exensio Unified Big Data Infrastructure

Diagnostics

Modeling

Traditional FDC/APC Approach

YieldAware Approach

Raw Files in a Data Lake Also Not Sufficient

Intelligence

- ✓ **Solutions**
- ✓ **Machine Learning**
- ✓ **Ease of Use**
- ✓ **Collaboration**

Infrastructure

- ✓ **Performance**
- ✓ **Control**
- ✓ **Automation**
- ✓ **Security**
- ✓ **Cloud**

Domain Knowledge

- ✓ **Unique Data**
- ✓ **Unique Analytics**
- ✓ **Semantic Models**

Data Quality

- ✓ **End-to-End**
- ✓ **Traceability**
- ✓ **Consistency**
- ✓ **Completeness**

Efficiency

Yield

Quality

ROI

Time to Mkt

Semantic Models - A Key Element for Advanced Analytics and Control

- Semantic models allow for automatically cleaning, aligning, and interpreting data

- Examples:
    - Aligning events in a fab with wafer data to answer question like "which wafers were processed with the new batch of resist"?
    - Mapping equipment signals across a fleet of tools to account for configuration differences
    - Meaningful merging of chip data as the chips flow through wafer sort, assembly, and final test

- Digital Twins require models and harmonized data collection to enable machine learning

Semantic models allow our customers to deploy advanced analytics and control to production
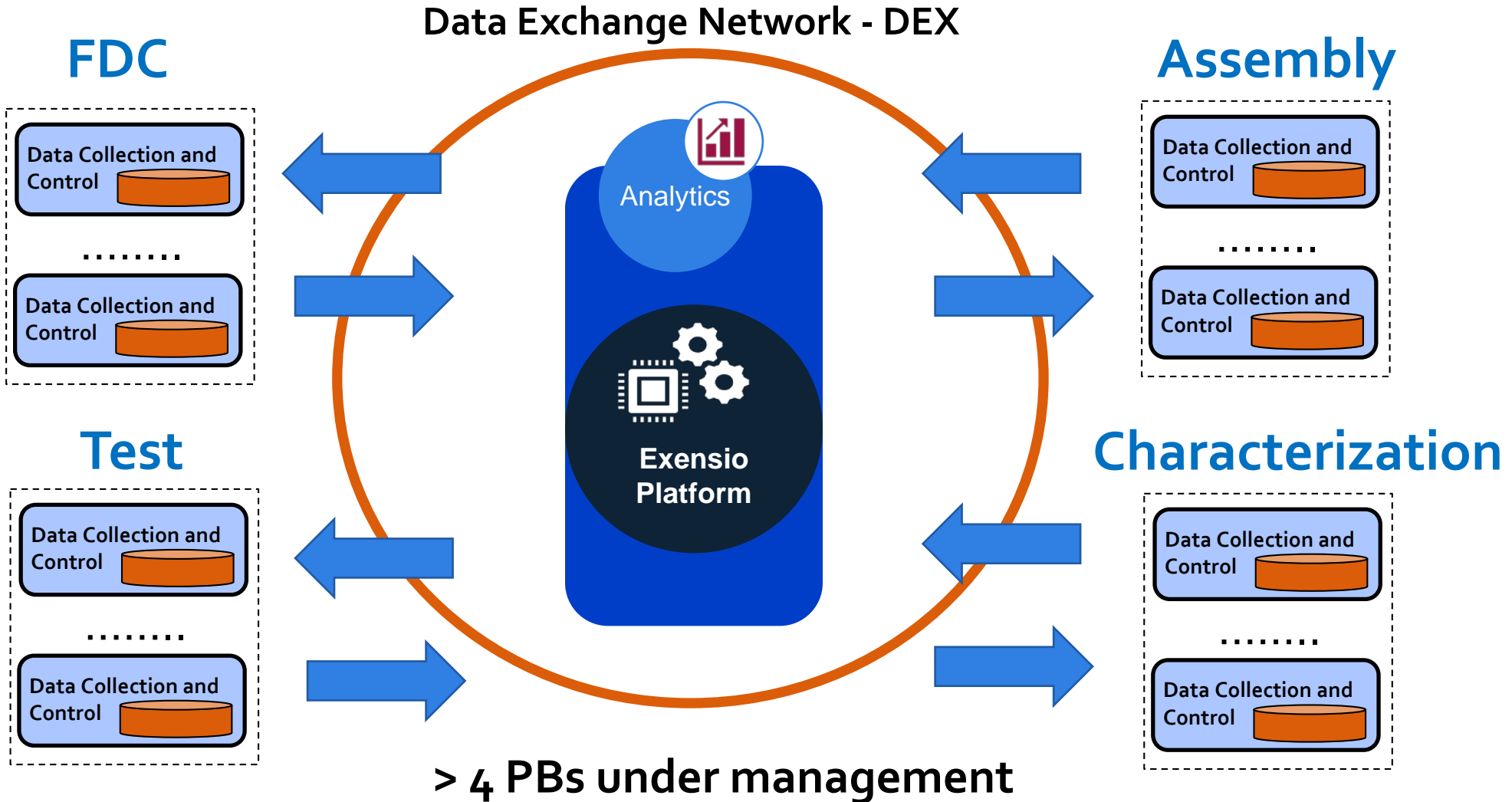
PDF/SOLUTIONS™

Data Quality – End-to-End

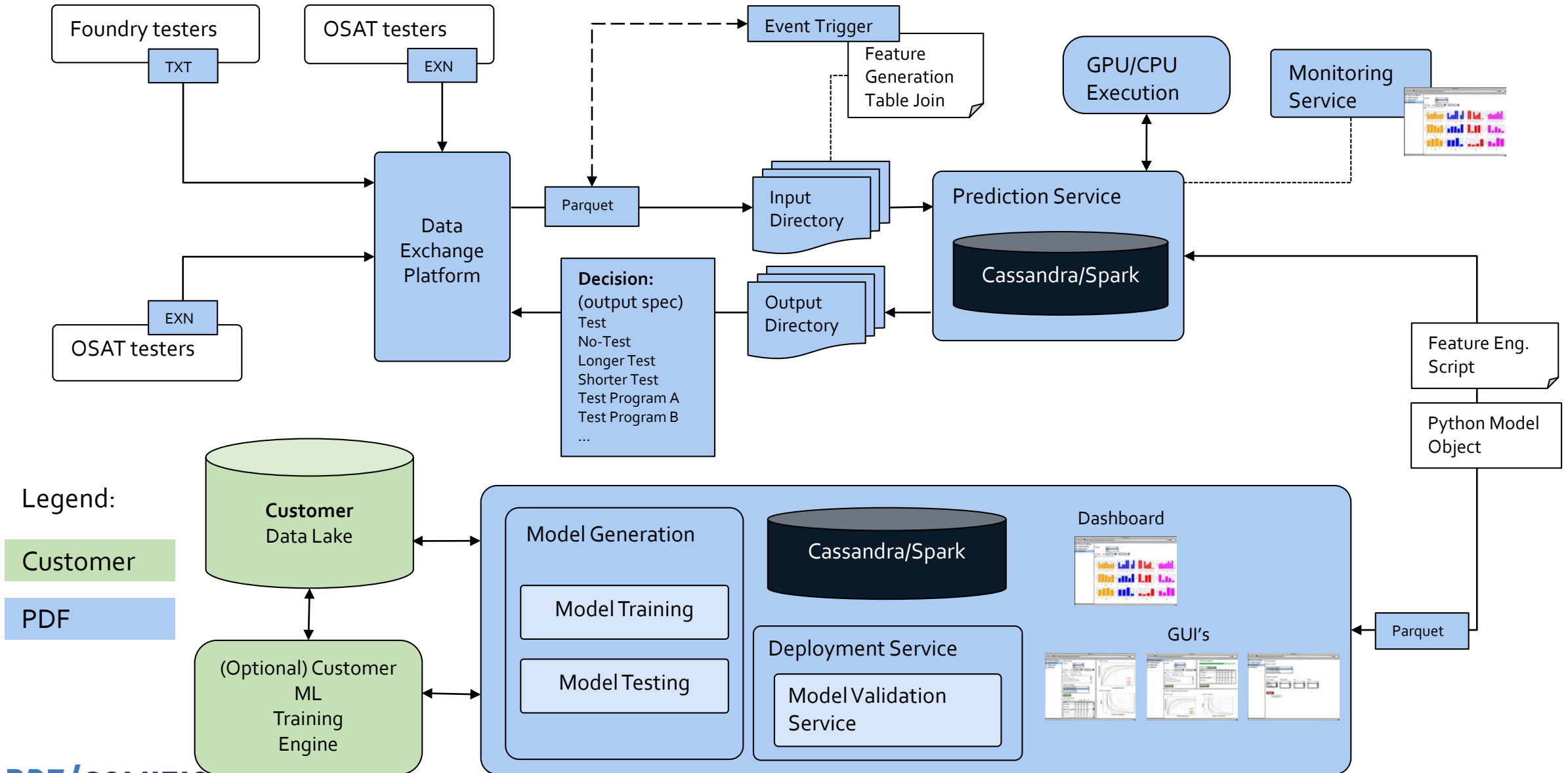| IC Design	Fab	Sort	Assembly	Final Test	System
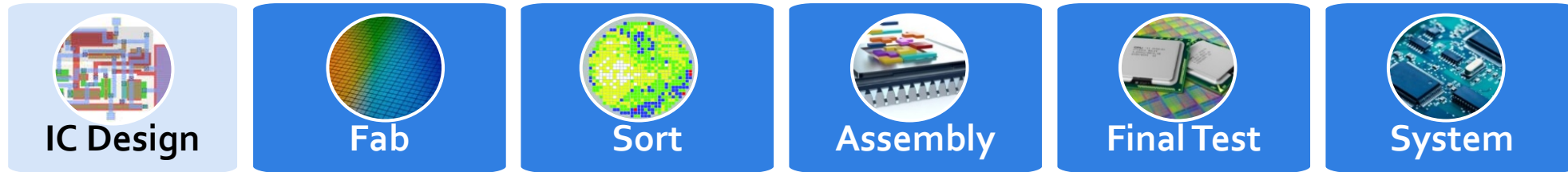
Material Descriptions In Hierarchy	Meta Data	MES/ WIP Equipment History	Fault Detection and Control (FDC)	Defect & Metrology	Equipment and Non-Lot	Product	Assembly / System	External Data Sources
Technology Family Process Product Source Lot Lot Wafer # Die	Equipment Operator Program Recipe Date/Time Process Flow Stages Steps	Equipment TrackIn/Out Recipe Operator Chamber QueueTime CycleTime Wfr Counts Reticle	**Indicators Summaries Trace Charts Model prediction Exensio real time data collection**	Parametric Categorical Lot / Wafer Summaries Defect Summary Kill Ratio Defect Images	Equipment SPC Fab chemical delivery Equipment counter data Equipment Event / PM Consumables	**sCV testchip DPCV PCM Wafer Sort Bin Map Multi-Bin Final Test Module Data**	Die traceability Location of reel/tube Solder paste batch, vendor Equipment parameters Operator logs	Other performance metric databases …

>100 Fab Tools Types supported, >20 Tester Types supported, >160 Assembly Tool Types supported, > 50 Data types supported

Data Quality – Completeness/Consistency – Data Collection/DEX

Data Exchange Network - DEX

FDC

Assembly

Test

Characterization

Analytics

Exensio Platform

Data Collection and Control

> 4 PBs under management

Edge Deployment - Smart Testing

Legend:

Customer

PDF

Direct Data Collection and Control

>40 vendors and **> 100** equipment models for manufacturing

> 50 vendors and **> 150** equipment models for assembly

> 20 vendors and **> 50** tester / prober / handler models for test

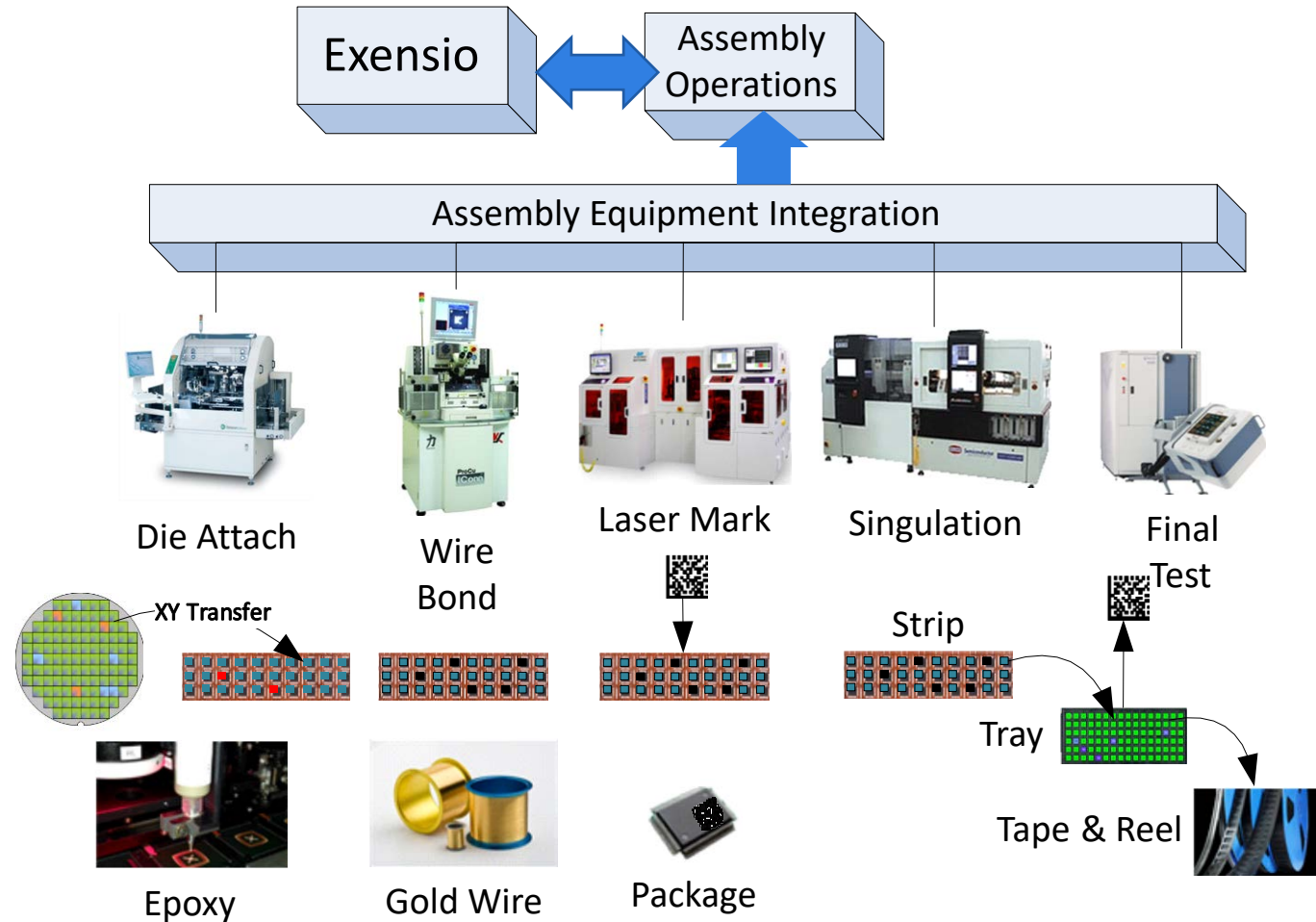## Continuously Adding to the Supported Platforms

Data Quality – Traceability - Single Device Tracking without ECID

o Required

  – Die Attach

    – Record Wafer ID + XY to Strip ID + XY

  – Device Mark

    – Mark package with unique ID

    – Upload strip map with ID + XY + Device ID

  – Singulation

    – Singulate and sort good packages for test

  – Final Test (singulated or strip test)

   – Read ID on package and insert in test data log

o Optional

  – Wire Bond, AOI

   – Skip FAIL bin locations and update strip map with wire bond defects

Exensio ↔ Assembly Operations

Assembly Equipment Integration

Die Attach | Wire Bond | Laser Mark | Singulation | Final Test

XY Transfer

Strip

Tray

Tape & Reel

Epoxy | Gold Wire | Package

Infrastructure – Performance

Exensio Big-Data as measured against Pure RDBMS architecture - Systems with same cost
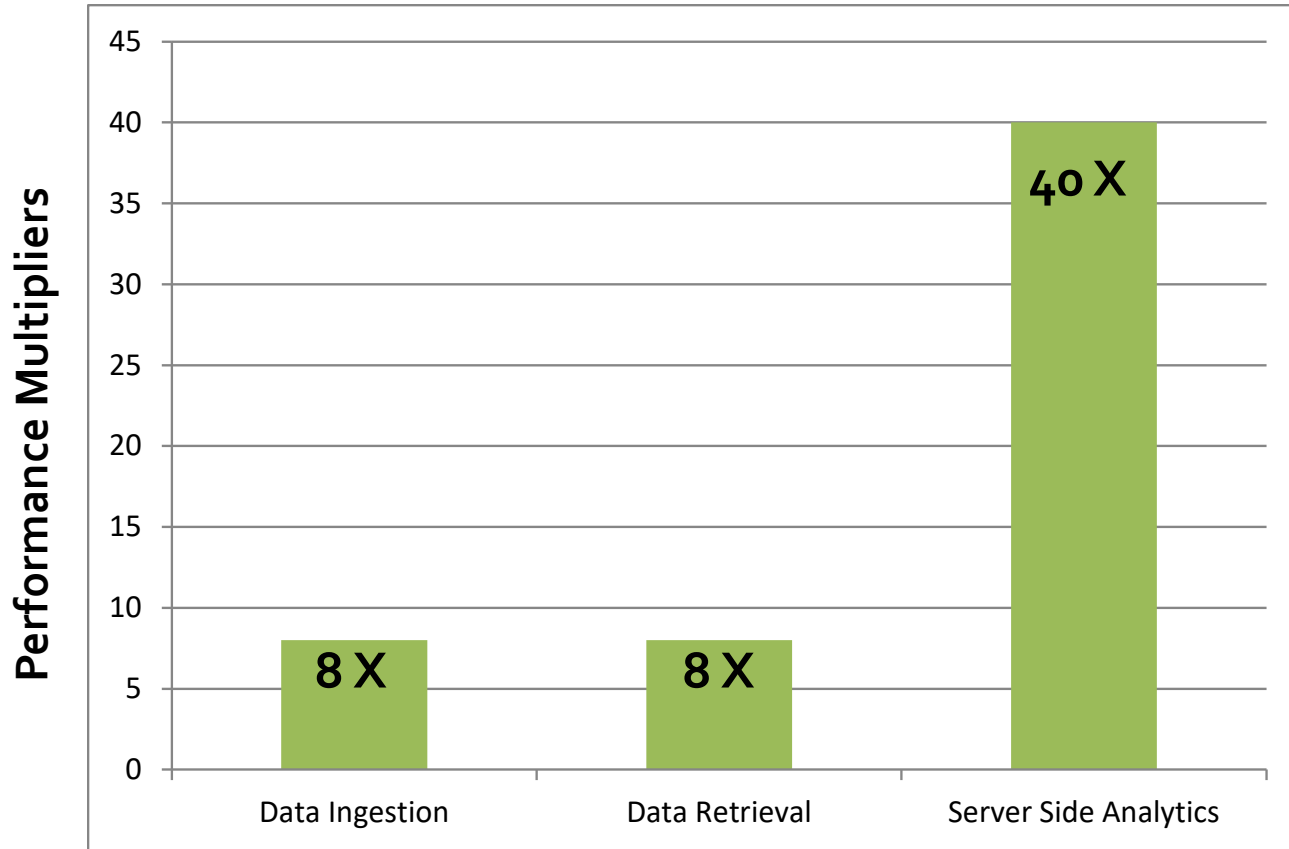
Average results from four pilots in 2019
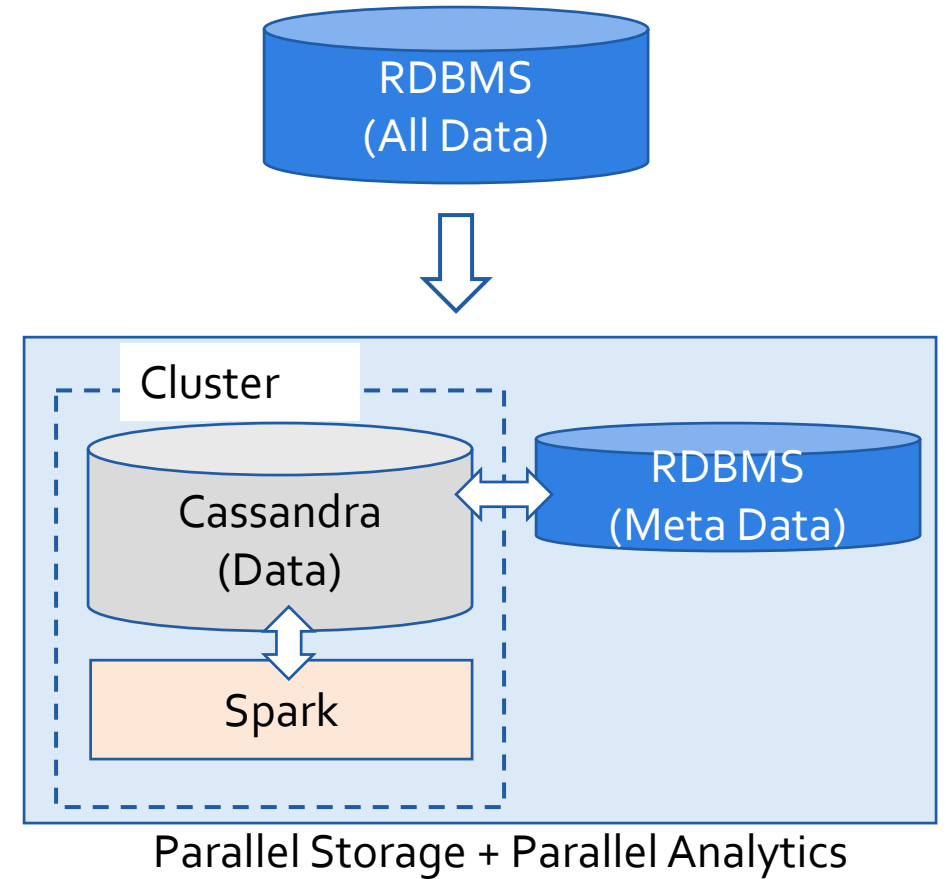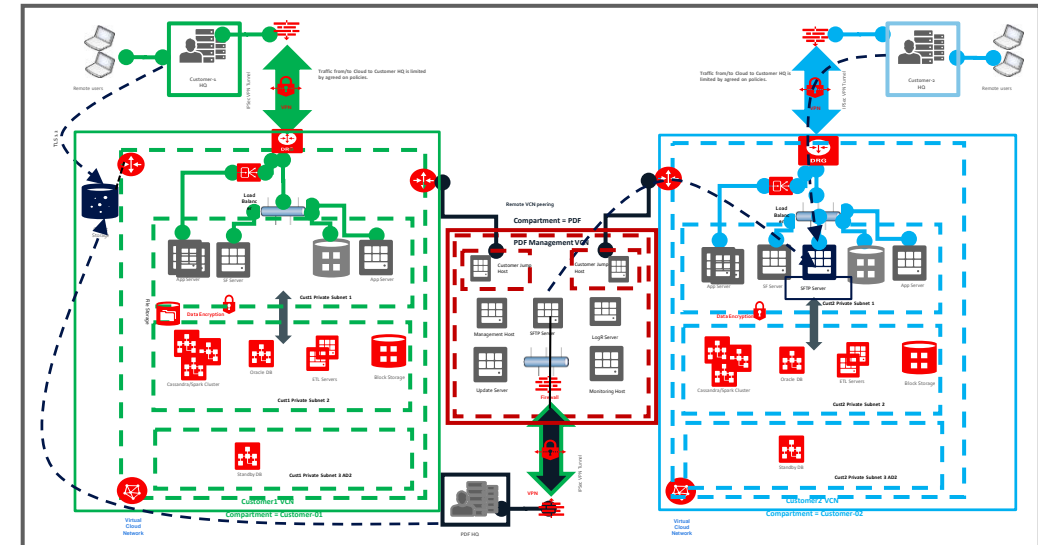
Example Benefits of Exensio Cloud Deployment

o Reduced costs compared to on-premise
  o For deployed projects range is between **18% and 34%**

o **24/7 support** and maintenance by expert resources
  o Faster access to latest releases and faster resolution of issues

o **Dynamic scaling** to fit future use scenarios
  o Organic growth (or reduction), Temporary needs, ML model training

o **Tiered storage** offered in future releases
  o Reduced costs and longer online data availability benefit

• **Consolidated environment** for the enterprise

• **Continuous Delivery** – Cloud releases and more feature/bug leading to continuous improvement in our solutions

  o 10% and 40% projected cost savings depending on retention and performance requirements

Acquired company in 2015 that was one of the first to deploy web-native analytics capabilities for the semiconductor industry on the cloud and integrated its capabilities within Exensio
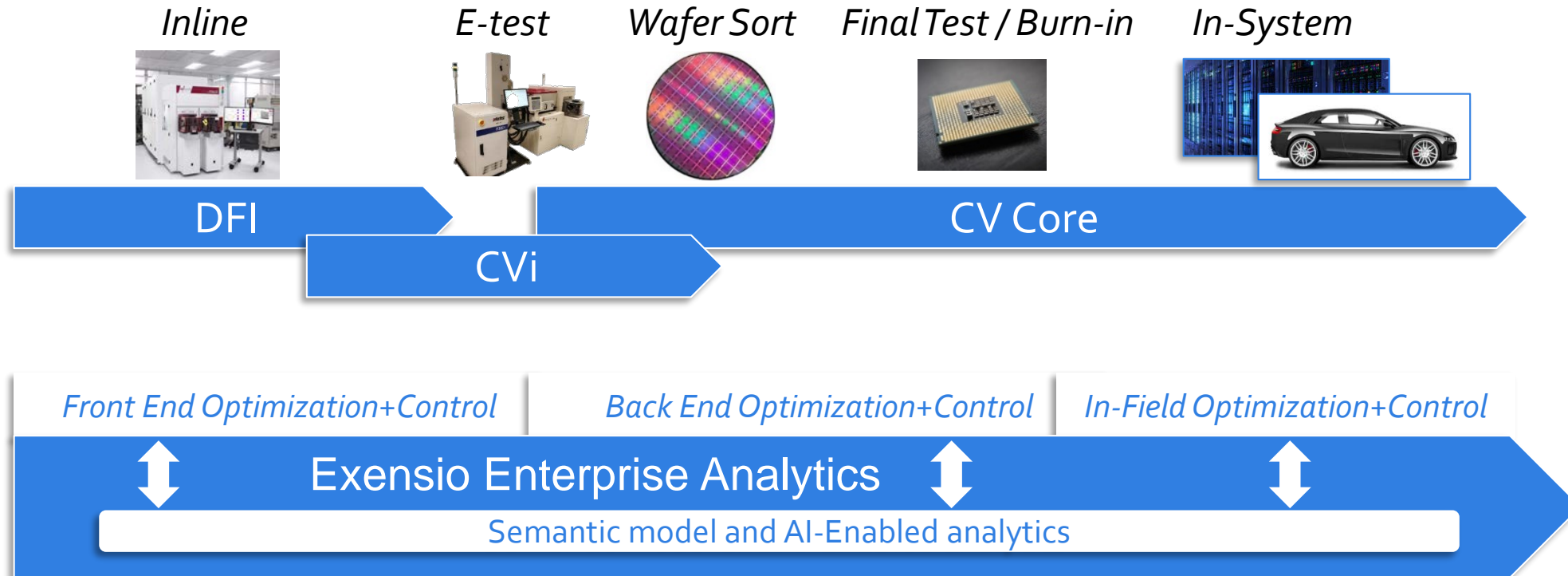
Constantly expanding percentage of accounts deploying Exensio on the cloud

Currently ~ 15% on the cloud with clear acceleration in this direction

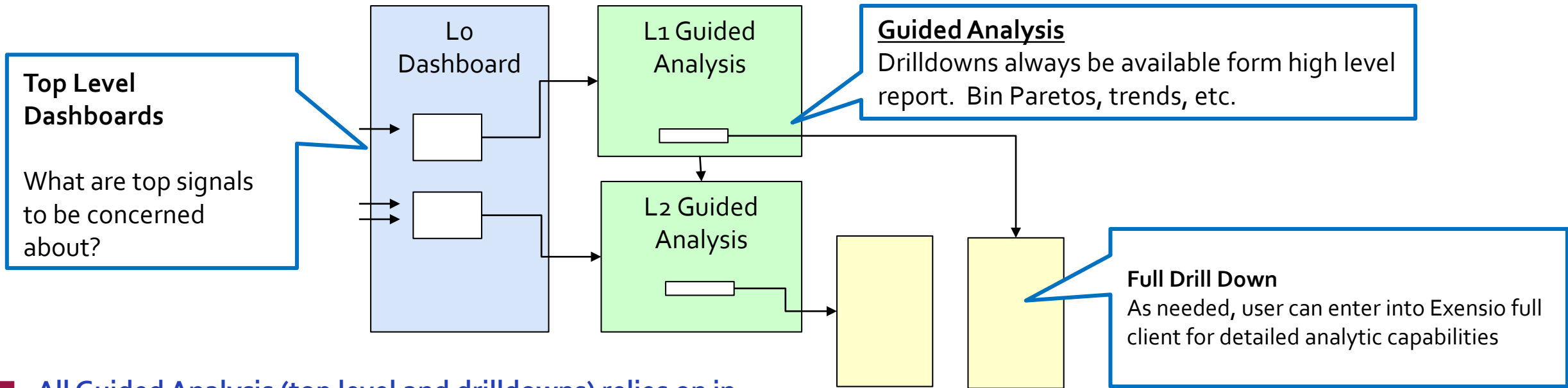AWS and AliCloud as primary cloud providers
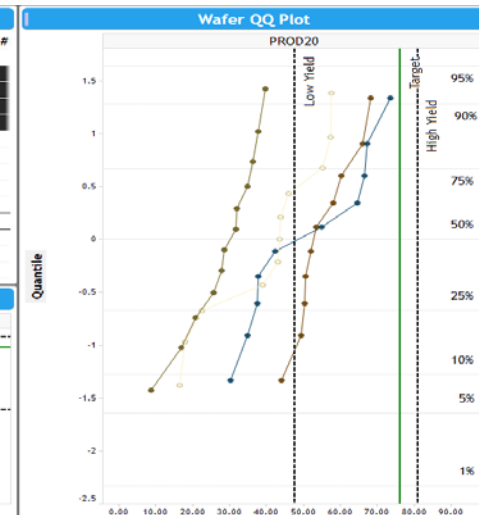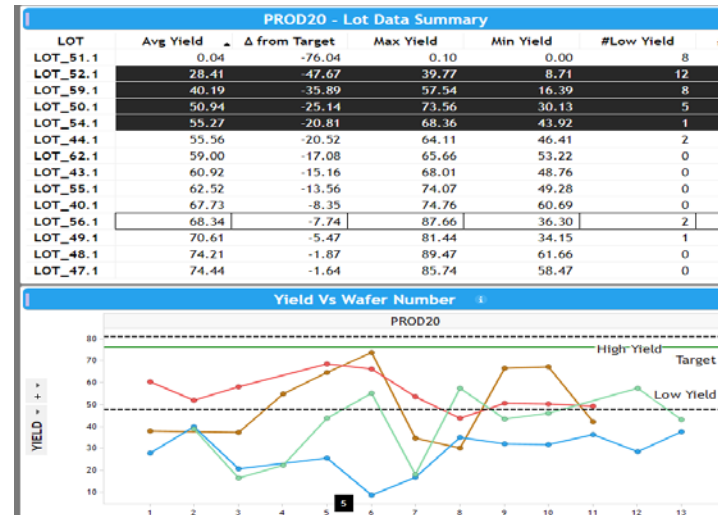
Domain Knowledge – Unique Data

Inline   *E-test*   *Wafer Sort*   *Final Test / Burn-in*   *In-System*

| DFI | | CV Core |

CVi

Front End Optimization+Control   *Back End Optimization+Control*   *In-Field Optimization+Control*

Exensio Enterprise Analytics

Semantic model and AI-Enabled analytics

Better Reliability (dppm, predictive fail) - Lower cost ($$) - Improved performance (speed, power)
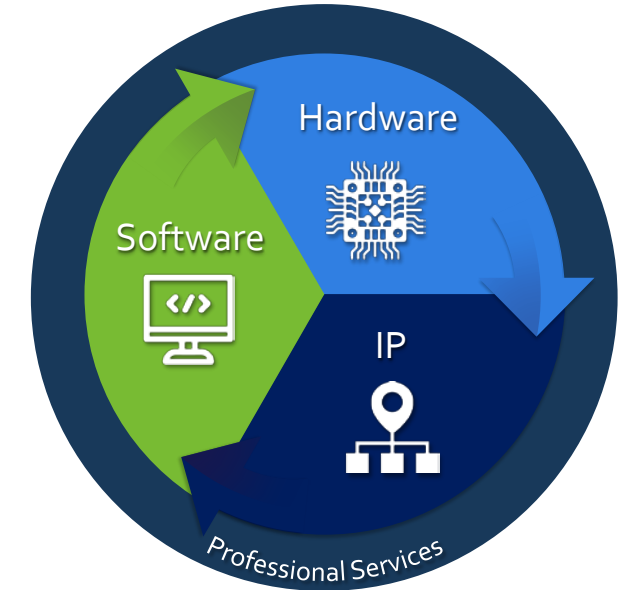
Ease of Use - Guided and Linked Analyses

Top Level Dashboards

What are top signals to be concerned about?

Lo Dashboard	L1 Guided Analysis

Guided Analysis
Drilldowns always be available form high level report. Bin Paretos, trends, etc.

L2 Guided Analysis

Full Drill Down
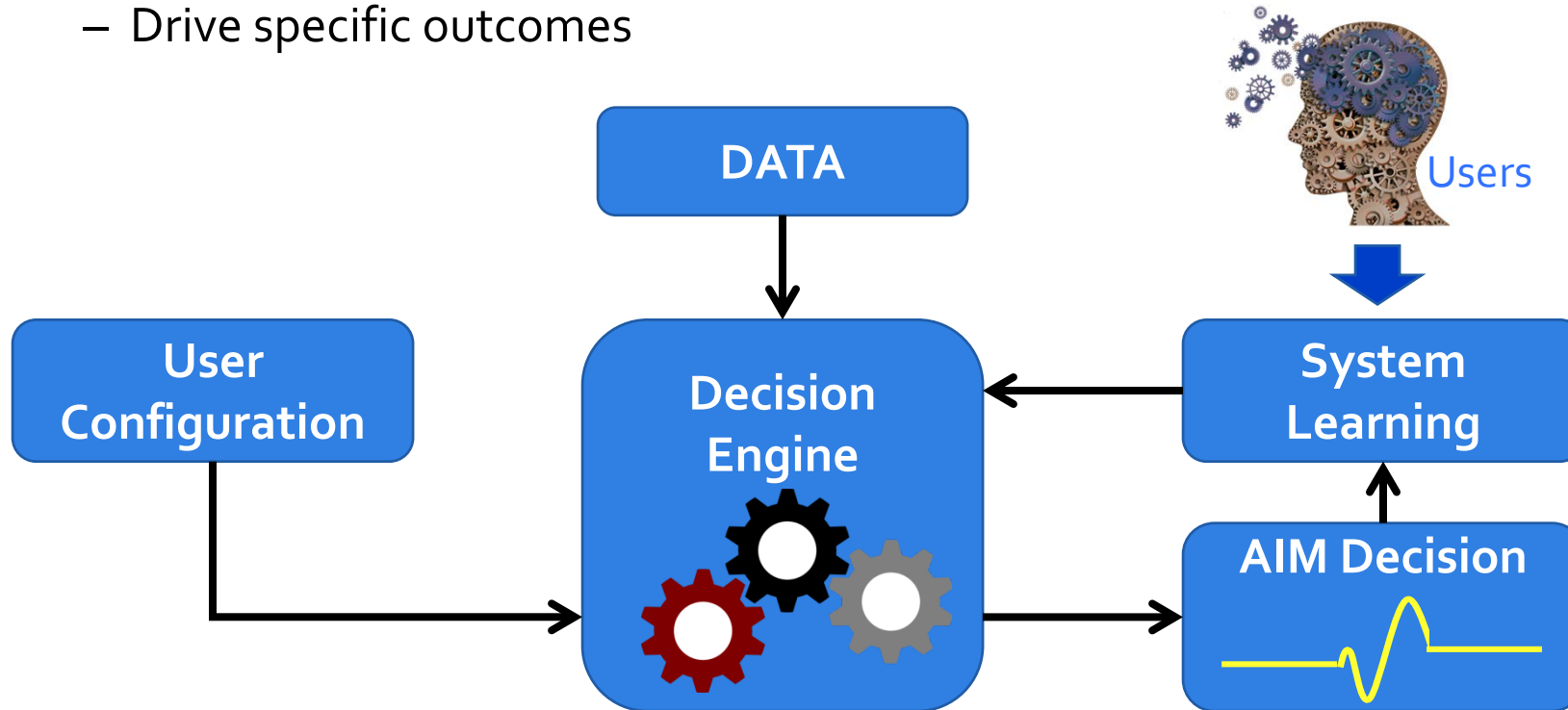As needed, user can enter into Exensio full client for detailed analytic capabilities

- **All Guided Analysis (top level and drilldowns) relies on in-database analytics, precomputed/summarized data, and our big data architecture → results are fast and ready for user.**

- **Hierarchical structure enable users to always know where there are in the guided analysis tree on left hand side with easy to use navigation tools.**

- **Ability to enter into "ad hoc mode" into full client Exensio-Yield capability, from any analysis as desired.**

PROD20 - Lot Data Summary

LOT	Avg Yield	Δ from Target	Max Yield	Min Yield	#Low Yield	#
LOT_51.1	0.04	-76.04	0.10	0.00	8	
LOT_52.1	28.41	-47.67	39.77	8.71	12	
LOT_59.1	40.19	-35.89	57.54	16.39	8	
LOT_50.1	50.94	-25.14	73.56	30.13	5	
LOT_54.1	55.27	-20.81	68.36	43.92	1	
LOT_44.1	55.56	-20.52	64.11	46.41	2	
LOT_62.1	59.00	-17.08	65.66	53.22	0	
LOT_43.1	60.92	-15.16	68.01	48.76	0	
LOT_55.1	62.52	-13.56	74.07	49.28	0	
LOT_40.1	67.73	-8.35	74.76	60.69	0	
LOT_56.1	68.34	-7.74	87.66	36.30	2	
LOT_49.1	70.61	-5.47	81.44	34.15	1	
LOT_48.1	74.21	-1.87	89.47	61.66	0	
LOT_47.1	74.44	-1.64	85.74	58.47	0	

Wafer QQ Plot — PROD20

Yield Vs Wafer Number — PROD20

Solutions: Combining Products & Expertise to Deliver Results

Advanced Insights for Manufacturing (AIM) Process & Test

- PDF's primary Solutions infrastructure
- Exensio SW Platform + ML + Change management
- Drive specific outcomes

Users

DATA

User Configuration

Decision Engine

System Learning

AIM Decision

Software

Hardware

IP

Professional Services

AIM solutions are not reports:

- **AUTOMATIC**
- **INTELLIGENT** AI + ML
- **CONFIGURABLE**

Embedding Best-In-Class Technologies for a Complete Solution

o PDF Focuses its development efforts on the areas where it can deliver value

o We license and OEM best in class components to leverage the expertise of others, including the open source community

o We handle all of the licensing from our suppliers, so our customers have only to reach agreement with PDF and get all sublicenses
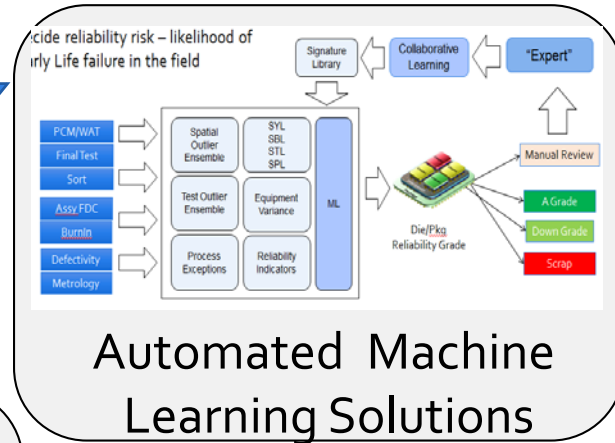
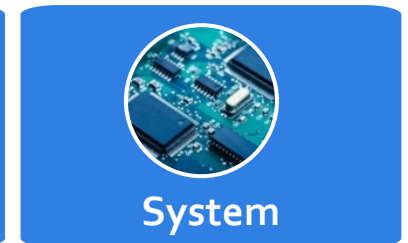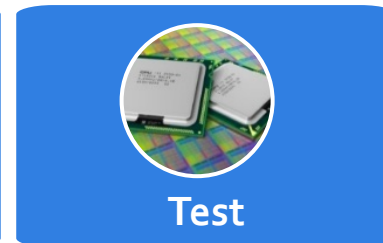# Exensio – The Organizing Principles
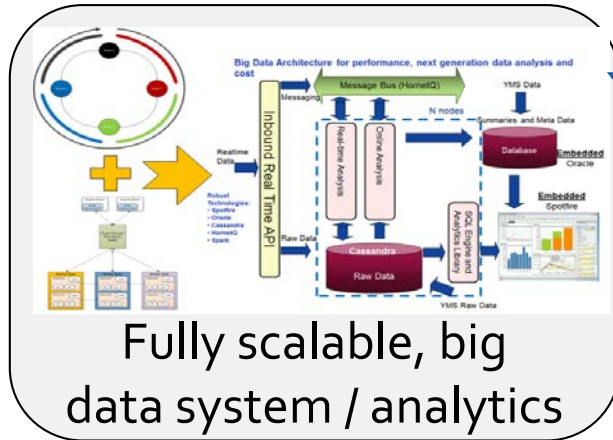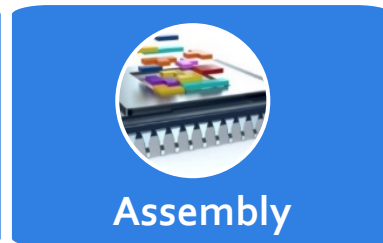

Fully scalable, big data system / analytics

PDF Domain Knowledge

Automated Machine Learning Solutions
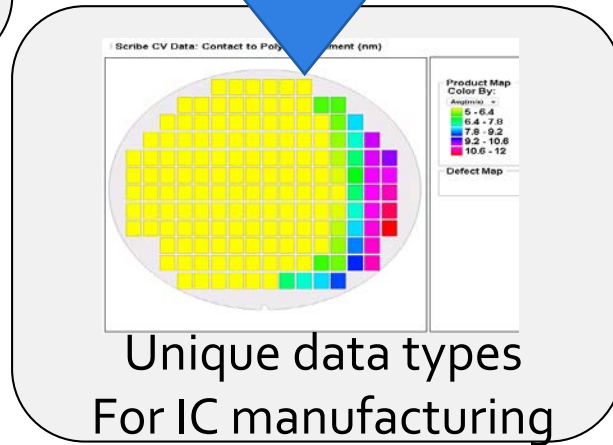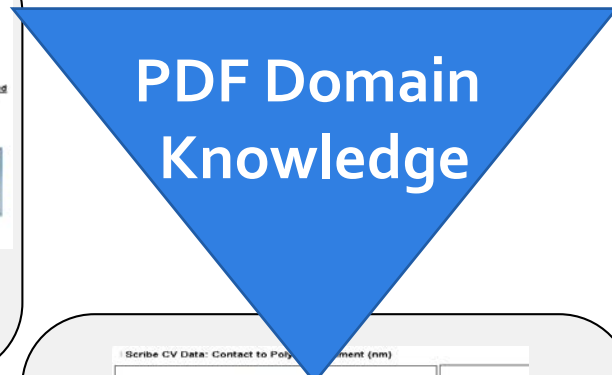
Unique data types For IC manufacturing

End-to-End Data

End-to-End Analytics & Control

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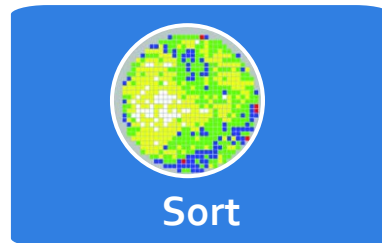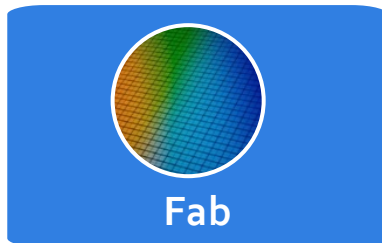
Thank You

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