Composite Index for Managing Product Stability Performance

NUS ISEM IE3100M Systems Design Project
NUS Supervisor: Associate Professor Chai Kah Hin
Industrial Supervisors: Mr Hee Boon Kiet, Ms Katherine Erika
Members: Chee Guo Ee, Choong Zhi Wen, Goh Ze Li, Kishorwaran S/O Selvaraju

1. Background

- ❖ **Infineon Technologies**
  - A world leader in semiconductor solutions, with its regional headquarters for the Asia Pacific region in Singapore

- ❖ **Product and Test Engineering (PTE) Department:**
  - Serves as the final checkpoint at the end of the semiconductor manufacturing process
  - Ensures that products are of acceptable quality before distribution

- ❖ **KPIs used by Infineon to track Product Performance**

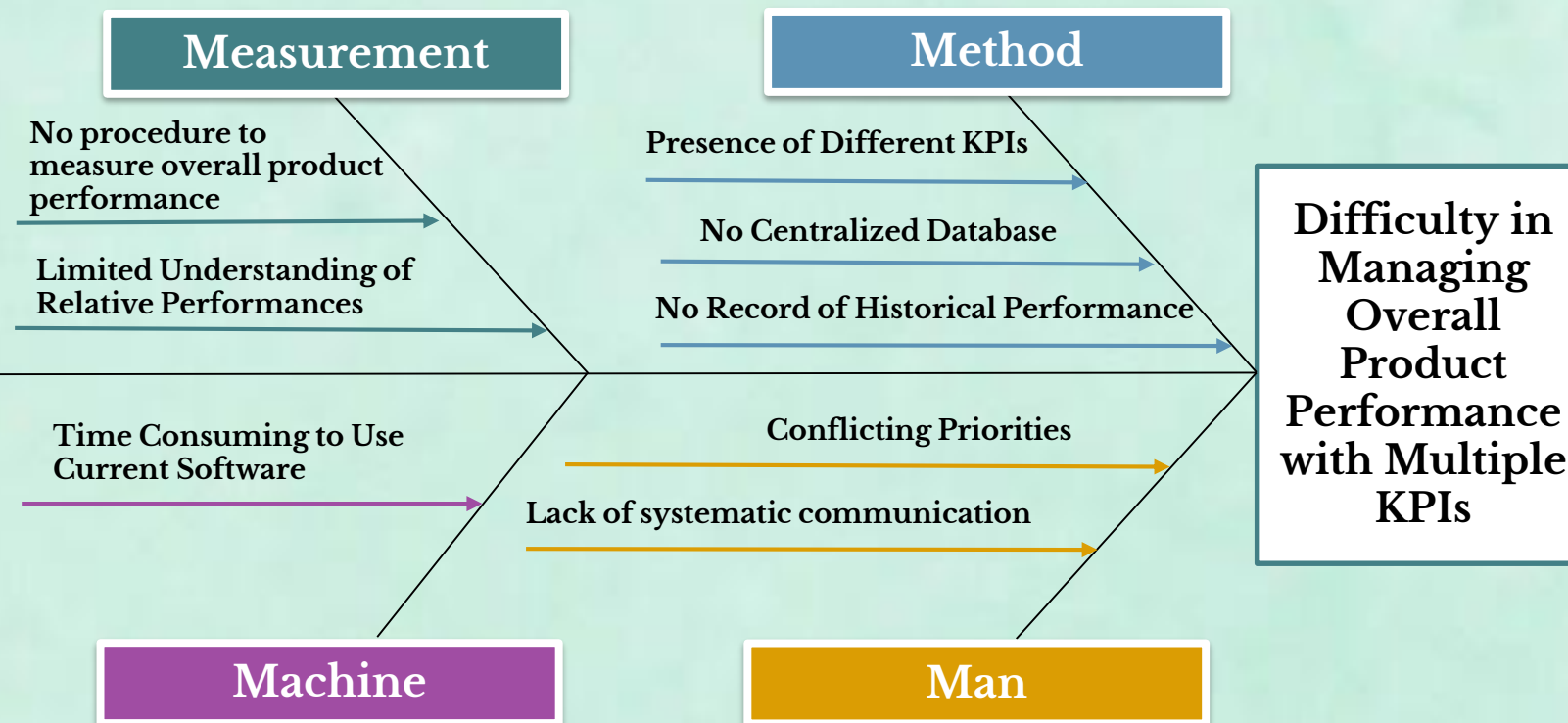| Product	• First Pass Yield • Yield Delta Spread • Yield Delta • Final Yield • Lot Rejection Rate • Final Yield Spread
Manufacturing	• Overall Equipment Efficiency • Rework Retest Percentage
Quality	• Failure Analysis Request • Assemble Case

- ❖ **Problem:** Difficulty in managing overall product performance with multiple KPIs
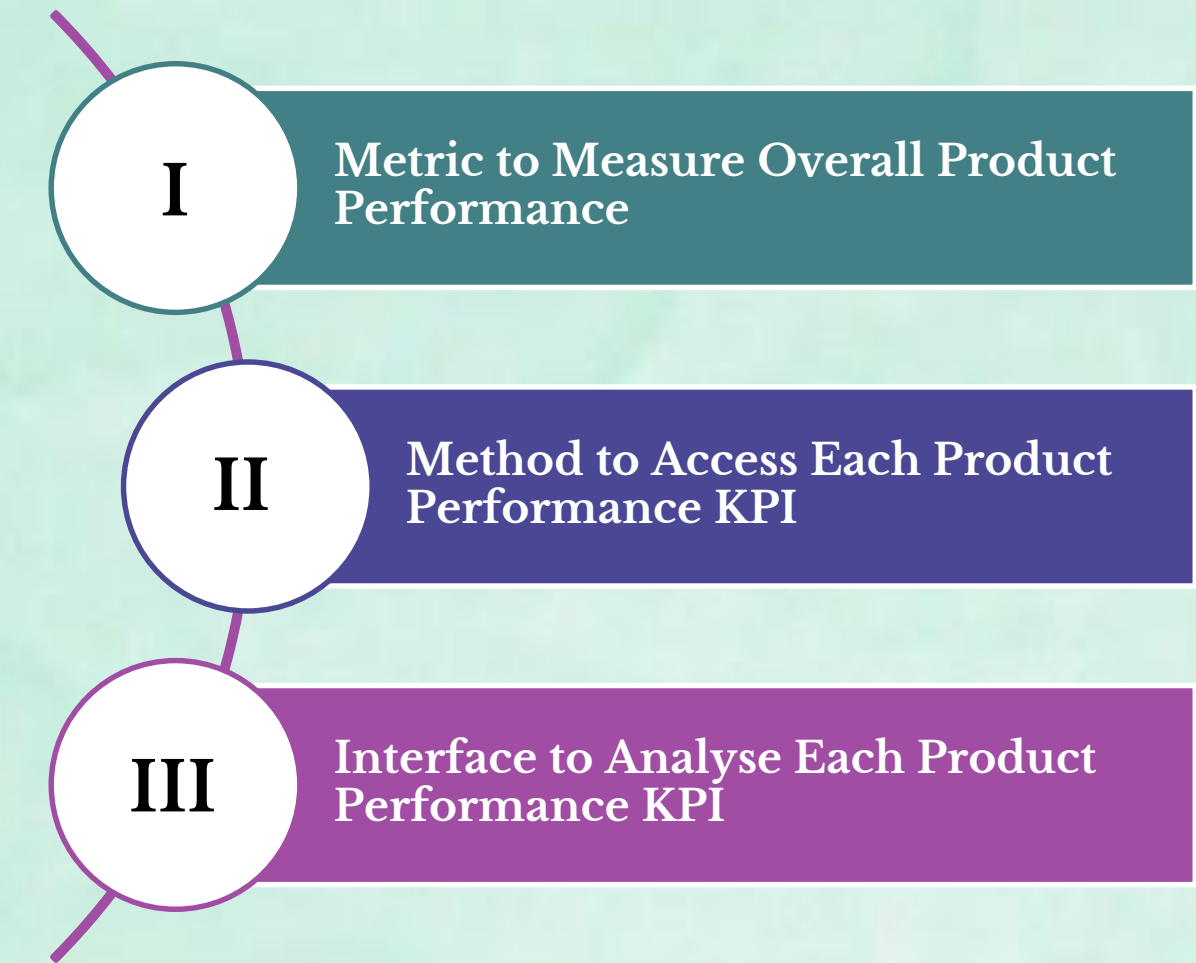
2. Problem Drivers

Problem Identification Process:

Understand PTE Job Scope → Interview Product Managers → Root-Cause Analysis → Problem Consolidation

Root Cause Analysis on Shortfalls of Current Practice:

Measurement
- No procedure to measure overall product performance
- Limited Understanding of Relative Performances

Method
- Presence of Different KPIs
- No Centralized Database
- No Record of Historical Performance

Machine
- Time Consuming to Use Current Software

Man
- Conflicting Priorities
- Lack of systematic communication

→ Difficulty in Managing Overall Product Performance with Multiple KPIs

Overall Summary of Key Problem Drivers:

- **I** — Metric to Measure Overall Product Performance
- **II** — Method to Access Each Product Performance KPI
- **III** — Interface to Analyse Each Product Performance KPI
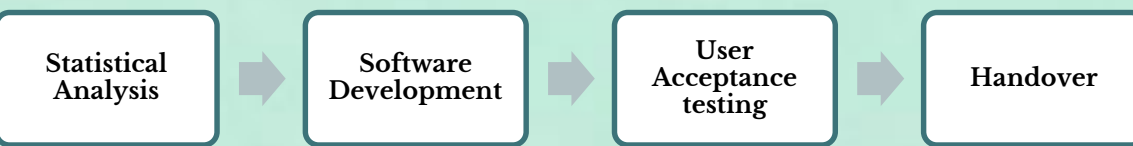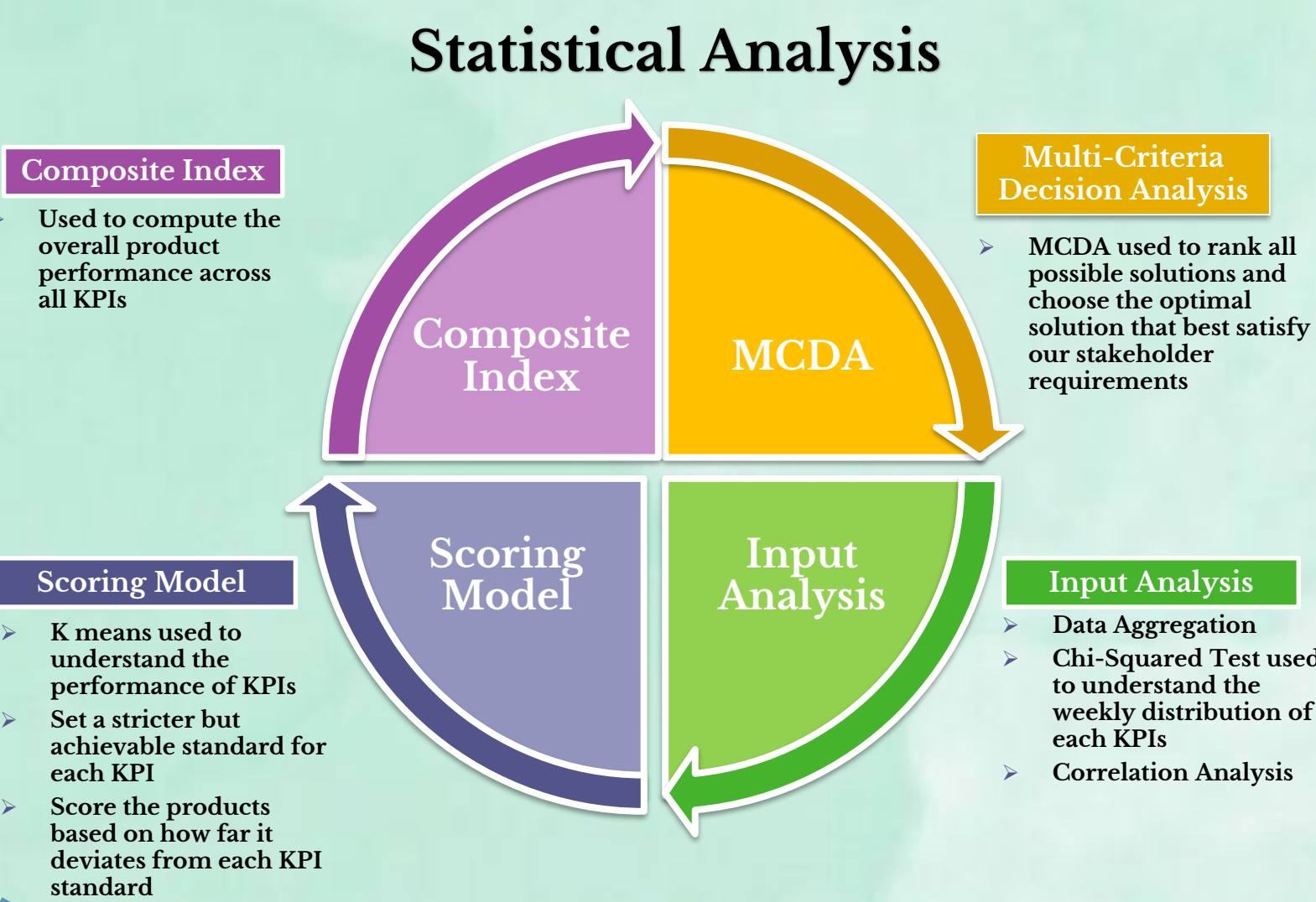
3. Objectives

- ❖ Formulate a single performance metric that captures all KPIs to give a comprehensive understanding of the overall product performance across all products
- ❖ Improve data pipelines to streamline existing workflow in managing all products' KPIs
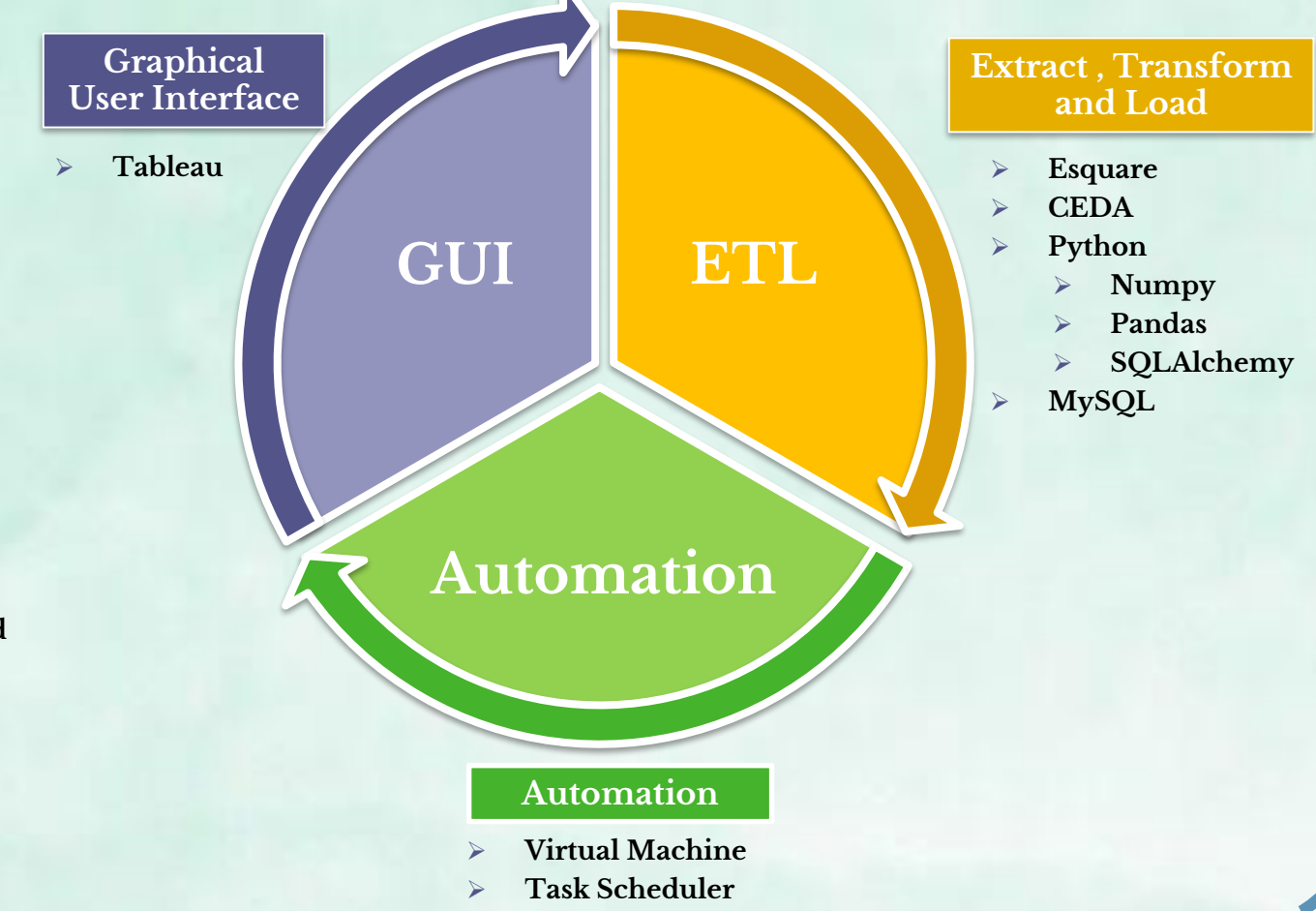- ❖ Create a user interface to display the different KPI performance and analysis

Project Milestones:

Statistical Analysis → Software Development → User Acceptance testing → Handover

4. Methodology

Statistical Analysis

Composite Index
- Used to compute the overall product performance across all KPIs

MCDA / Multi-Criteria Decision Analysis
- MCDA used to rank all possible solutions and choose the optimal solution that best satisfy our stakeholder requirements

Input Analysis
- Data Aggregation
- Chi-Squared Test used to understand the weekly distribution of each KPIs
- Correlation Analysis

Scoring Model
- K means used to understand the performance of KPIs
- Set a stricter but achievable standard for each KPI
- Score the products based on how far it deviates from each KPI standard

Software Development

Graphical User Interface
- Tableau

Extract, Transform and Load
- Esquare
- CEDA
- Python
  - Numpy
  - Pandas
  - SQLAlchemy
- MySQL

Automation
- Virtual Machine
- Task Scheduler

5. Deliverables

Composite Index (PSPI)

Product Stability Performance Index (PSPI),

$$X(t) = \alpha_1 A(t) + \alpha_2 B(t) + \alpha_3 C(t) + \alpha_4 D(t) + \alpha_5 E(t) + \alpha_6 F(t) + \alpha_7 G(t) + \alpha_8 H(t)$$

$X(t)$: *PSPI Score at time t*

$A(t)$: *First Pass Yield Score at time t*

$B(t)$: *Final Yield Score at time t*

$C(t)$: *Yield Delta Score at time t*

$D(t)$: *Final Yield Spread Score at time t*

$E(t)$: *Yield Delta Spread Score at time t*

$F(t)$: *Lot Rejection Rate Score at time t*

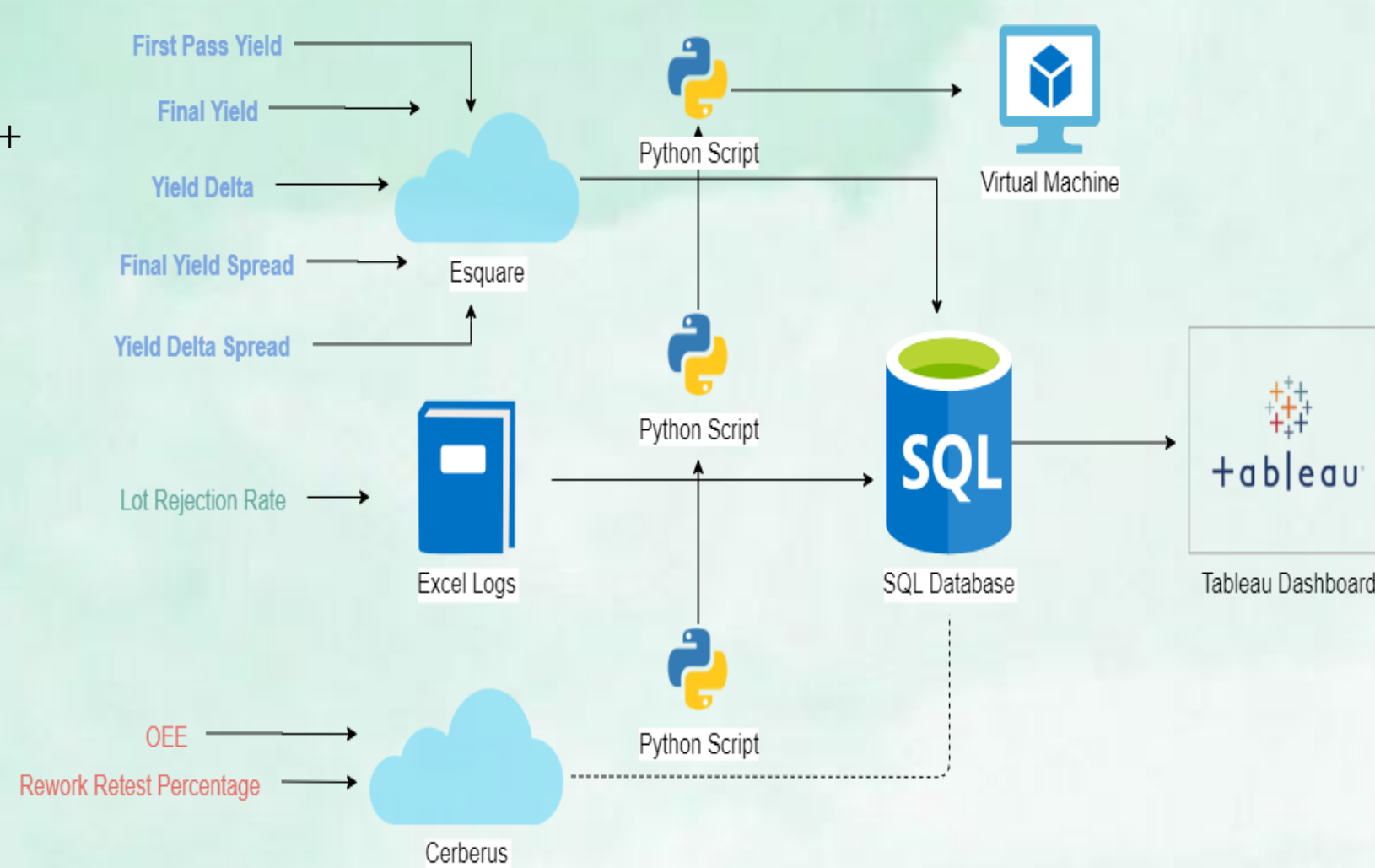$G(t)$: *Overall Equipment Effectiveness Score at time t*

$H(t)$: *Rework Percentage Score at time t*

α_x: *Respective Weights of each KPI*

Product Stability Performance Index:
- ✓ Single metric to measure Overall Product Performance
- ✓ Made up of different KPIs in Infineon
- ✓ Weights of KPI determined by Analytical Hierarchy Process
- ✓ Unique Scoring System

Data Architecture

First Pass Yield, Final Yield, Yield Delta, Final Yield Spread, Yield Delta Spread → Esquare → Python Script → Virtual Machine

Lot Rejection Rate → Excel Logs → Python Script → SQL Database → Tableau Dashboard

OEE, Rework Retest Percentage → Cerberus → Python Script

Customized Data Architecture:
- ✓ Follows standard ETL protocol to Extract, Transform and Load large amount of data
- ✓ Fully Automated solution controlled using Python and Virtual Machine
- ✓ Data Transformation to merge multiple KPI metadata to unique basic type combination
- ✓ Dedicated connection with Tableau using direct query method
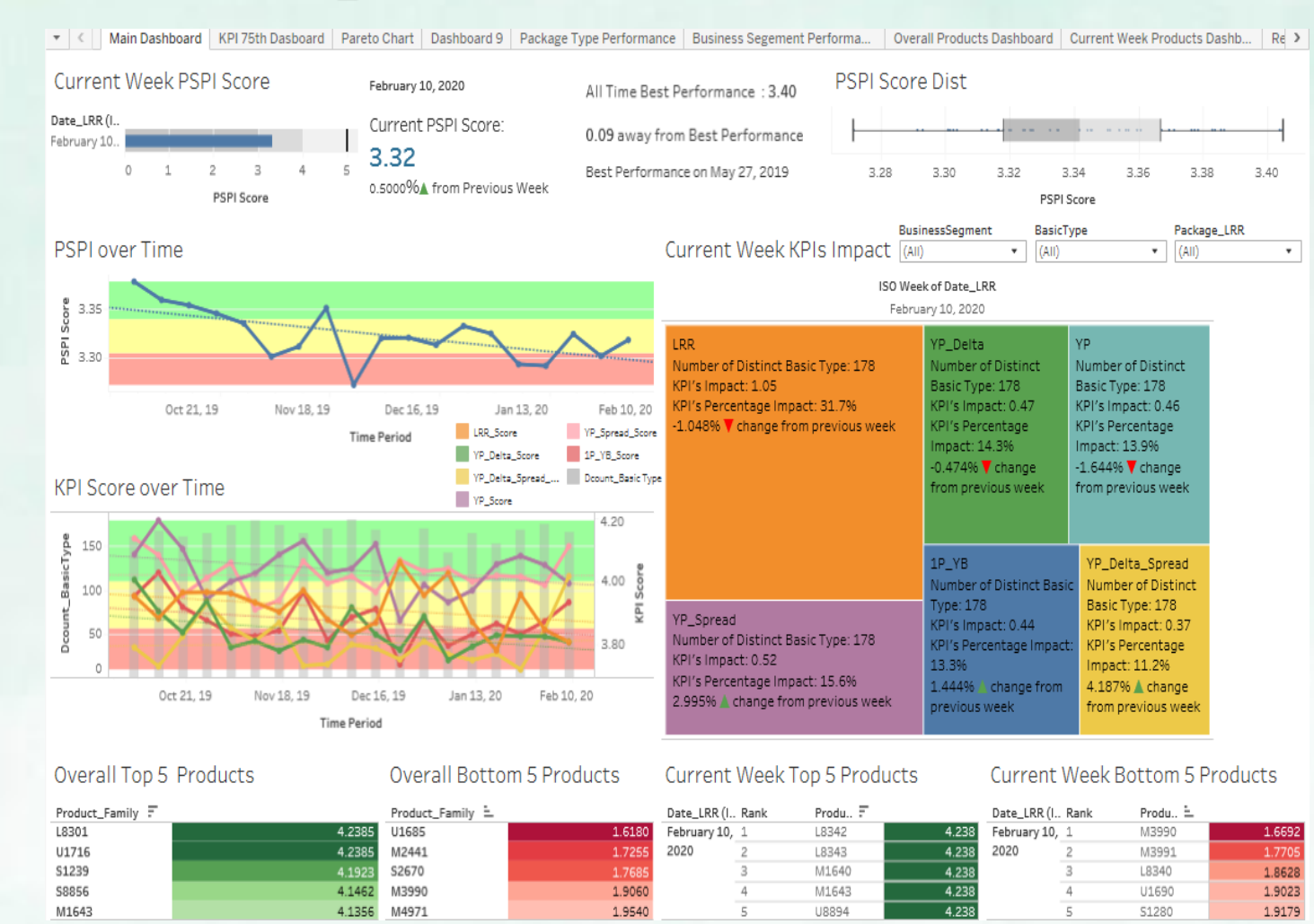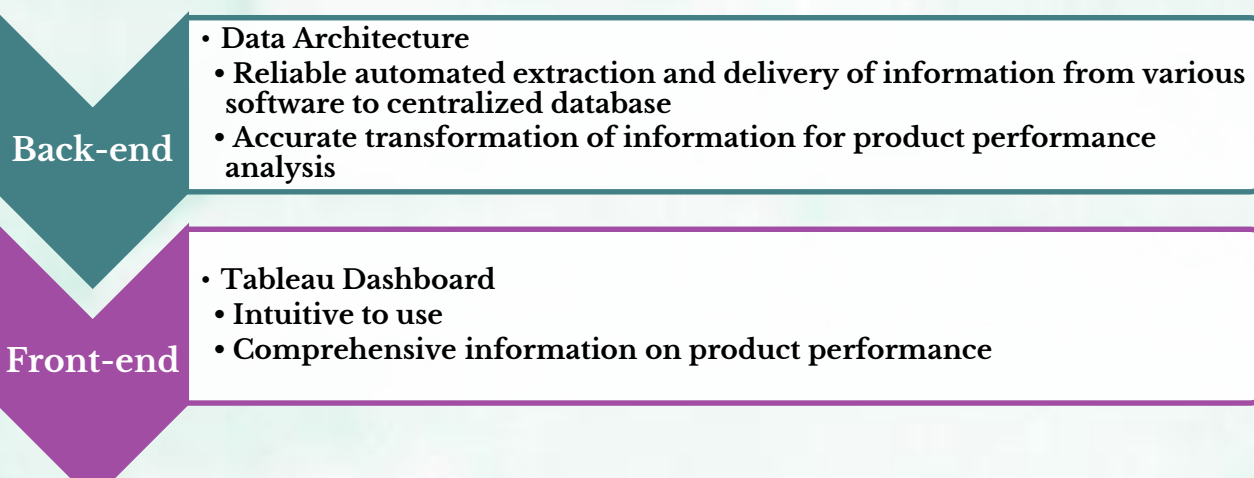
Graphical User Interface (GUI)

Tableau Dashboard Functionality:
- ✓ 9-Page Dashboard providing multiple-level overview of product performance
- ✓ Multiple Categorical Filters for drill-down and analysis
- ✓ Easily conduct week-over-week analysis for up to a year
- ✓ Intuitive Dashboard design with meaningful application of Human Factor Engineering

6. User Acceptance Test

- ❖ Two-week pilot-test of final solution
- ❖ Goals: back-end and front-end functionality

Back-end
- Data Architecture
- Reliable automated extraction and delivery of information from various software to centralized database
- Accurate transformation of information for product performance analysis

Front-end
- Tableau Dashboard
- Intuitive to use
- Comprehensive information on product performance

- ❖ **Procedure:** automated data refresh scheduled weekly to deliver latest data from past week
- ❖ **Outcome:**
  - ✓ Significant improvement in workflow of managing product performance
  - ✓ Fresh and valuable insights provided by Tableau visualizations and analyses

7. Benefits and Future Development

Benefits:
- ✓ Efficient Data-driven Resource Allocation
- ✓ Centralised Accessibility to Product Performance Information
- ✓ User-friendly GUI for Data Visualisation and Analysis

Future Developments:
- ✓ Predictive Model for Future PSPI Score
- ✓ Automatic Diagnostic Recommendations for Managing Products' Performance

8. Conclusion

Skill-set used in this System Design Project:

- Statistics in Engineering
- Programming
- Human Factor Engineering
- Project Management
- Decision Making Model
- Database Engineering
- Automation and Systems Design