SWTEST 2026 CONFERENCE

35th ANNIVERSARY

# Telemetry-Driven Predictive Maintenance for Wafer Acceptance Test Probe Cards

GlobalFoundries®

**GlobalFoundries Singapore**

Mohammed Hussain SUHAIL
Chuan Hau CHUAH
Tee Whay LIM
Meng Yew SEAH
Joo Chuan GOH
Ei Zin EI

# Overview

- Introduction
- Objectives
- System Architecture
- Exploratory Data Analysis (EDA)
- Modeling Approach
- Results and Outcome
- Key Takeaways

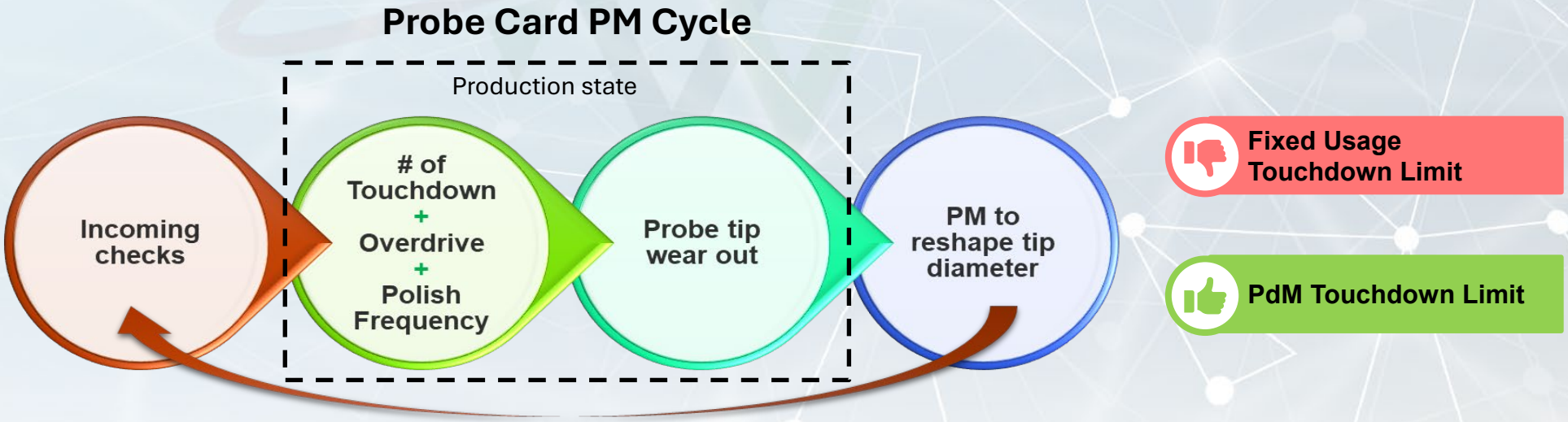
# Introduction

## Background for Wafer Acceptance Test (WAT) Probe Card

- Critical for wafer parametric measurements and data integrity
- Fixed Touchdown Limits (usage-based interval) for Preventive Maintenance (PM)

## Challenges

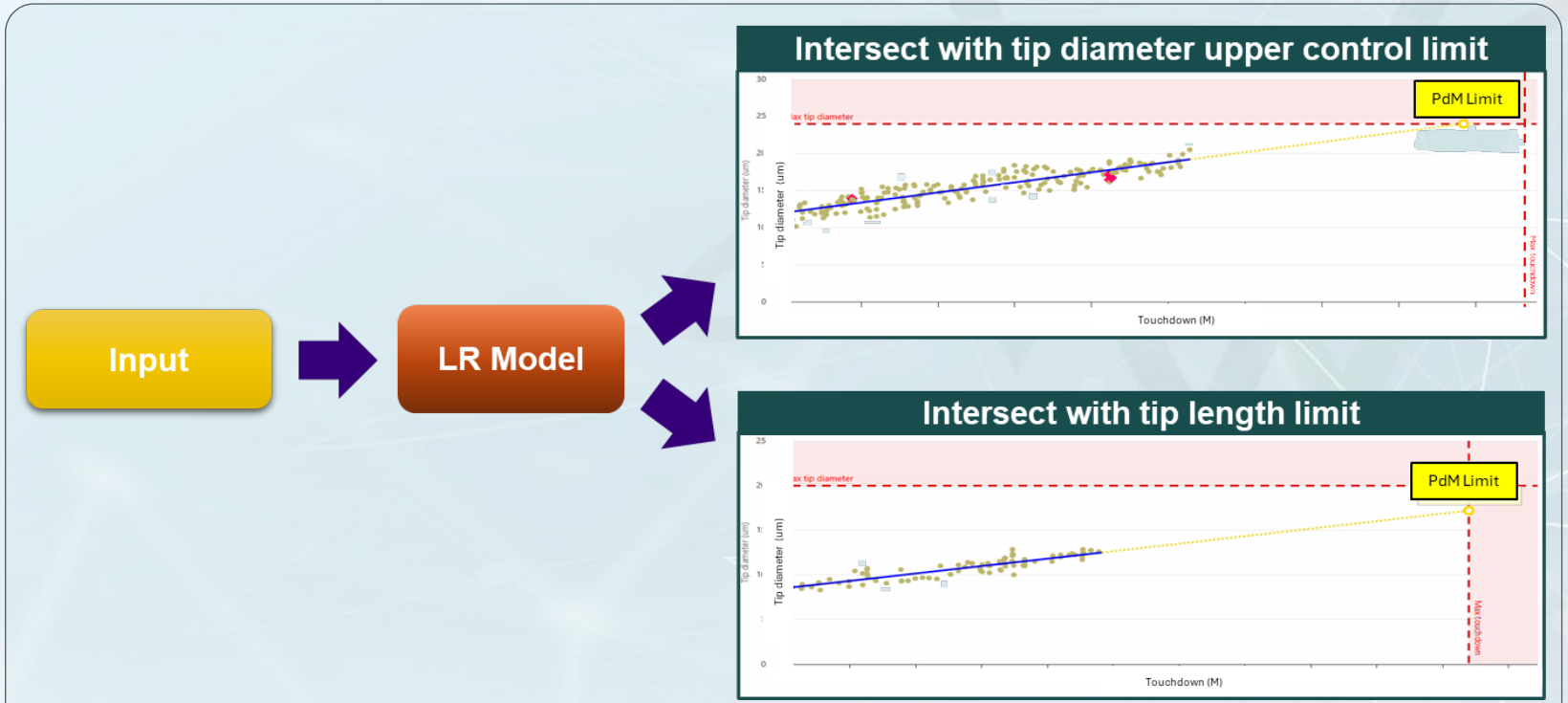
- Premature Maintenance of Good probe cards
- Unnecessary PM cost and Logistics (Probe Card Downtime)



# Objectives

## Primary Objectives

1) Telemetry-driven PdM model to Predict Probe Card Touchdown (TD) Limits
2) Replace Fixed PM rules with condition-based, adaptive thresholds




Telemetry-Driven PdM Model System

- ✓ Reduce PM cost
- ✓ Reduce Maintenance Work
- ✓ Minimize Probe Card Downtime

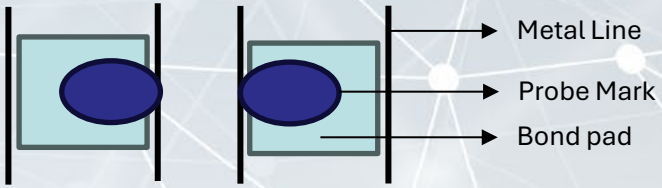
# System Architecture

**Probe Card Events**
- Up / Down Status
- PM Cycle Time

**PM Inspection Report**
- Probe Tip Length
- Pre & Post Inspection

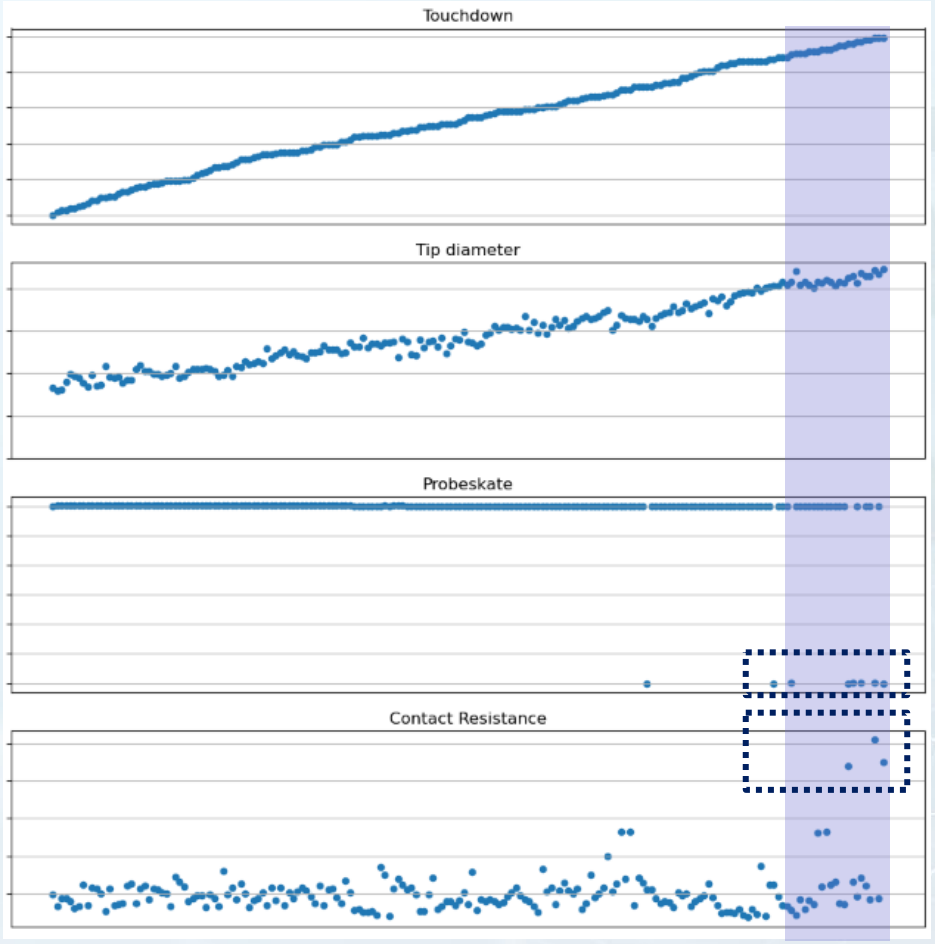
**Parametric Test Data**
- Touchdown Count
- Pin Tip Diameter
- Contact Resistance
- Probe Skate Detection

Input into Telemetry-Driven PdM Model System




*Probe-skate refers to scenario when the probe needle touches the bond pads edge and the metal line surrounding it causing it to detect short*

# Exploratory Data Analysis (EDA)




**Primary Predictor**

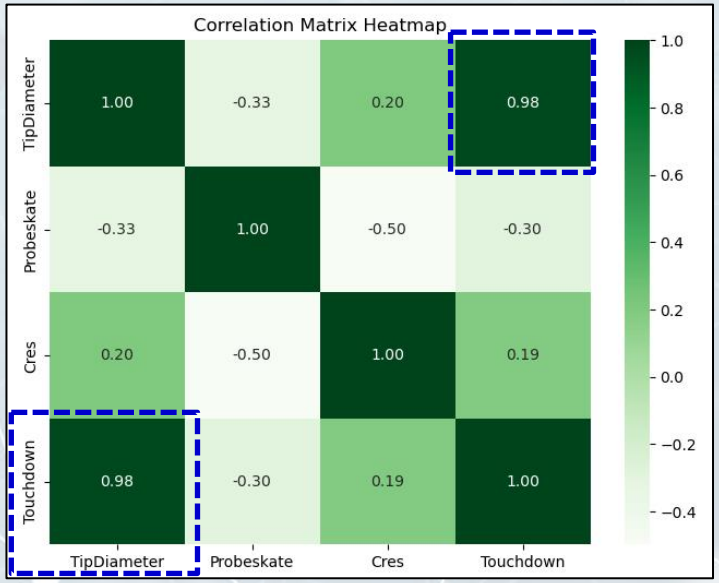
**Strong Linear Relationship**

- Tip Diameter

**Early Degradation Signals**

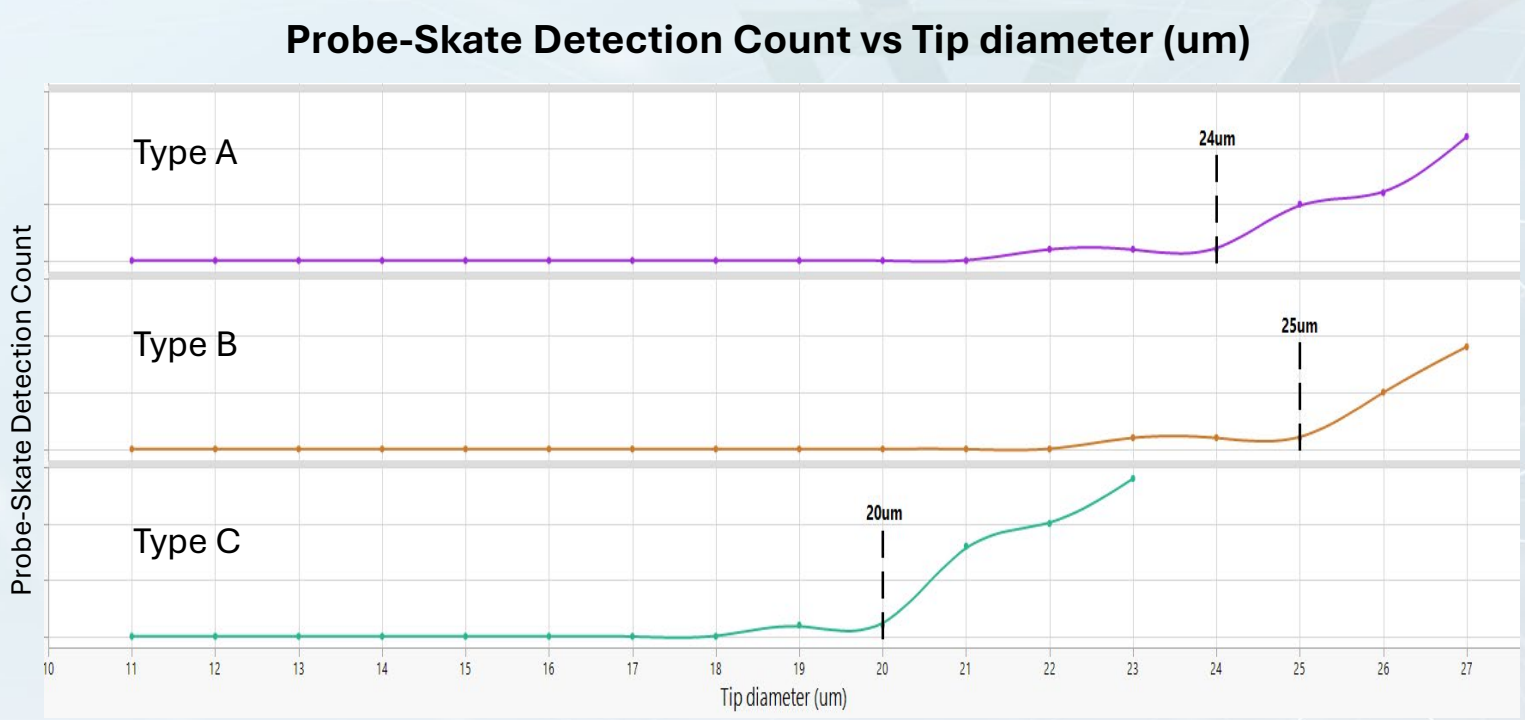
**Supporting Indicators**

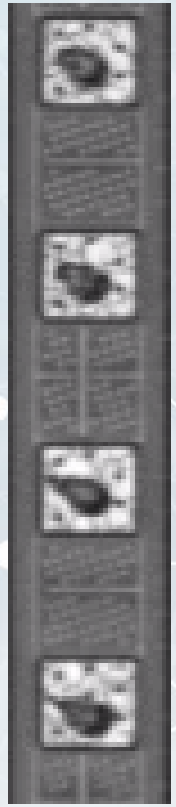
- Probe-Skate Detection
- Contact Resistance (Cres)



# Tip Diameter Upper Control Limit

- Model established based on Probe-Skate Detection count vs Different Pin Tip Diameters
- Registered as 1 Count whenever Probe Mark(s) touch the Pad edges (Probe-Skate Detection)
- Tip Diameter upper control limit (UCL) is defined when Tip Diameter is < 2 Count
- Tip Diameter UCL ranges based on different Probe Card Type used for different Pad Size



Tip Diameter 10um

Tip Diameter 20um

# Tip Length Wear Out Rate

A. Tip Length Wear Out Rate is calculated from the difference between Incoming and Outgoing tip length measurements over the PM cycle

B. With the Tip Length Wear Out Rate, the Maximum Touchdown Limit is calculated

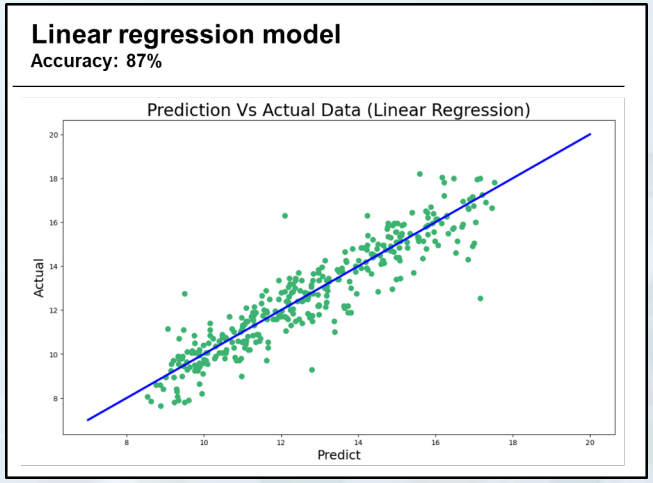
**Calculation of maximum touchdown limit (Tip Length Limit)**

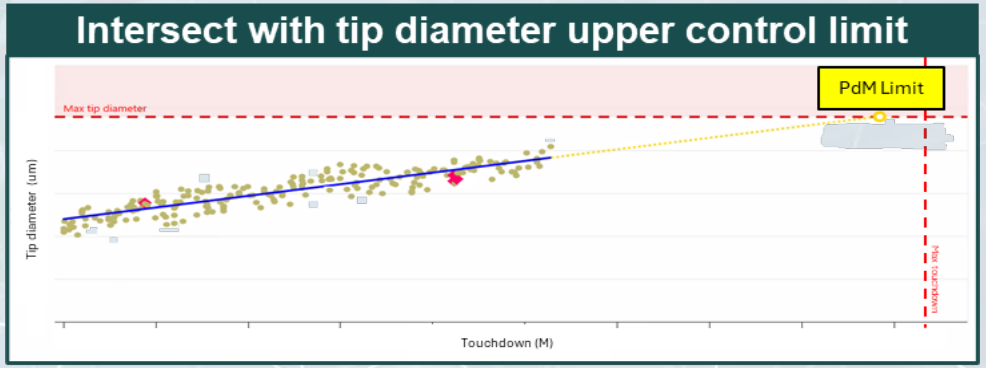
$$\frac{Incoming\ Tip\ Length\ -Outgoing\ Tip\ Length}{Accumulated\ Touchdown\ (TD)} = \boldsymbol{Tip\ Length\ (TL)\ wear\ out\ rate}$$

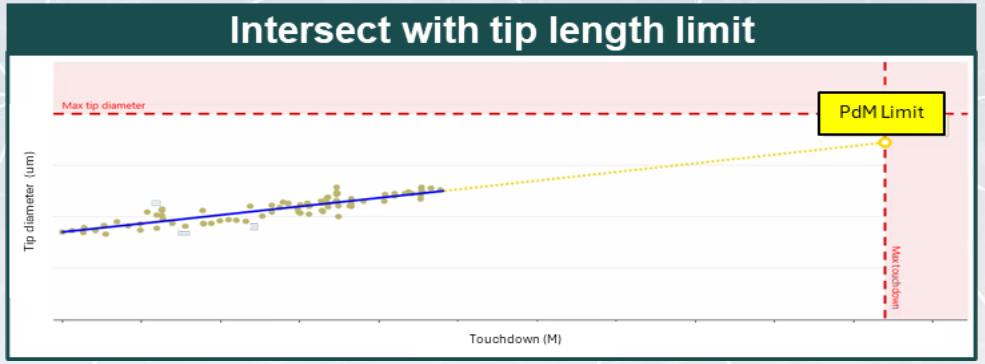
$$\frac{Incoming\ Tip\ Length\ -Usable\ Tip\ Length}{\boldsymbol{TL\ wear\ out\ rate}} = \boldsymbol{Maximum\ Touchdown\ Limit}$$

# Modeling Approach

- **Model Choice**
  - Linear Regression (LR)
- **Inputs**
  - Pin Tip Diameter
  - Touchdown Count
- **Target**
  - Predict Remaining Usable Touchdown
- **Model Performance**
  - Accuracy: ~87%
- **Outcome**
  - Simple, interpretable, and robust
  - Suitable for production deployment and explainability

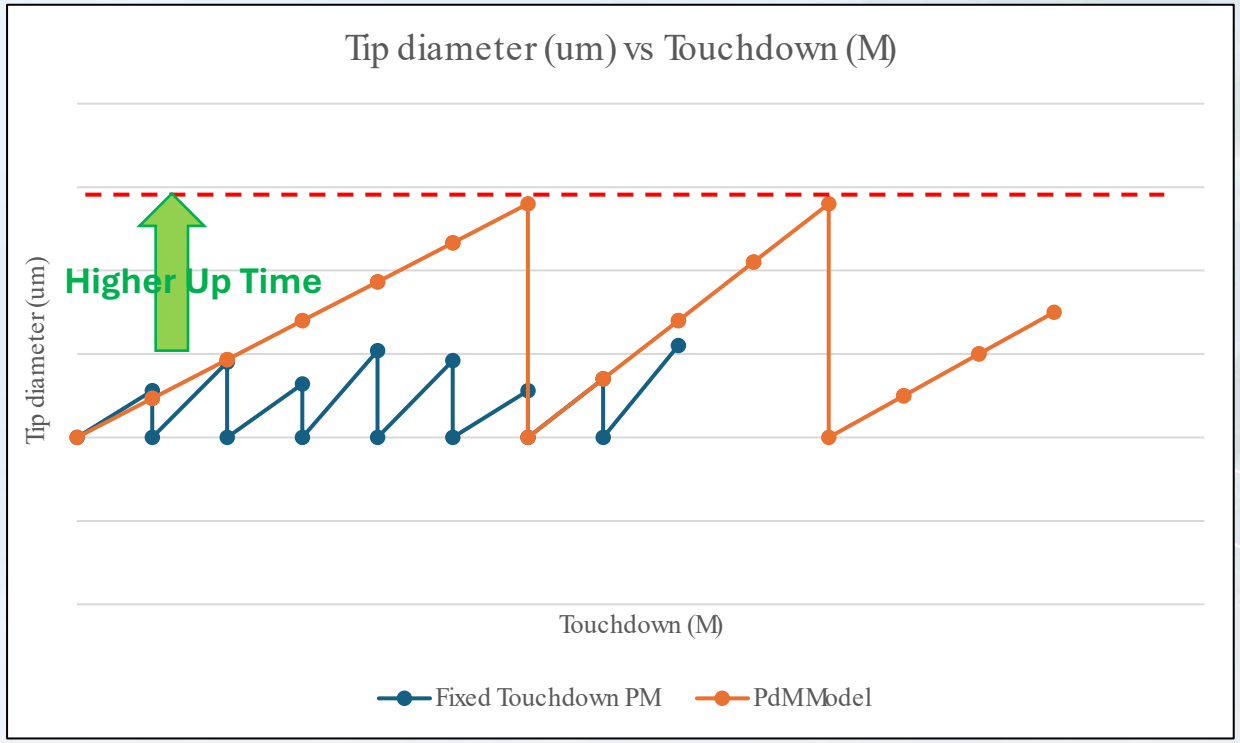


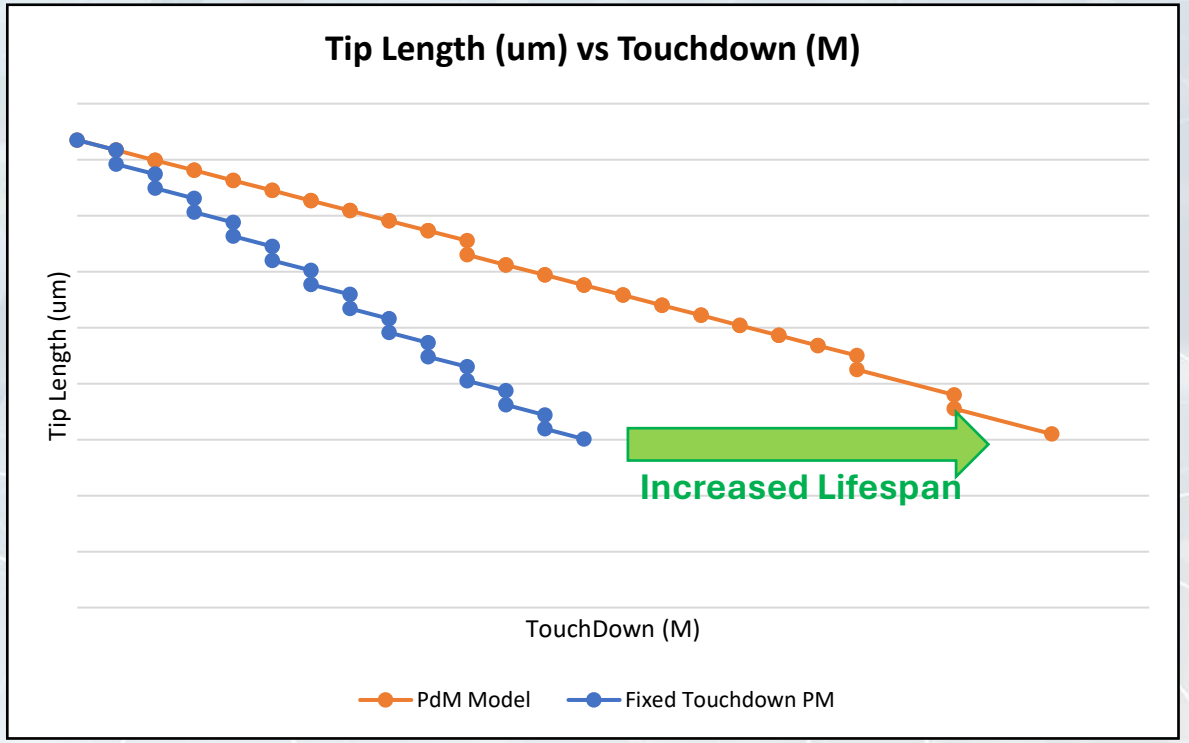



# Results and Outcome

- Touchdown Limits based on PdM greatly surpass the fixed PM limits
- Need for PM (Tip Reshape) is significantly reduced under the PdM model
- Average Lifespan of Probe Card is significantly increased for the given Tip Length



# Safeguards for PdM Model

## Dual Layer Protection

1. Linear Regression Model-based for PdM Limit
2. Condition-based Monitoring on Parametric Data to detect Premature Degradation
   a) Contact Resistance (Cres)
   b) Probe-Skate Detection
   c) Tip Diameter

# Key Takeaways

## Telemetry-Driven Predictive Maintenance (PdM)

- ✅ Replaced Fixed Touchdown Limits PM with Telemetry-Driven PdM Model
- ✅ Identified Tip Diameter as the Primary Predictor for the LR model
- ✅ Achieved overall high PM cost reduction
- ✅ Reduced overall Probe Card Downtime required previously for Fixed Interval PM

# Acknowledgements


- Tee Whay Lim
  - Director, Test Engineering, GlobalFoundries
- Meng Yew Seah
  - Manager, Test Engineering, GlobalFoundries
- Joo Chuan Goh
  - Section Manager, Test Engineering, GlobalFoundries
- Ei Zin Ei
  - MTS, Test Engineering, GlobalFoundries