Active Monitoring of Statistical Bin Analysis

IE3100M Systems Design Project - Group 19
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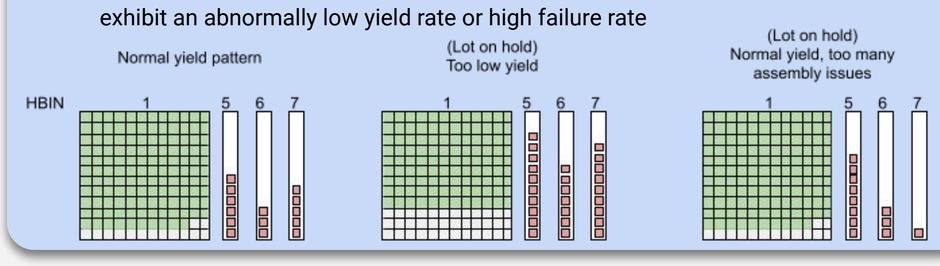
Background

Infineon Technologies
- Global leader in the semiconductor systems and smart solutions industry

Product Test Engineering Department
- Oversees the back-end final testing phase of the semiconductor supply chain

Final testing phase
- Chips are tested and sorted into designated bins (e.g. HBIN or SBIN) based on test outcomes and type of defects
- Statistical Bin Analysis (SBA) is then used to identify abnormal chip lots that exhibit an abnormally low yield rate or high failure rate

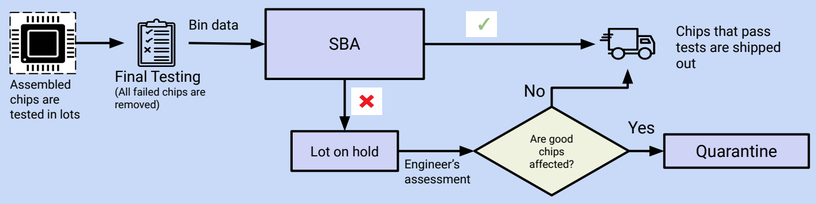


Problem Overview

Statistical Bin Analysis (SBA) process
- Use SBA limits to determine if lots have abnormally high fail rates
- These lots may carry risk of additional underlying defects
- Test engineers will assess these abnormal lots to determine if they should be accepted
- SBA limits are calculated using:

$$\text{UCL} = Q_{50} - 3.5\sigma_{upper}, \quad \text{LCL} = Q_{50} - 3.5\sigma_{lower}$$

where: $\sigma_{upper} = \frac{Q_{95} - Q_{50}}{1.644854}, \sigma_{lower} = \frac{Q_{50} - Q_{05}}{1.644854}$



Problem Statement
- SBA limits are reviewed regularly every 6 months
- However, having a fixed review interval does not account for:
  - Varying production rates and lot sizes
  - Spontaneous changes in the manufacturing process
- The SBA limits may become too narrow or wide for the new distribution:
  - Too narrow: Too many lots will be identified as abnormal and placed on hold
  - Too wide: Abnormal lots are erroneously accepted

Objectives

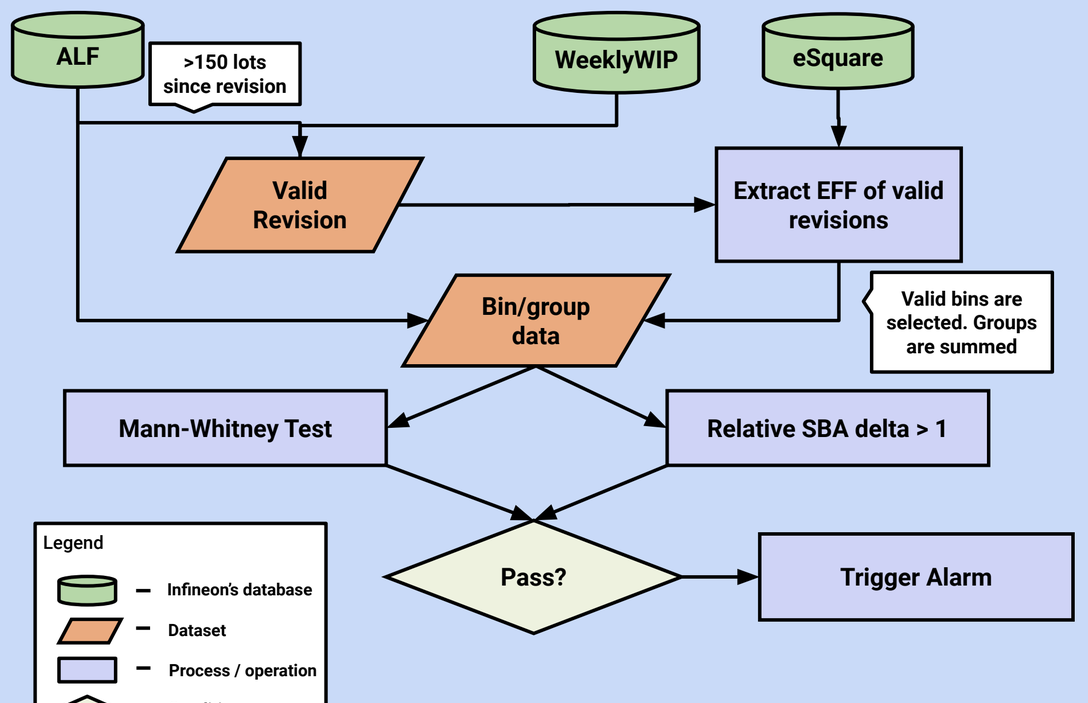
To propose a model that actively monitors and detect changes in the baseline fail rate distribution

To implement an active monitoring model to help account for variation in lots

To develop a SBA alarm to notify engineers to investigate the cause

Model

Logic Flowchart



Methodology

Variation In Parameter Fail Rates:

$$y = f(x) + \varepsilon$$

- Parameter fail rates observed by test equipment
- Variation from upstream changes in process
- Unexplained variations

Goal
- SBA monitoring system detects changes in distribution to account for changes in f(x)

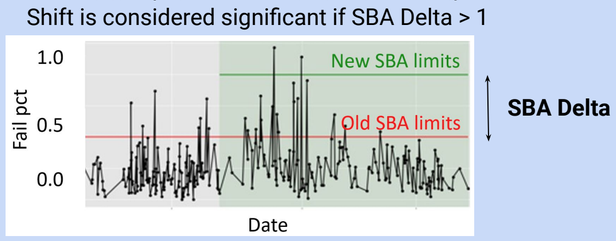
1) Detecting Distribution Shifts

1. Mann-Whitney Test
2. Anderson-Darling Test
3. Kolmogorov-Smirnov Test

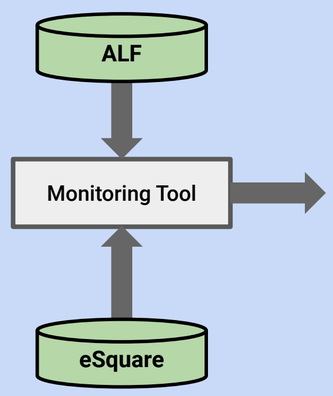
*As all 3 statistical test results largely agree with each other, the decision to choose the MW Test was based on familiarity with it

2) Detecting SBA Limit Shift

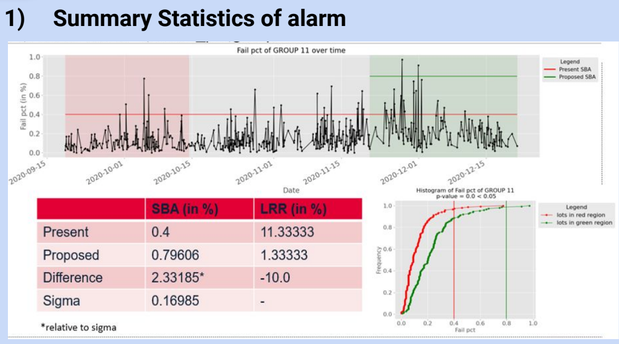
SBA Delta = |New SBA limit - Old SBA limit| ÷ σ
Shift is considered significant if SBA Delta > 1



Deliverables



1) Summary Statistics of alarm



	SBA (in %)	LRR (in %)
Present	0.4	11.33333
Proposed	0.79606	1.33333
Difference	2.33185*	-10.0
Sigma	0.16985	-

*relative to sigma

2) Compiled and cleaned dataset for engineer's analysis

Lot	Yield	HBIN5	HBIN6	SBIN1	Group1
1					
2					
3					
4					

3) Automated email module to alert engineers

4) Summary of data with issues
- To help product owners clean their dataset
- Errors may include:
  - Mismatch between ALF and eSquare parameters
  - Duplicated entries in ALF

Benefits
- Alerts engineers to distributions shifts due to process changes, and encourages more frequent SBA review which may improve outgoing lot quality
- Automatically integrates and cleans data for engineers, therefore optimizing the workflow of the review process

User Acceptance Testing

The 3 metrics used to validate the proposed model

1. Effectiveness Of Model — Model has to be robust enough to run through various scenarios and cater for different products triggered during the process
2. Precision Of Alarm — Validity of the trigger in the model
3. Overall Effort Required — Relative to the benefits that can be gained from using the model

- UAT was carried out from 1st Mar 2021 to 29th Mar 2021
- During the UAT period, the model was run on 4 iterations
  - 1155 parameters processed on average
- UAT results:
  - Robust enough to handle abnormality in the dataset:

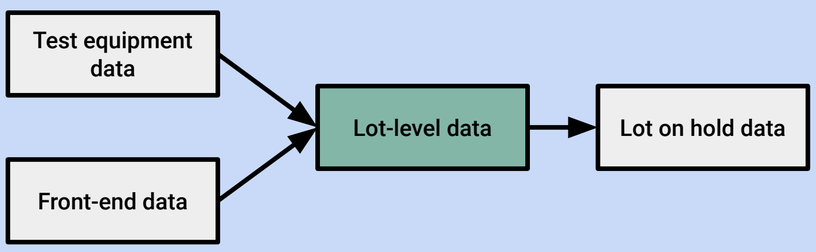
    > 99% successful execution by third iteration

Issues raised
- Pre-aligned limits are scenarios where SBA limits are set as part of agreements with customers, instead of calculated limits
- Such cases are invalid triggers, since these limits should not change
- Issue will be fixed by collecting data on which limits are fixed
- Low precision achieved (20%), however, fixing the pre-aligned limit issue solved 80% of false positive cases

Future Actions

Short term actions
- Collect information about pre-aligned limits to drastically reduce false-positives
- Record actions taken by engineers after alarm triggers, creating a feedback loop to fine-tune the alarm

Future Recommendations



- Lot-level data:
  - Influenced by test equipment data and front-end process data
  - Analysed with SBA, rejected lots are handled by engineers, producing the Lot on hold data.
- Current model only uses lot-level data
  - When more data is available, SBA monitoring should consider these related data
- Test equipment and front-end data can be used to model its impact on lot-level data
- Lot on hold data should be studied as it can be used as a feedback to evaluate SBA limits

Key Skill Sets