IMPROVED YIELD, TEST AND QUALITY

PDF SOLUTIONS USER CONFERENCE

DATE: OCTOBER 25, 2023
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CENTRAL ENGINEERING DIVISION
RENESAS ELECTRONICS CORPORATION

AGENDA

➢Renesas Overview

- Data and Product Engineering Challenges
- Renesas Usage of PDF Cloud Yield Tool
- Examples of Usages
- Benefits of PDF Cloud Yield Tool

RENESAS OVERVIEW

Renesas empowers a safer, smarter and more sustainable future where technology helps make our lives easier.

The leading global provider of microcontrollers, Renesas combines our expertise in embedded processing, analog, power and connectivity to deliver complete semiconductor solutions. These Winning Combinations accelerate time to market for automotive, industrial, infrastructure and IoT applications, enabling billions of connected, intelligent devices that enhance the way people work and live.

Headquarters
Tokyo, Japan

Approx. 21,000
employees *

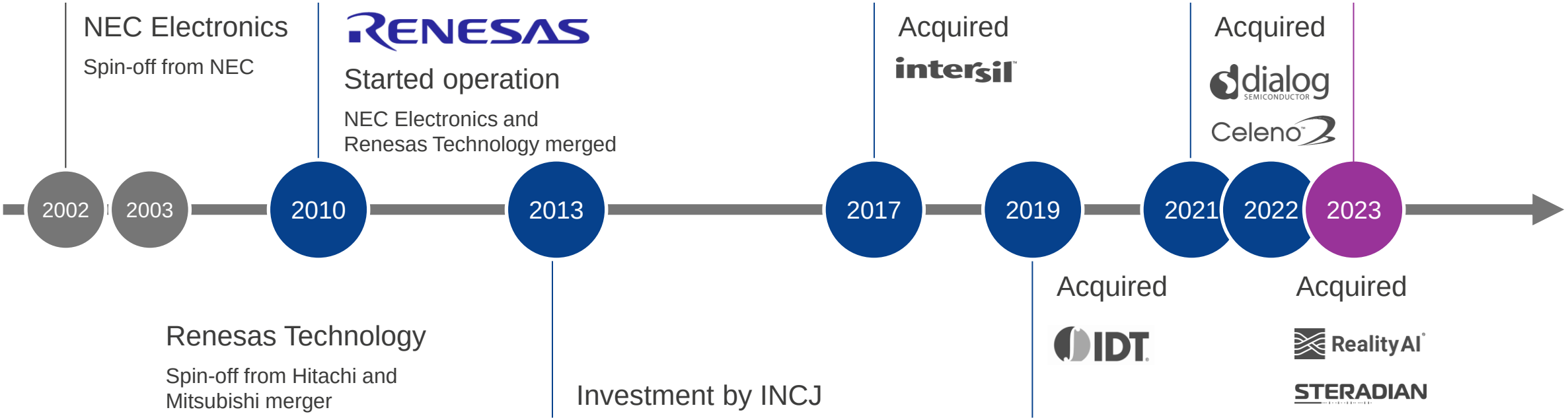
Operating in
30+ countries

1,502.7 billion yen
revenue in 2022
(~$10 billion USD)

Approx. 20,000
patents & pending applications

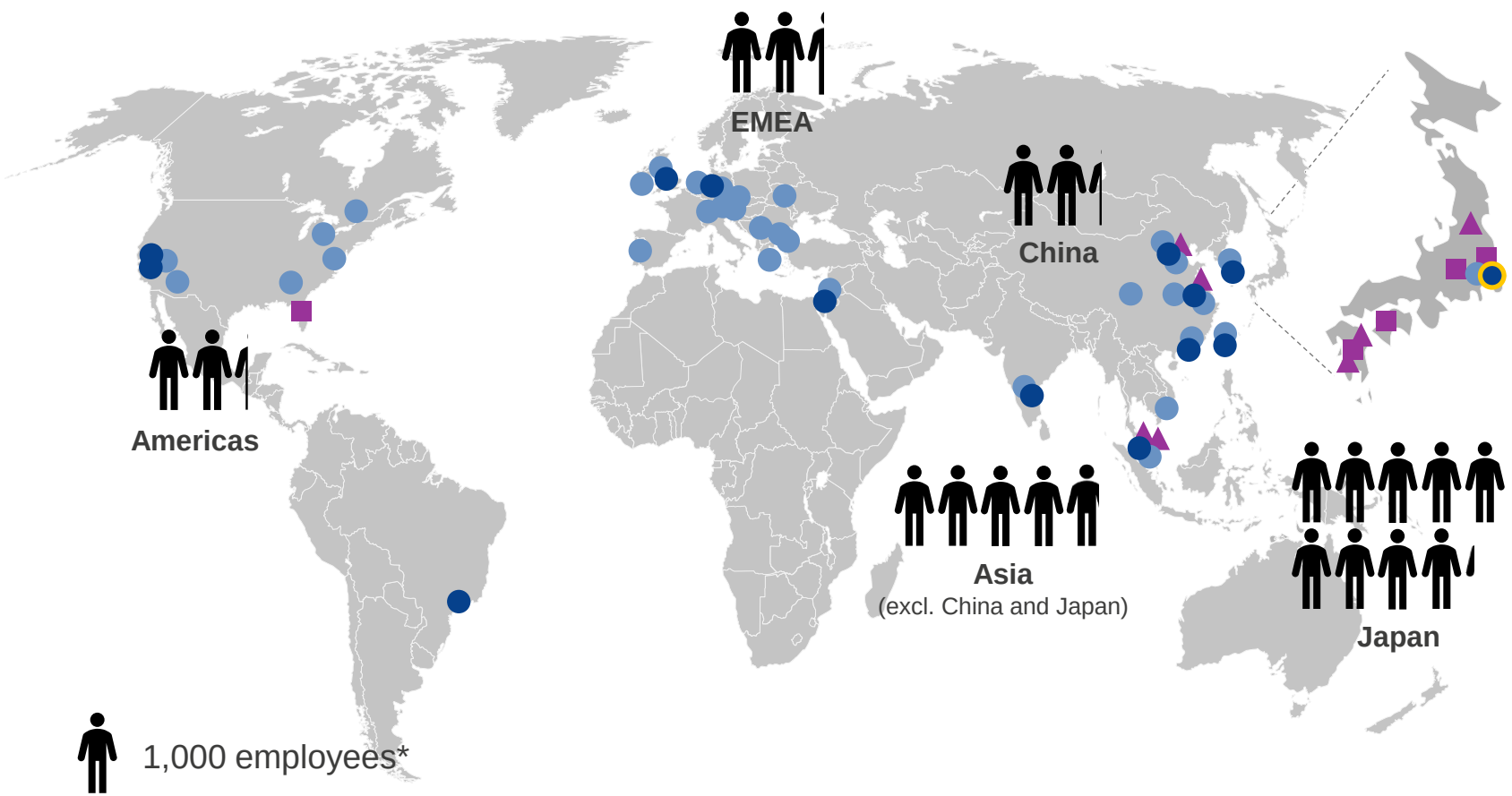
OUR HISTORY

Renesas is built on the foundation that combines the rich culture of technology and innovation of Hitachi, Mitsubishi and NEC. Since 2017, we have expanded our analog product portfolio through many acquisitions including Intersil, IDT, and Dialog. Renesas will continue to grow as a global leader in embedded solutions for high-growth markets: automotive, industrial/infrastructure and IoT.



Intersil: Intersil Corporation, IDT: Integrated Device Technology, Inc., Dialog: Dialog Semiconductor Plc, Celeno: Celeno Communications, Reality AI: Reality Analytics, Inc., Steradian: Steradian Semiconductors Private Limited

GLOBAL NETWORK



Global sales network operating across more than 20 countries

Comprehensive R&D capabilities enable seamless support across the globe

12 manufacturing facilities in Japan, China, Southeast Asia, and the US

Global partners such as TSMC and GLOBALFOUNDRIES

Headquarters Major sales offices R&D sites Manufacturing sites (□Front-end, △Back-end)

RENESAS EPSG CENTRAL ENGINEERING GROUP

Sailesh Chittipeddi
EVP / GM

SCOTT MARTIN
VP
Central Engineering Division

HELEN YU
Sr. DIRECTOR
PE/TE/PM/Foundry

Product Test Engineering

Program Management

Foundry Operations

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DATA CHALLENGES

- **Huge, World-wide organizations**
  - High number and large variety of products
  - Need to handle large data sizes and produce meaningful analysis
- **Comprised of many mergers / acquisitions with different procedures and formats of data**
  - Various databases, loading structures and methods
  - Different retest and binning methodology.
  - Different naming systems for test insertions.
  - Different naming systems for test hard wares (e.g. handler IDs, LB IDs, ATE tester IDs)
- **Data integrity challenges**
  - Different data loading rules in different acquisitions
  - Inconsistent STDF file format
  - Old type of ATE tester platforms don’t support STDF file format

PRODUCT ENGINEERING CHALLENGES

- **Comprised of many mergers with various analysis tools and analysis styles across x-companies**
  - Acquired companies have different tools to analyze data
  - Results in non-unified and non-standard reports
  - High tool maintenance cost
- **Most product engineers used another vendor and/or internal tools**
  - In the other vendor's tools, data analysis was slow.
  - Sometimes engineers need to wait for custom template generation before doing the analysis.
  - Sometimes engineers need to wait a whole night to download the data from a remote server before doing analysis.
  - Sometimes engineers have difficulties to merge test data (e.g first test vs retest).
  - Internal tools are excellent for fast generation of overall yield summaries, but lack in-depth data analytic capability.

LOOK FOR NEW SOLUTIONS

- **To solve these data and product engineering challenges it faced for years, Renesas decided to evaluate several SW packages and decided to run a pilot with PDF Solutions at the end of 2020**

- **Key metrics for this pilot included**
  - Data loading compatibility
  - Ease of analysis
  - Analytics features and capability
  - Analysis scope and ability to customize
  - Scalability of the tool

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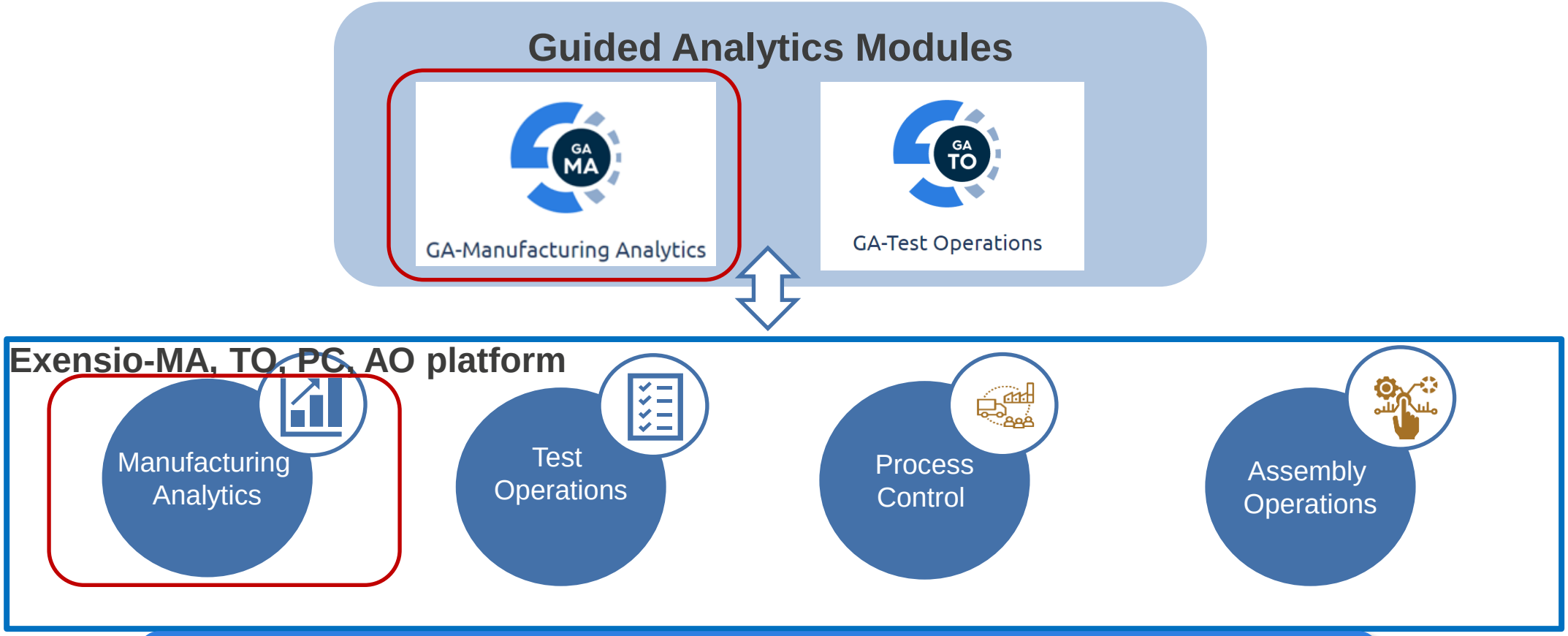
WHAT IS GUIDED ANALYTICS?



Guided Analytics provides easy to use, fast, and structured analysis flows

GUIDED ANALYTICS: *POWERFUL AND EASY TO USE*

Automates up to 90% of analysis; Quickly review with few clicks

- High level dashboard: At-a-glance prioritization across products
- Accelerate root cause diagnosis using AI/ML saving weeks of engineering effort
- Issue-based flow: Guides novice users through typical Product Engineering analyses
- Easy to customize analysis and perform ad-hoc drill-down

Easy to learn, high efficiency product analysis

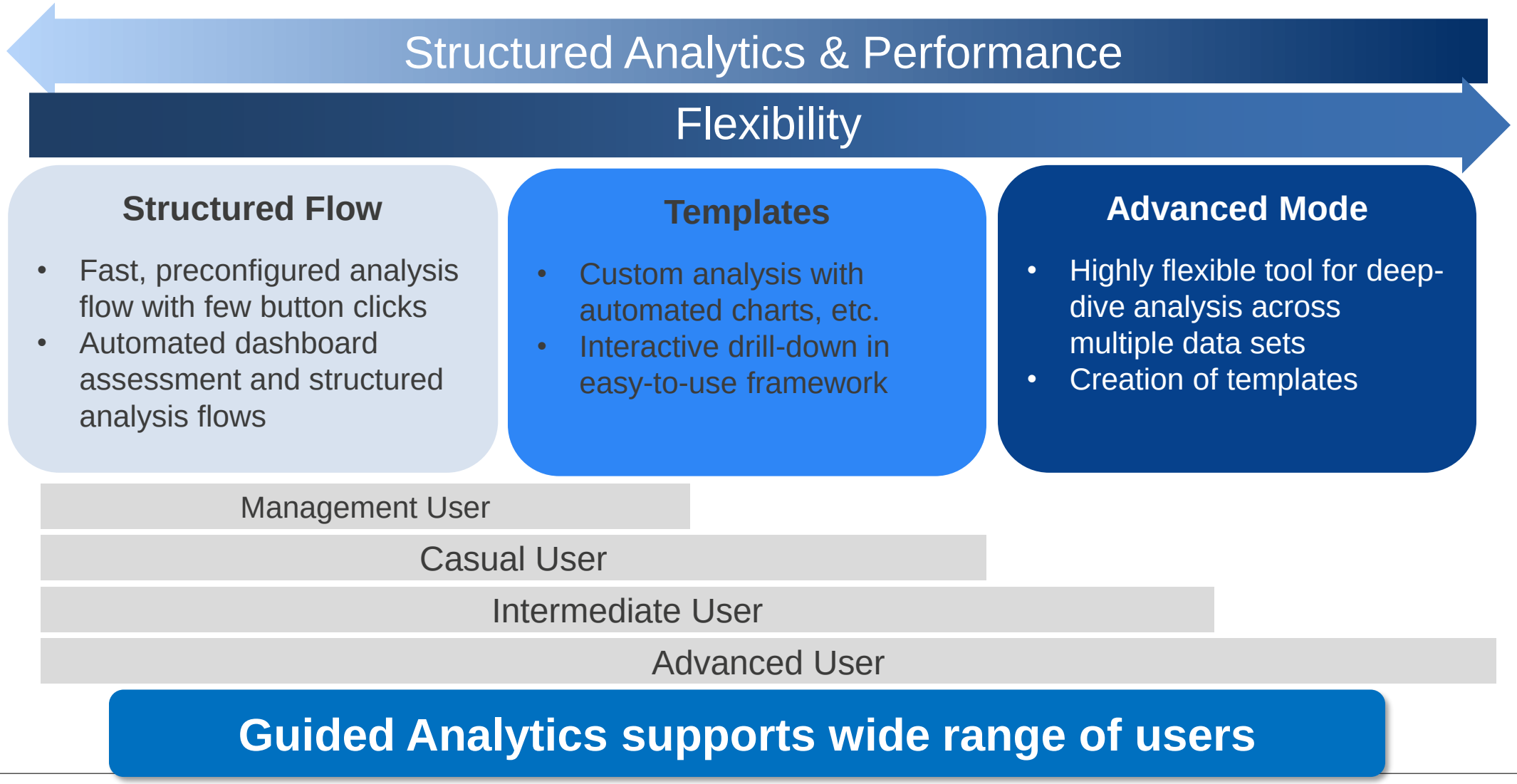
Ultra-fast performance

- Views within seconds: pre-summarized analysis, data, and images
- Powered by Cassandra and Spark: 40x faster than relational dB for raw data summarization
- Performance advantage improves with data size

Analyze all your data types

- Continuously mine 100% of your data: Identify problems while you sleep
- Seamless integration of data types: Hard Bin, Soft Bin, parametric, PCM, test tools, etc.
- Industry leading semantic data model automatically identifies data relationships

GUIDED ANALYTICS: *FAST TIME TO MEANINGFUL RESULTS*



GUIDED ANALYTICS – MANUFACTURING ANALYTICS (GA-MA)

- **Benefits of data integration efforts to align data**
  - Set up & enforced rules before data loaded, e.g. WS wafer configuration standardization, STDF file standardization, Renesas TDTF file template to standardize non-standard file formats.
  - Determine protocols with PDF to determine final yield consolidation
    - Retest Hard Bin standardization
    - Aggregate yield calculation methodology by considering various retest protocols
- **Develop data error count report in GA to reduce data and loading errors**
  - Establish user data integrity error tracking sheet
  - Develop data error count by comparing with MES data
- **Initially deployed to REN Analog, then rolled out to REN Power, Celeno, REN Core, REN Dialog**

GUIDED ANALYTICS TODAY AT RENESAS: DATA

- GA-MA is deployed across 96% of Divisions/ BU in EPSG
- ~2000 products in DB and more coming
- Consistency in data loading across most BU's; benefits of structured test operations
  - PDF DB combines & merges data across data sources
  - PDF DB aligns data such as HB/SB/parametric, FT vs. PCM and WS bins vs. FT bins
  - Data loading errors reduced from ~5000 to ~< ~20
- 96%of production data analyzed daily by GA-MA system
- Daily quality monitoring emails on selected products

GUIDED ANALYTICS TODAY AT RENESAS: PE

- GA-MA covers large percentage (~96%) of PE production analysis
  - GA-MA has been selected as the standardized production data analytic tool
  - Consistency in analysis methodology across the company
  - Easy for novice PE users to achieve results with the guided analytics
  - Experienced users create useful templates and save to GA for novice users
  - More/deeper analysis capability
  - Yield Dashboard of Yield vs. Targets (auto monitoring and easy drill down)
  - Combination of Exensio and GA to provide the data analysis flexibility

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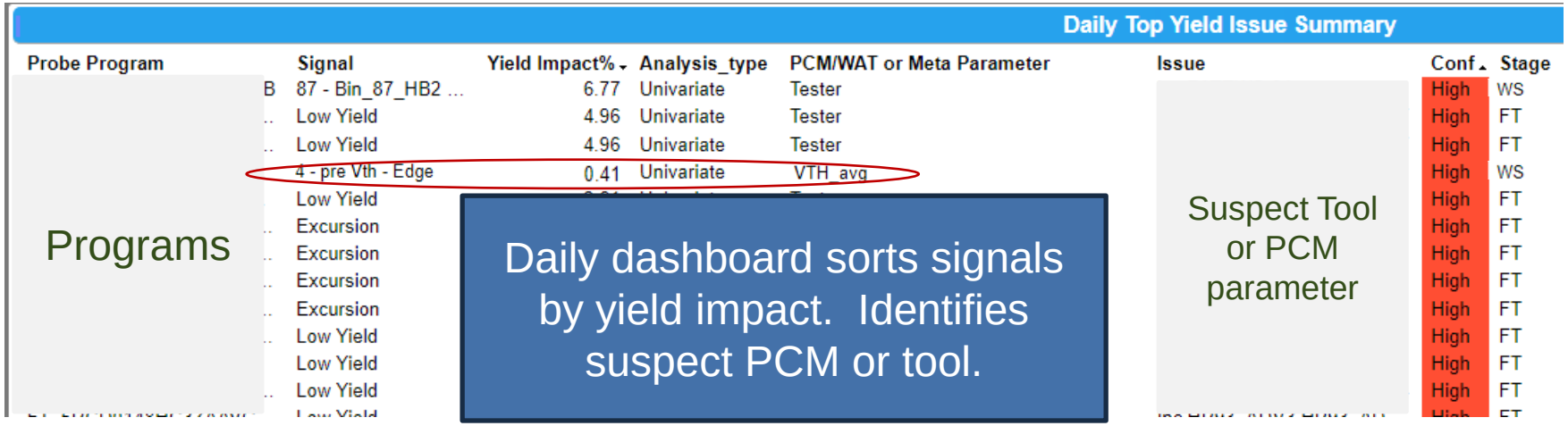
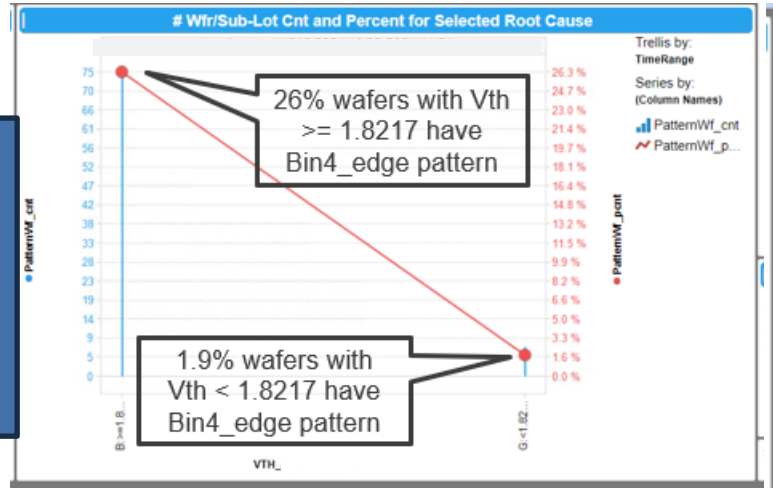
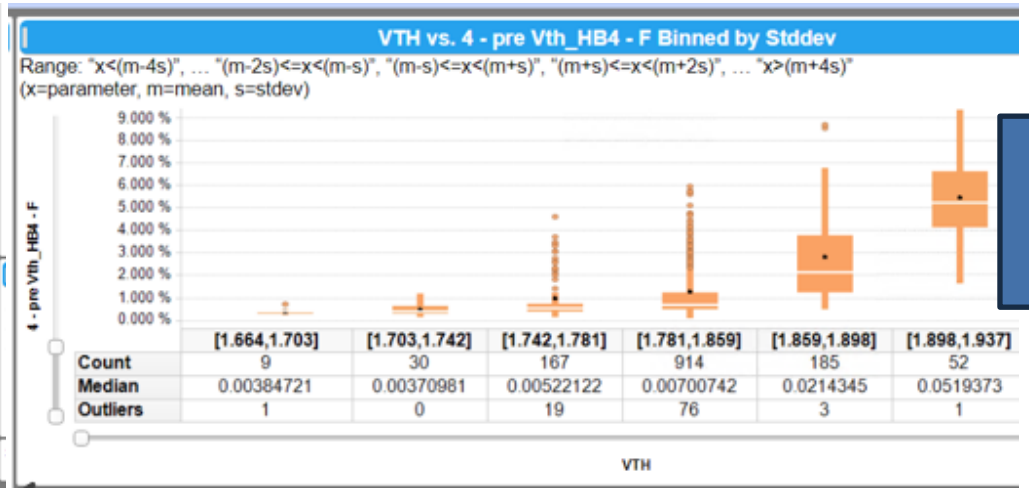
GA-MA EXAMPLE: AI/ML FOR ACCELERATED ROOT CAUSE



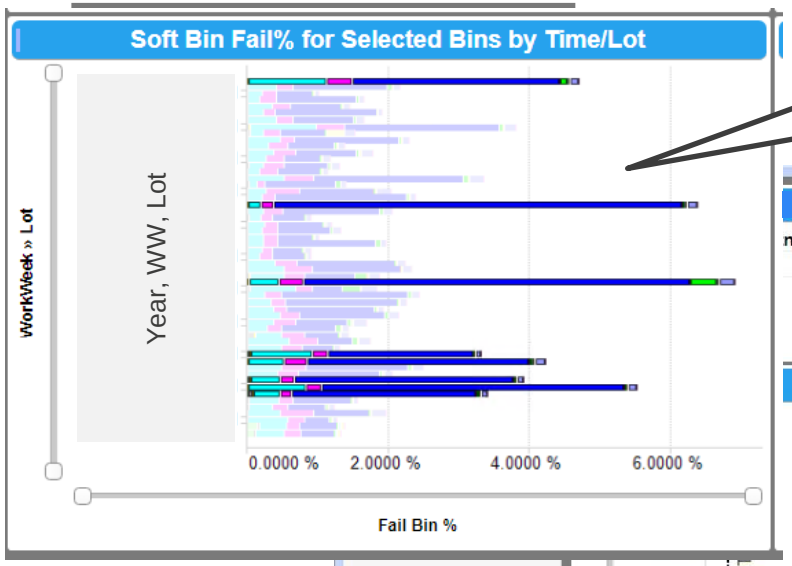
AI/ML identifies PCM values causing Bin4 edge fallout





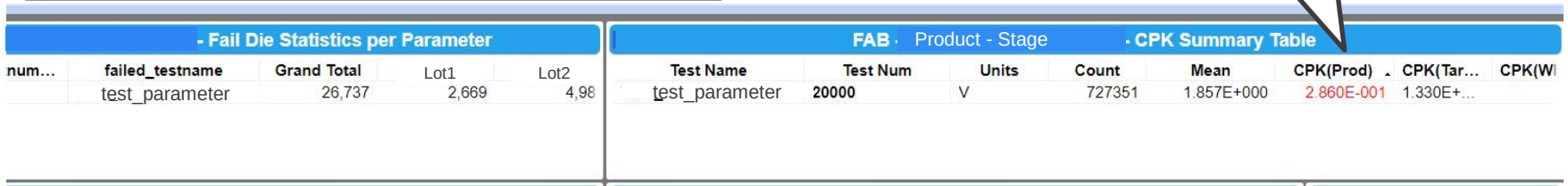
Trend with PCM parameter supports signal

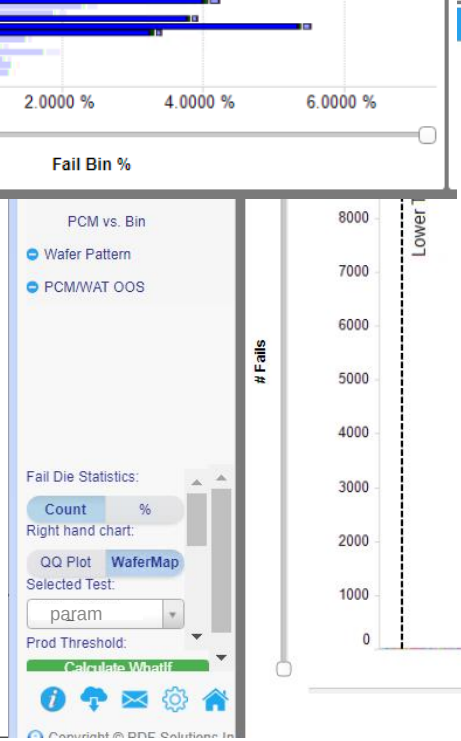
WS PARAMETRIC DATA: *STRONG EDGE PATTERN*

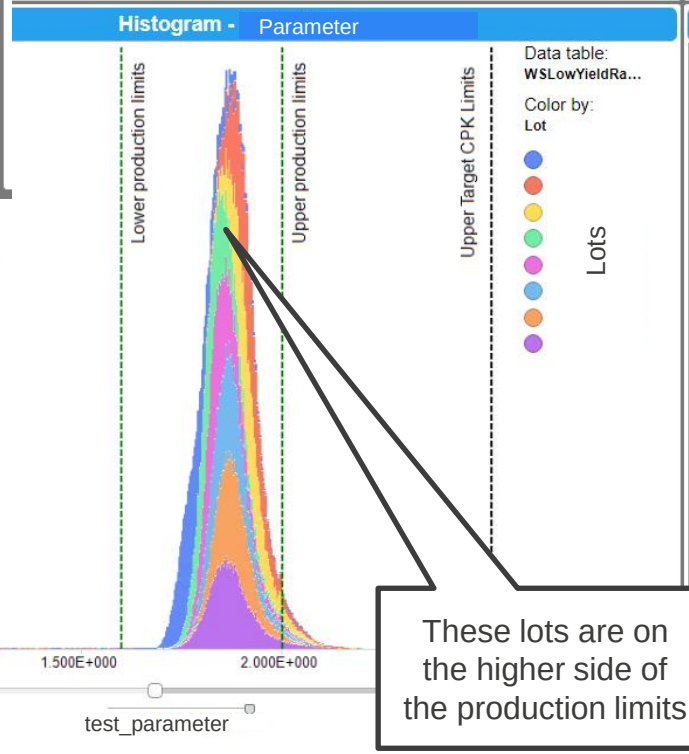


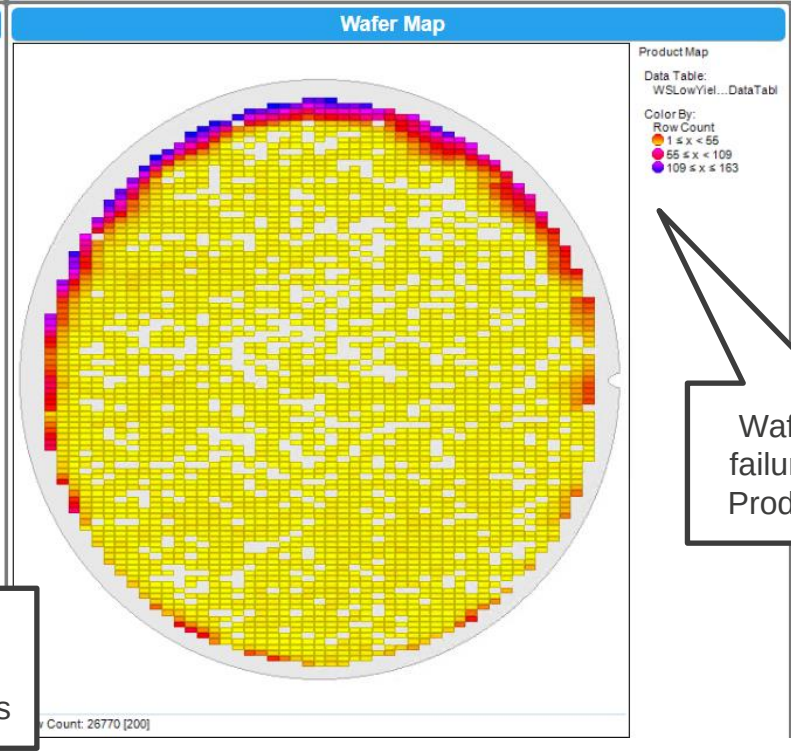
Select several lots with high Bin4 failures, and plot the associated test parameter for that bin.

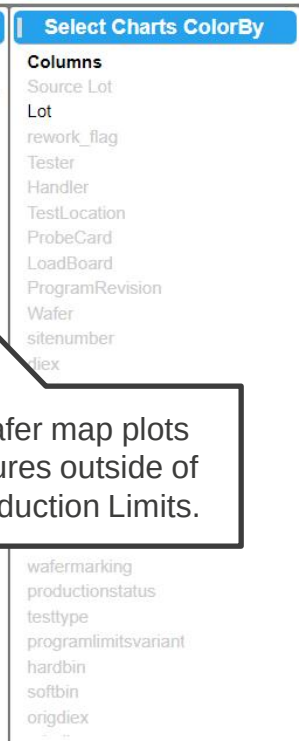
Low CPK







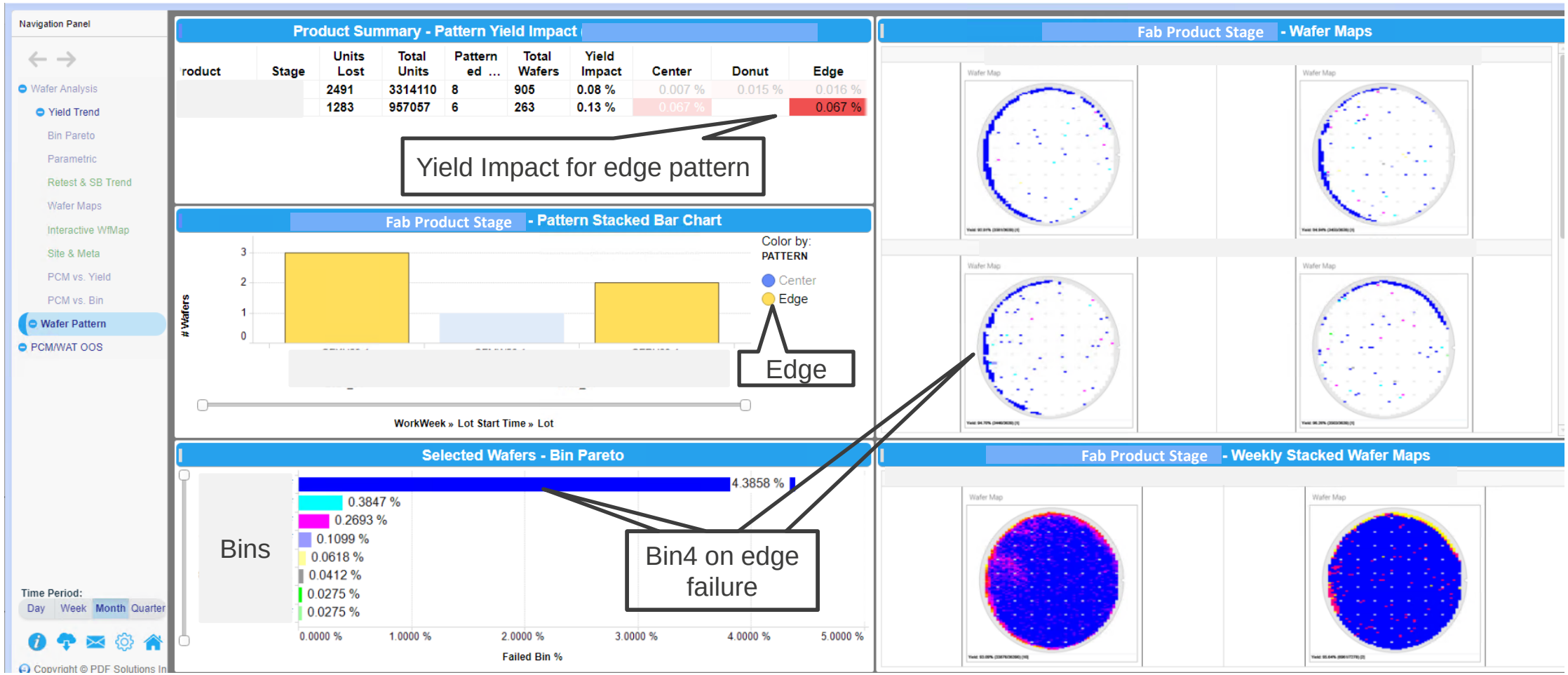




These lots are on the higher side of the production limits

Wafer map plots failures outside of Production Limits.

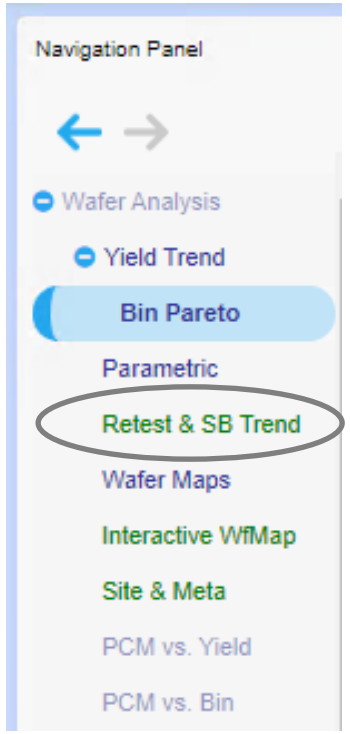
WAFER PATTERN: *EDGE PATTERN AUTOMATICALLY DETECTED*



SEAMLESS FLOW FROM GA TO EXENSIO TEMPLATES

1. Super User creates template

2. Hook up to GA



3. All users of GA benefit

- User 1
- User 2
- User 2
- ...
- User N

Super Users can create standard templates for all to use in GA

CUSTOM TEMPLATE: DIV DASHBOARD

- ❑ Critical project yield vs target yield auto monitoring per division/ family/ test stage.
- ❑ Seamless drill down from the divisional dashboard to low yielding lots.
- ❑ Easy guidance to cost yield adjustment

By Product/Stage/Location Stats

DIV_PL	Family	Product	Stage	AveYield%	Weighted Yield By Family	Gate1 Yield%	TargetYield%	AveYield–Target%	Lot	TotalPassUnits	TotalUnits
IAD			CP1	97.3	97.3		98.00	-0.71	41	2048999	2106155
			CP1	99.4	99.4		98.90	0.51	1	436322	438900
MIIBD			CP1	99.1	99.0		99.30	-0.24	50	10496774	10596402
			CP1	99.5	99.0		99.30	0.20	2	427536	429700
			CP1	98.8	98.8		99.30	-0.49	9	1876615	1899274
			CP1	97.7	99.0		99.20	-1.55	2	419607	429700
			CP1	98.8	99.0		99.10	-0.26	17	3457305	3497758
			CP1	99.2	99.2		99.10	0.05	17	3612889	3643856
			CP1	97.7	97.7		97.50	0.23	11	1371272	1403082
			CP1	99.7	99.7		98.50	1.22	1	170415	170890
			CP1	96.8	96.8		93.00	3.81	37	8145357	8414000
			CP2	99.0	99.0		93.00	6.01	37	8070636	8151270
			CP3	98.7	98.7		98.00	0.72	22	4980247	5044669
			CP1	96.6	96.6		93.00	3.60	13	2314789	2396176
			CP2	98.9	98.9		93.00	5.88	1	227797	230384
			CP3	98.9	98.9		95.00	3.91	3	682863	690386
			CP1	99.0	99.0		93.00	6.05	25	8356616	8436808
			CP2	99.3	99.3		93.00	6.32	4	1321050	1330160
			CP3	97.9	97.9		98.00	-0.12	5	1223576	1250042
SPBD			820	97.6	97.6		98.30	-0.67	28	1108108	1135050
			826	94.9	94.9		95.30	-0.42	30	1155015	1217300
			828	93.3	93.3		91.70	1.60	36	1365900	1464050

Colors:

All values

(Empty)

- Greater than 5.0
- Between 1.0 and 5.0
- Between -1.0 and 1.0
- Between -5.0 and -1.0

CUSTOM TEMPLATE: ECID TEMPLATE

Purpose

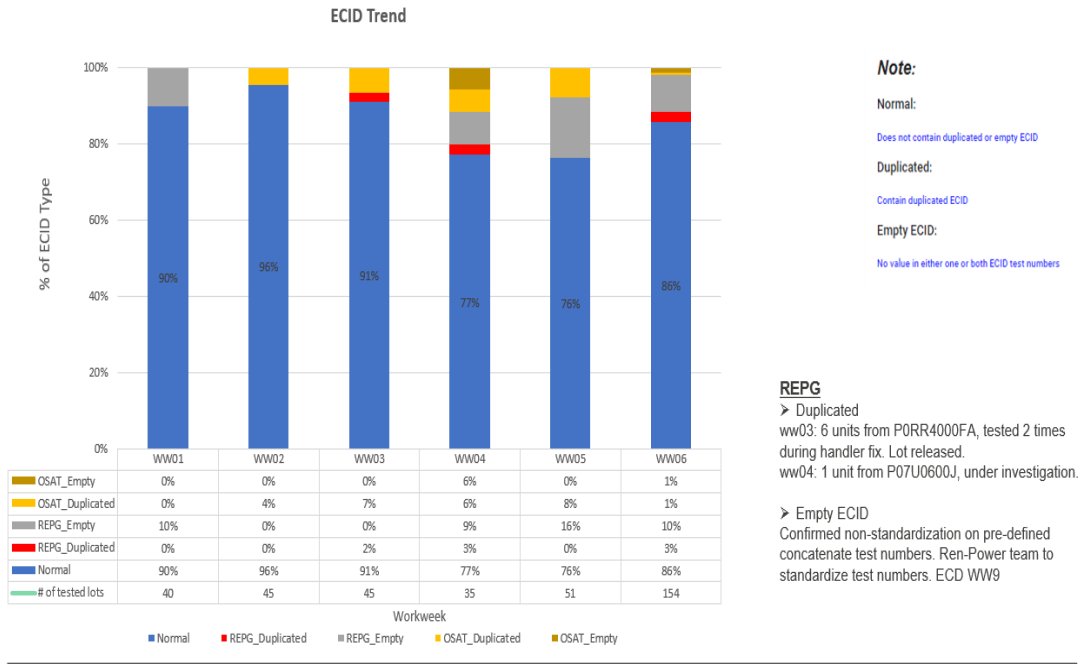
- Detect unit stuck-in socket problem, which could cause false passing results.
- Good units stuck in sockets. The subsequent units always show passing results

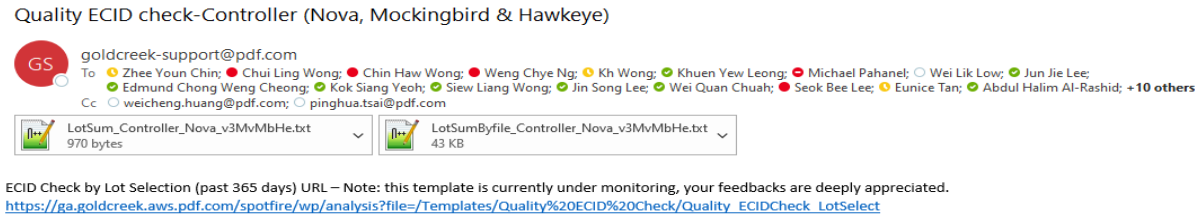
Solution

- Generate unit ECID from the STDF file
- Flag if ECID duplicated ECID count > 1

Auto Alert emails

- Email alert to engineering team on duplicated ECIDs





ECID Check by Lot Selection (past 365 days) URL – Note: this template is currently under monitoring, your feedbacks are deeply appreciated.
https://ga.goldcreek.aws.pdf.com/spotfire/wp/analysis?file=/Templates/Quality%20ECID%20Check/Quality_ECIDCheck_LotSelect

CUSTOM TEMPLATE: SAFE LAUNCH TEMPLATE

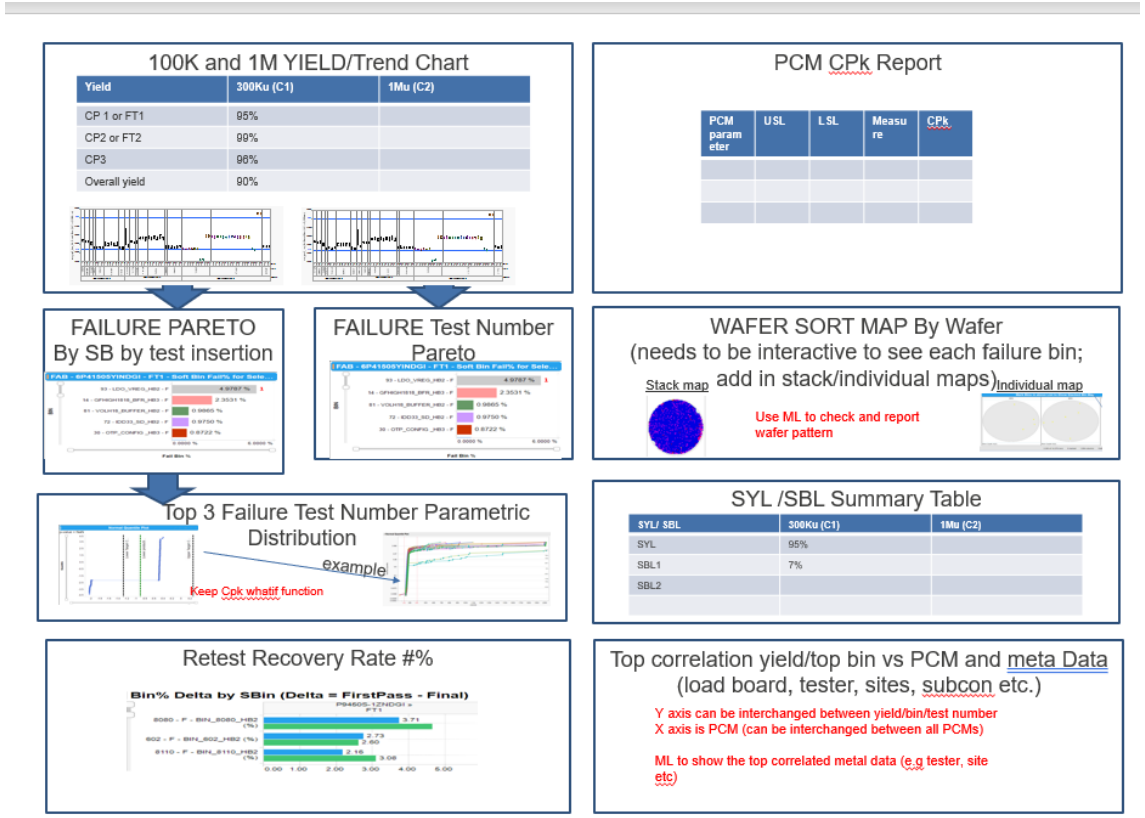
Purpose

The objective is to make ENG's safe ramp data analysis more efficient by leveraging PDF yield tool

- New product yield, test time and quality monitoring and improvement

Implementation

- Score products based on yield, LRR, test recovery
- Identity TTR opportunities
- Identify yield improvement opportunities
- Identify retest recovery rate reduction opportunities
- Auto report generation



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BENEFITS OF PDF CLOUD YIELD TOOL: RECAP

- Harmonized data and report format.
- Rolled out to ~96% of the EPSG divisions and more than ~2000 products loaded to PDF cloud database
- Automatic yield saving report (easy to track passive yield savings)
- Easy TTR and retest reduction opportunity findings
- Cost efficient solution by combining GA with Exensio.
  - ✓ Seamless flow from GA to Exensio for more in-depth analysis
  - ✓ Novice engineers can perform statistic analysis with Guided Analytics.
  - ✓ Experience engineers can develop custom templates with Exensio and save to GA for novice engineers
- Engineering efficiency improvement by leveraging custom templates and AI algorithms
- Custom quality templates can expand the capability of the tool to more than just a yield tool, but also a quality shield for critical products.

Renesas.com