SWTEST 2026 CONFERENCE

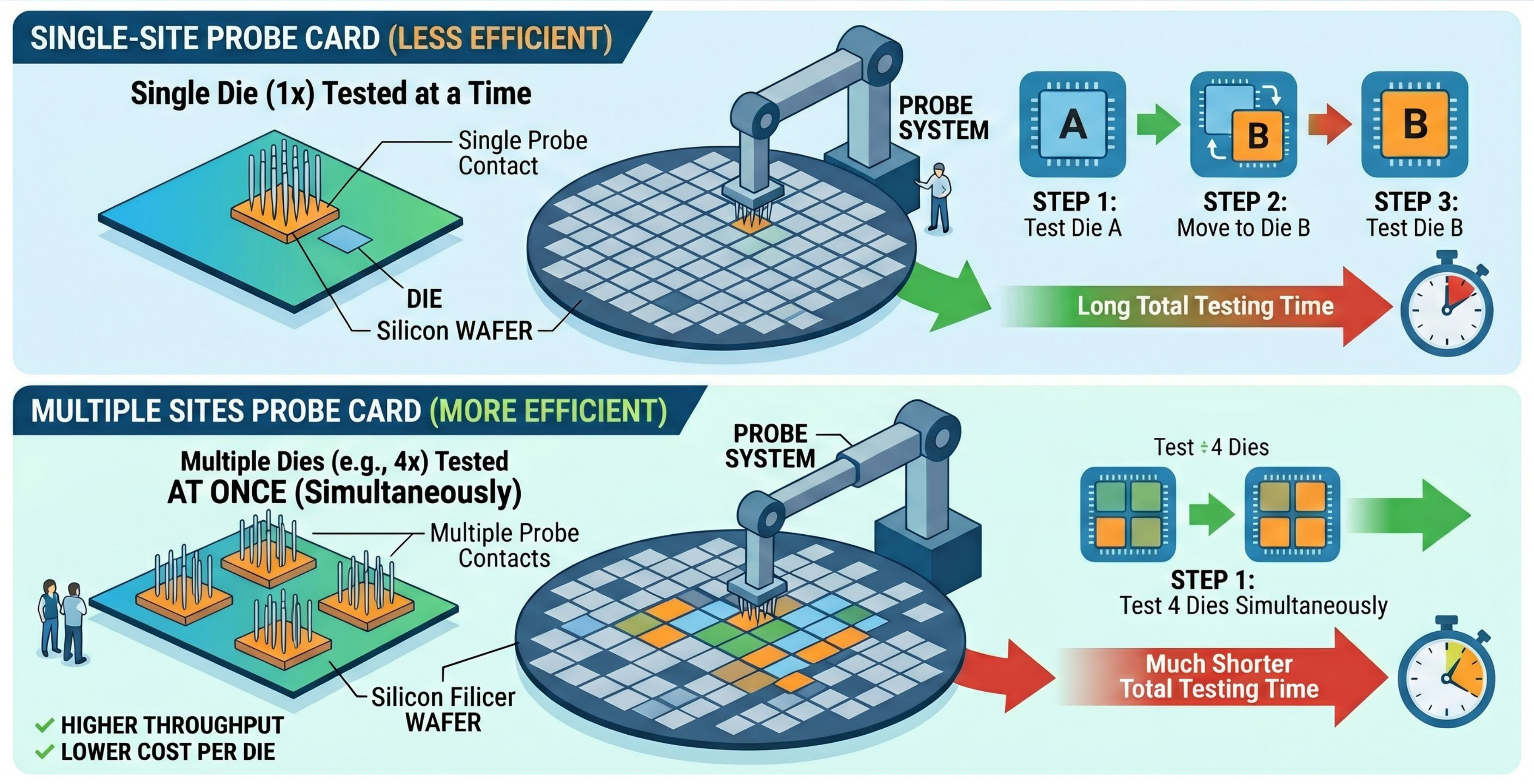
35th ANNIVERSARY

Integer Linear Programming Optimization For Wafer Sort Touchdown Reduction And Mechanical Risk Mitigation

Google

Kelvin Lo

Wafer Sort Industry Context

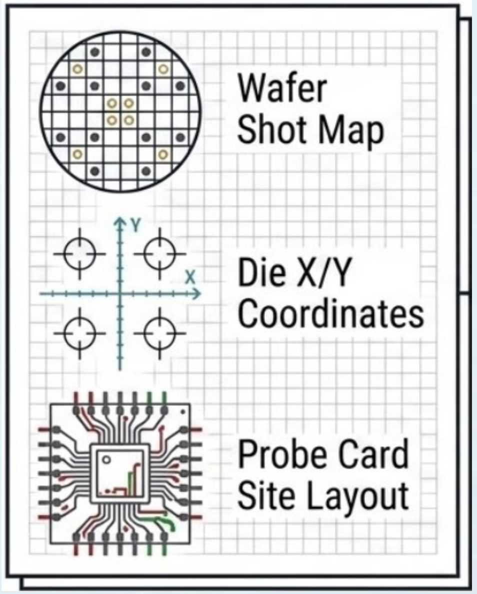


Agenda

- **Motivation**
- **Objectives of Optimization**
- **Algorithm & Methodology**
- **Case Study & Results**
- **Takeaway & Summary**

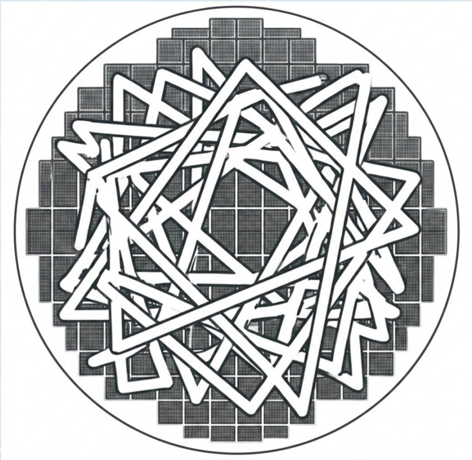
Motivation

Customer Input



OSAT 3rd Party Software (Multi-Site Optimizer)

Stepping Wafer Map



Hidden Inefficiency!

3rd Party Software often gets non-optimal touchdown or inefficient stepping causing waste of time.

Objective

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The Traditional OSAT Procedure	The Improved Customer-Driven Procedure
Engine: 3rd Party Software Multi-Site Optimizer	**Engine:** Customer-Driven AI Simulation (Gemini)
Visibility: Black Box (Unverified by customer)	**Visibility:** Fully transparent and auditable
Logic: Traditional 'Greedy' Algorithm	**Logic:** Integer Linear Programming (ILP) + Travel Salesman Problem (TSP)
Test Time Impact: Suboptimal touchdowns	**Test Time Impact:** Mathematical minimum touchdowns and travel distance
Hardware Impact: Blind to mechanical edge risks (bent pins)	**Hardware Impact:** Flexible Safe-Zone Adjustments (Edge protection)
Flexibility: Limited custom constraints (manual edit probing path by OSAT)	**Flexibility:** Add custom probing constraints (Max-Hits, Inside/ Outside Probing)

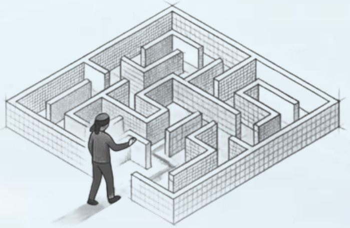
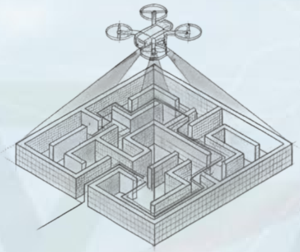
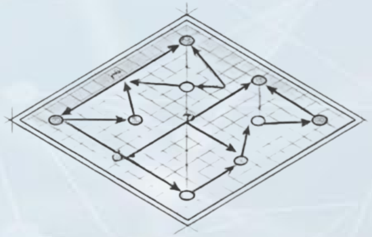
Question the Black Box

Challenge the default
Validate logic
Drive optimization

Test Time Reduction

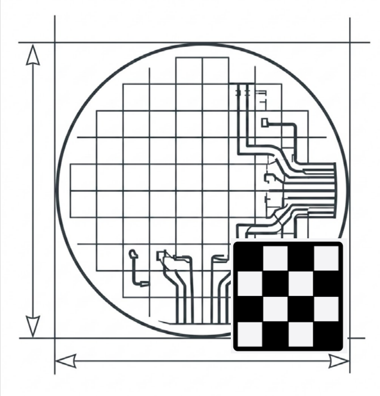
Minimize touchdowns
Optimize probing path
Reduce mechanical risk

AI Algorithm Comparison

Greedy Algorithm (Baseline Approach)	**Integer Linear Programming** (ILP)	**Traveling Salesman Problem** (TSP)
		
Focus: Local step-by-step optimization	**Focus:** Global whole wafer optimization	**Focus:** Probing route optimization
Objective: Find the next best immediate move	**Objective:** Targets mathematical minimum touchdowns	**Objective:** Find the shortest travel distance
• Common in prober industry 3rd party software • Often leads to non-optimal total touchdowns with hidden inefficiency • Results in higher mechanical risk at wafer edges (Outside probing)	• Allow to apply complex wafer sort constraints (eg. Max overlapping hits, inside/ outside probing, edge safe zone landing)	• Find the optimal and efficient shortest physical path between a set of points • Minimize prober index time

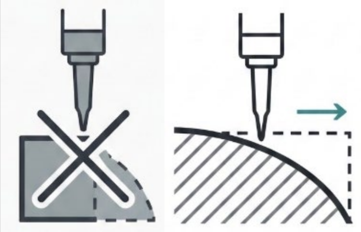
Methodology

Step 1: Data Import



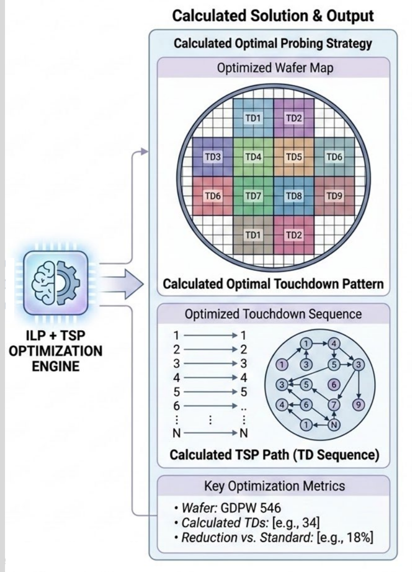
Import Wafer Shot Map (or X, Y coordinate) and Probe Card Site Layout

Step 2: Design Probing Constraints



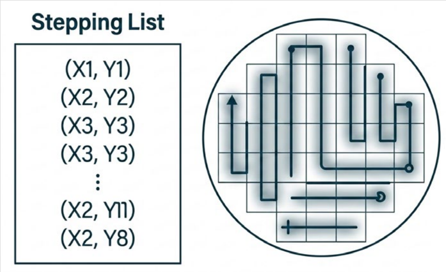
Inside/Outside Probing
Max Overlapping Hits
Optimal Travel Distance
Edge Overhang

Step 3: AI LLM Chatbot



Optimize touchdowns with applying probing constraints

Step 4: Visualization & Validation



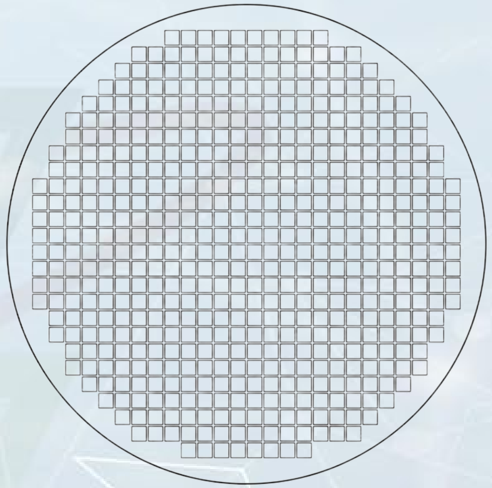
Output the optimized stepping list and validate by prober map setup

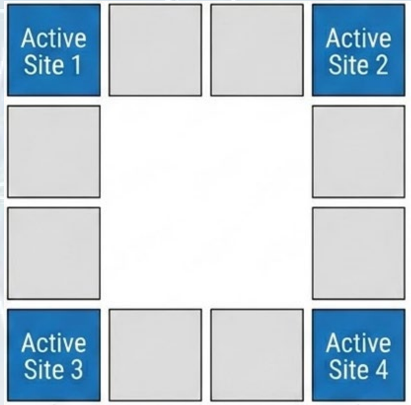
Case Study

Scenario 1

- **GDPW:** 546
- **Probe Card Multi-Site Configuration:**
  4 active sites with site spacing 2-Die skip in both X and Y directions

- **Constraints:**
  - Inside Probing to minimize mechanical risk
  - Reduce TDs Overlapping Hits to minimize probe mark on micro-bump
  - Optimal travel distance to reduce prober index time

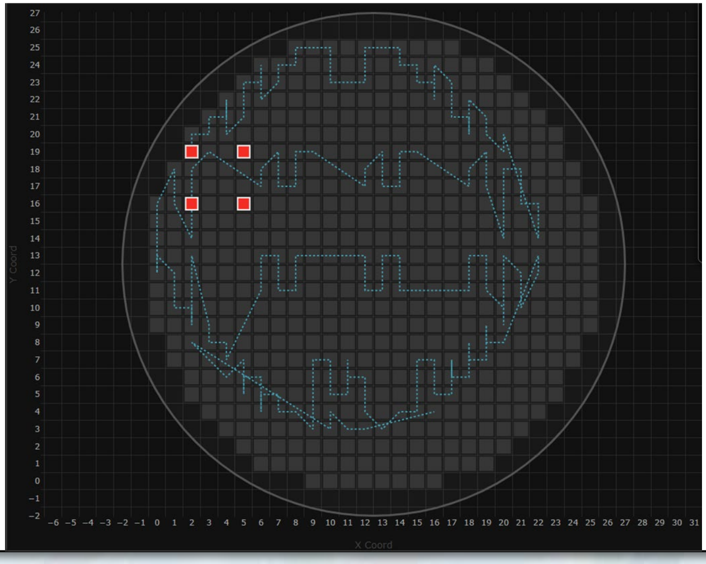


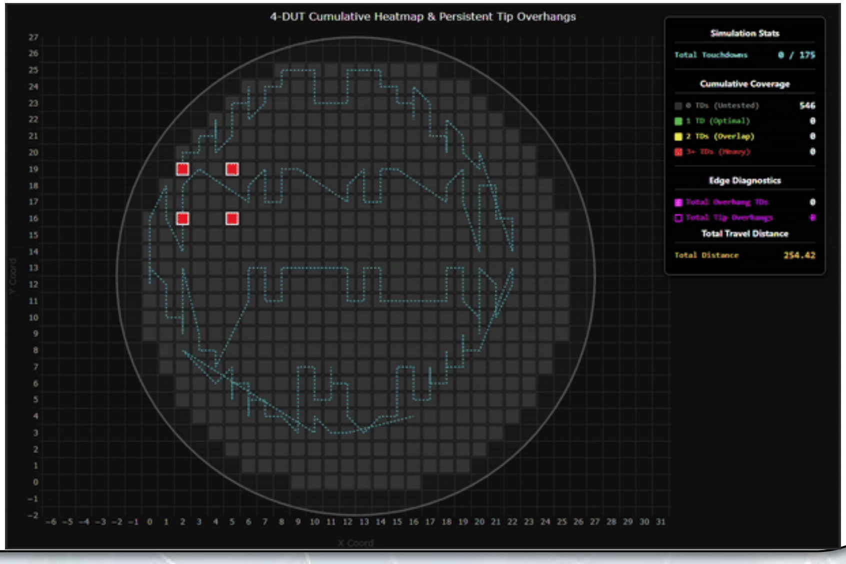


Scenario 1 Inside Probing Visualization

Industry Baseline
(3rd Party Software - Greedy)

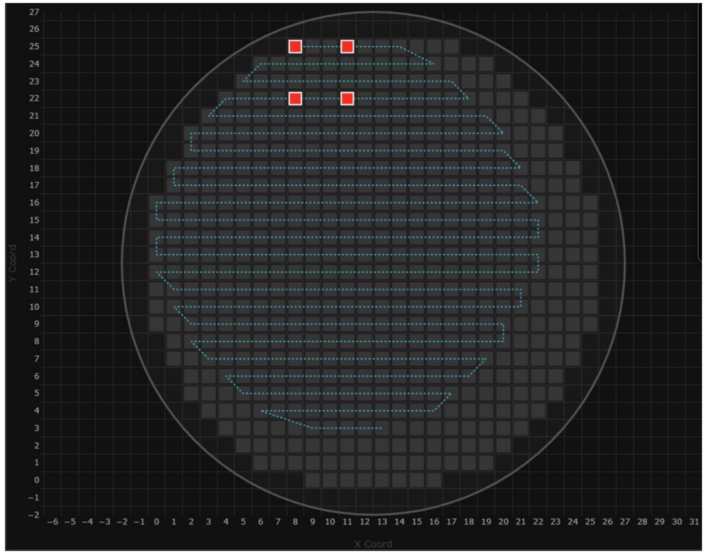
TDs 175
Vortex in X-Axis
Travel Distance 254.4

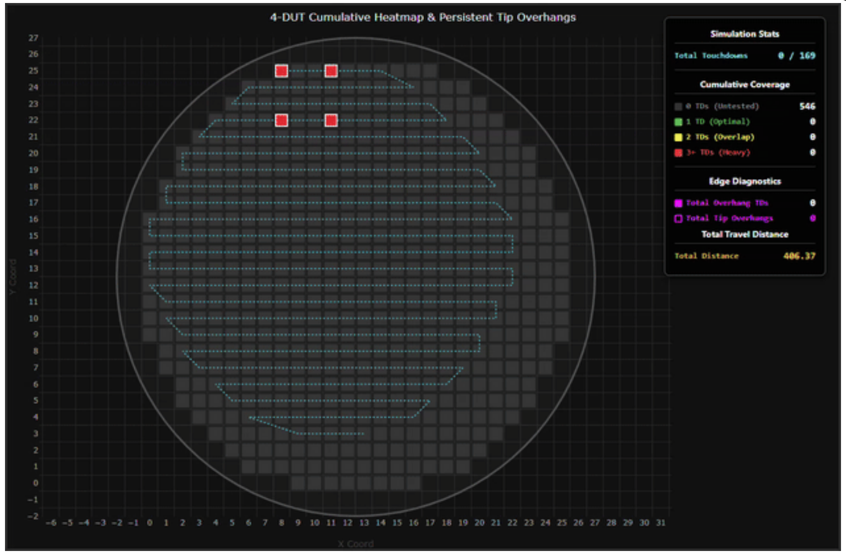




Gemini AI Assisted
(ILP)

TDs 169 (-3.4% ⬇)
Snake path
Travel Distance 406.4

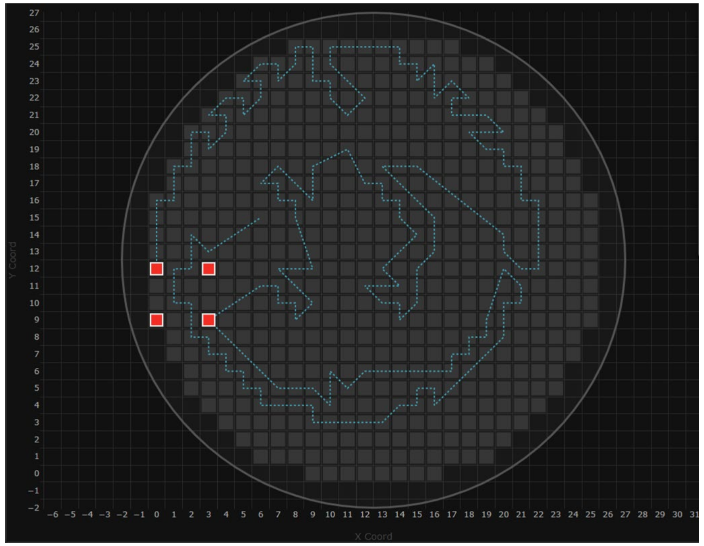


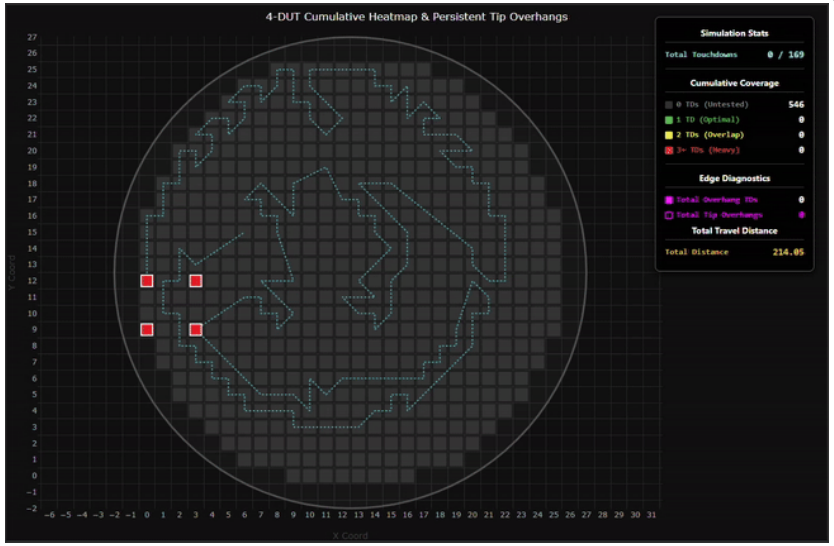


Scenario 1 Inside Probing Visualization

Gemini AI Assisted
(ILP + TSP)

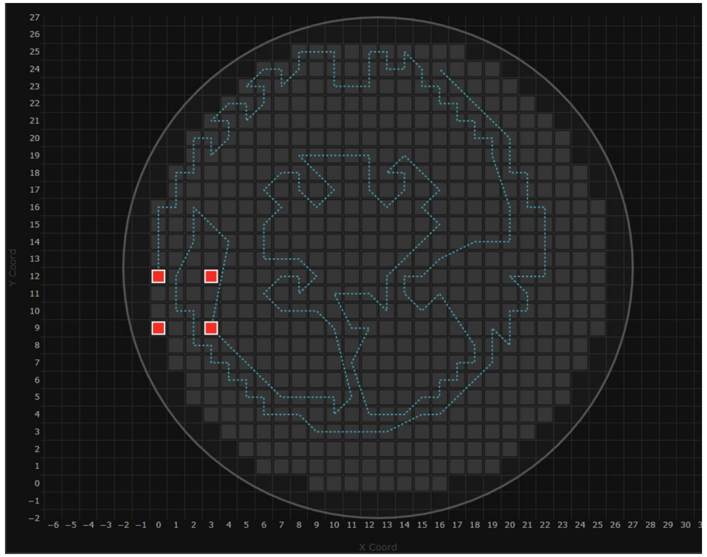
TDs 169
Shortest Path
Travel Distance 214.0
Max 3-Hits

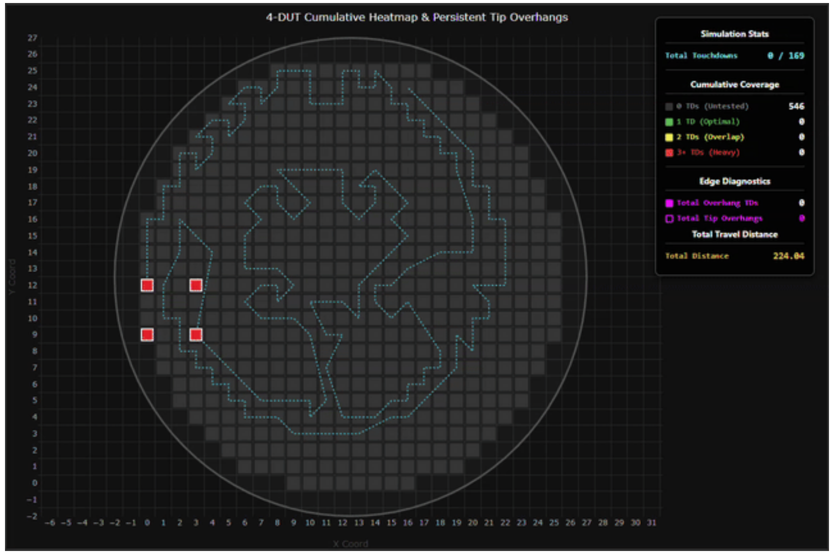




Gemini AI Assisted
(ILP + TSP)

TDs 169
Shortest Path
Travel Distance 224.0
Max 2-Hits





Scenario 1 Inside Probing Summary

Metric	Industry 3rd party software (baseline)	Gemini AI-Assisted Optimization 👑		
Touchdowns	175	**169** (mathematical limit)	**169** (mathematical limit)	**169** (mathematical limit)
Travel Distance (Units, normalized)	254.4	406.4	**214.0** 👍	**224.0**
Probe Route Strategy	Vortex in X-axis	Snake path	TSP shortest path	TSP shortest path
Maximum Hits/Dies	1-Hit: 404 2-Hit: 130 3-Hit: 12	1-Hit: 421 2-Hit: 120 **3-Hit: 5**	1-Hit: 421 2-Hit: 120 **3-Hit: 5**	1-Hit: 416 2-Hit: 130 **3-Hit: 0** 👍
Algorithm	Greedy	ILP	ILP + TSP	ILP + TSP
Constraints	Inside Probing	Inside Probing	Inside Probing	Inside Probing + Strict Max 2-Hits

-3.4% Test Time Saving

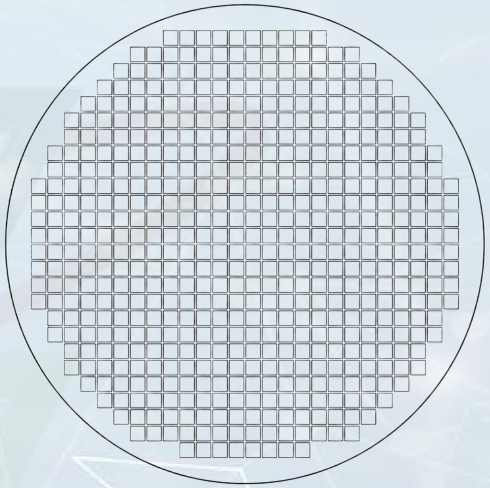
+12~16% stepping efficiency

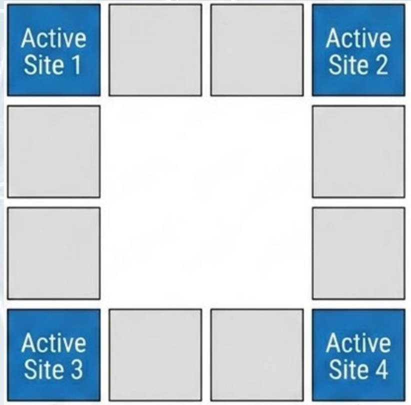
Reduce Max-Hits to minimize probe mark on micro-bump

Case Study

Scenario 2

- **GDPW:** 546
- **Probe Card Multi-Site Configuration:**
  4 active sites with site spacing 2-Die skip in both X and Y directions
- **Constraints:**
  - **Outside Probing with edge overhang 1-die to minimize mechanical damage risk**
  - **Reduce TDs Overlapping Hits to minimize probe mark on micro-bump**
  - **Optimal travel distance to reduce prober index time**

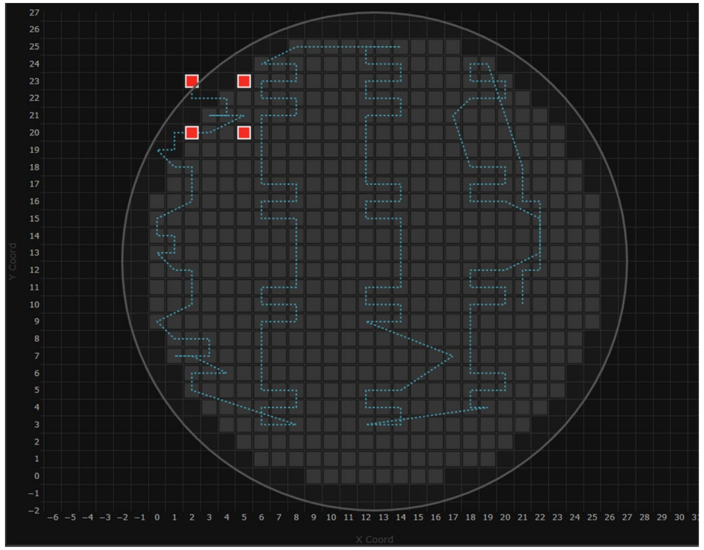


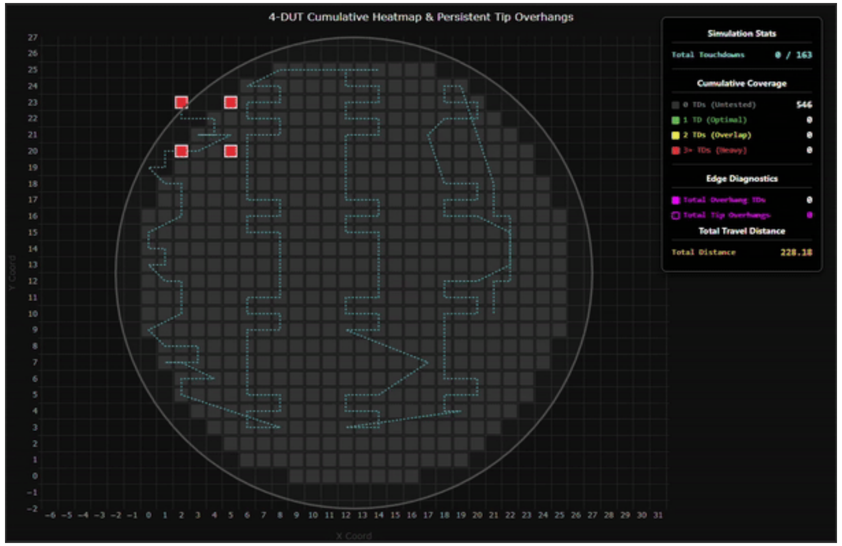


Scenario 2 Outside Probing Visualization

Industry Baseline
(Vendor Software - Greedy)

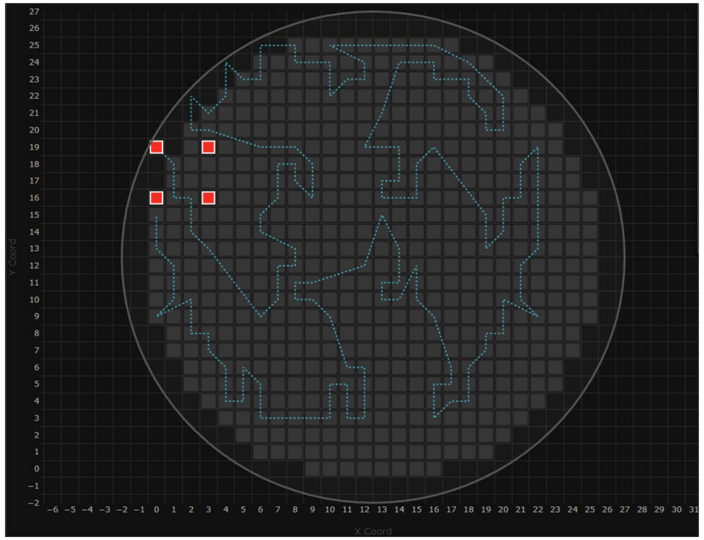
TDs 163
Sequence in Y-Axis
Travel Distance 228.2
Max 3-Hits
Edge Probing 29 dies

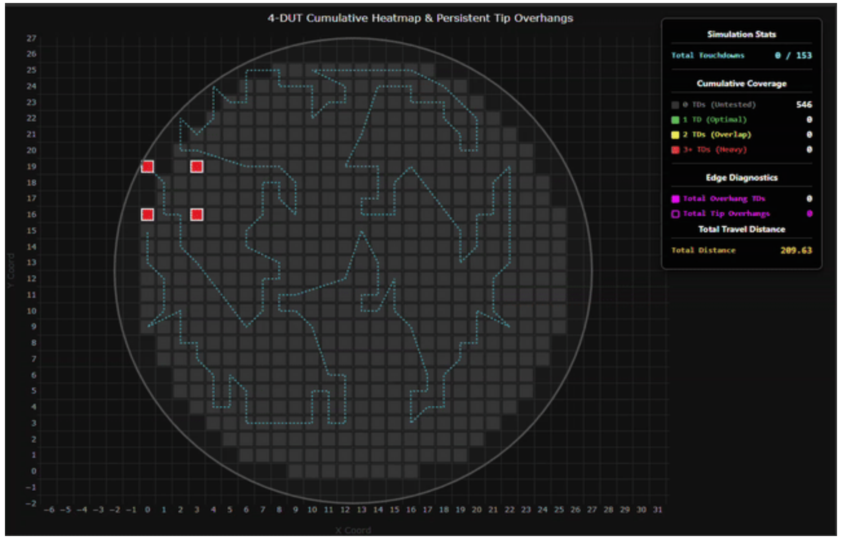




Gemini AI Assisted
(ILP + TSP)

TDs 153 (-6.1%)
Shortest Path
Travel Distance 209.6
Max 2-Hits
Overhang 1-die distance
Edge Probing 22 dies





Scenario 2 Outside Probing Summary

Metric	**Industry 3rd party software (baseline)**	**Gemini AI-Assisted Optimization**
Touchdowns	163	**153** (mathematical limit)
Travel Distance (Units, normalized)	228.2	**209.6**
Probe Route Strategy	Sequence in Y-axis	TSP shortest path
Maximum Hits/Dies	1-Hit: 477 2-Hit: 61 3-Hit: 8	1-Hit: 502 2-Hit: 44 **3-Hit: 0**
Edge Probing	29 dies Edge overhang 3-die distance	**22 dies** Edge overhang 1-die distance
Algorithm	Greedy	ILP + TSP
Constraints	Outside Probing	Outside Probing + Strict Max 2-Hits

-6.1% Test Time Saving

+8% stepping efficiency

Reduce Max-Hits to minimize probe mark on micro-bump

-24% edge probing TD

Results of Business Impact

Cost Saving

- **Touchdown Reduction:** Optimal probe route leads to significant Test Time Reduction
- **Prober Index Time Reduction:** Minimal travel distance further decreases overall Test Time
- **Software Fees:** Enables in-house probe route optimization and simulation with complex constraints

3~6% TDs Saved Per Wafer ➡ **X Wafers Processed Per Week** ➡ **$X Annual Cost Savings**

Wafer Sort Process Benefits

- **Micro-bump Protection:** Minimizes repeated touchdowns to prevent large probe marks
- **Risk Mitigation:** Probing constraint management through flexible safe zone adjustment and improve planarity
- **Planarity Improvement:** Edge overhang constraints for outside probing

Takeaway & Summary

- **Build your own simulation via AI LLM Chatbot (like Gemini) and get immediate TTR feedback**

  (Wafer shot map → Probe card site layout → Constraints → Algorithm → Output)

- **Engineer Empowerment: Challenge the default. Achieve better probing throughput & efficiency by leveraging AI**

- **Future Opportunities: Shifting from Passive to Active from Probe Card Design Point of View**

Passive	Active Design
• Wait for probe card delivery • Run default MSO probe map • Accept inefficiencies	• Identify the absolute most effective site layout skip pattern during probe card design phase! • Maintain target TD while minimizing active site to reduce probe card cost!