Manufacturing Test Strategy Cost Model

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Purpose

• Manufacturing Test Strategy Cost Model developed in conjunction with NEMI.
• Cost model embraces best practices and methodologies used by the participating companies.
• To benchmark and measure the financial impact of selecting a particular test strategy.
• Perform trade-off analysis among various test strategies and gain visibility on the impact of field failures on warranty costs.
Outline

• Introduction
• Current use
• Case Study
• Model Limitations
• Future Work
• Conclusion
Introduction

- The test strategy cost model can help drive quick decisions by demonstrating the value of adding or removing test stages vs. utilizing sampling strategies vs. 100% inspection methods.

- The model is available as an Excel spreadsheet and it is intended to be used on post-reflow PCA test strategies.

- It comprises of 4 major sections: Inputs, Defaults, Calculations, and Outputs Sections.
Introduction

Options → Inputs → Calculations → Outputs

DEFAULTS
Introduction

Options Inputs Calculations Outputs

• Production Volume
• Board Cost
• Field Return Cost
• Number of Components
• Number of Joints
• Test Effectiveness

• Repair Cost
• Diagnostic Cost
• Equipment Cost
• Fixture Cost
• Programming Cost
• Maintenance Cost
Introduction

Options —→ Inputs —→ Calculations —→ Outputs

DEFUALTS

Options
• Test Strategy Flow
• Yield at each stage
• Defect Escapes
• Test Effectiveness

Inputs

Calculations
• Savings Summary
• Test Cost Charts
• ROI Metrics
• TTM Savings

Outputs
Introduction

Options

Inputs

Calculations

Outputs

DEFAULTS

• DPMO
• Yield
• Time To Market
• Test Effectiveness
• Access Multiplier
• Test Time
• Equipment Cost

• False Reject Rate
• Annual Operator Cost
• Repair Yield
• Re-Test Cycles
• Repair Cost
• Diagnostic Cost
• Maintenance Cost
Introduction

The cost model and the user’s guide are available to industry (free of charge) on the NEMI website at the following URL:

http://www.nemi.org/projects/ba/test_strat.html
Introduction

http://www.nemi.org/projects/ba/test_strat.html

Field Return Rate

Number of test or inspection stages at Strategy 1

Number of test or inspection stages at Strategy 2

Test Strategies Inputs

Step 4: Please Complete the following Test Strategies Inputs.

Strategy 1 Types of Test/Inspection

Field Return Rate: 1 Default

Number of test/inspection stages on Strategy 1: 2

Stage 1 (Name): ICT
Stage 2 (Name): FT
Stage 3 (Name): 
Stage 4 (Name): 

Strategy 2 Types of Test/Inspection

Number of test/inspection stages on Strategy 2: 3

Stage 1 (Name): AXI
Stage 2 (Name): ICT
Stage 3 (Name): FT
Stage 4 (Name): 
Current use of the model

• Since the inception of the model each participating company has continued to validate its accuracy.

• The model’s output has been proven to deliver conservative estimates on warranty costs.

• In a recent study, conducted by Hewlett-Packard, the model’s accuracy with respect to actual warranty cost impact was validated.

• This comparative analysis was conducted on a product that already had market history.
Case Study - Background

• Product with market & manufacturing history.
• Medium complex board:
  - 600 components 3,000 joints.
• Annual production volume ~ 50K.

Current Strategy

ICT → FT → ST

Proposed Strategy

AXI → ICT → FT → ST
Case Study - Options

- Select to use Yield.
- Time To Market savings not selected.
- ROI metrics selected.
Case Study - Inputs

• Board cost, Field Return cost & Field Return Rate data available.

• All other Information available only for current strategy.

• AXI test effectiveness study performed.
  – Test partner programmed AXI equipment.
  – Experiment consisted in 500 boards tested with AXI

• Obtained accurate Test Coverage and Test Time from experiment.

• Estimation of all other inputs based on the experiment.
Case Study - Inputs

- Equipment cost based on % of utilization.

<table>
<thead>
<tr>
<th></th>
<th>AXI</th>
<th>ICT</th>
<th>FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Cost</td>
<td>$600,000</td>
<td>$300,000</td>
<td>0</td>
</tr>
<tr>
<td>Fixture Cost</td>
<td>0</td>
<td>$15,000</td>
<td>$110,000</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>$25,000</td>
<td>$20,000</td>
<td>$12,000</td>
</tr>
</tbody>
</table>
Case Study - Inputs

- Production volume: 50K.

<table>
<thead>
<tr>
<th></th>
<th>AXI</th>
<th>ICT</th>
<th>FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Time</td>
<td>1 min</td>
<td>0.47 min</td>
<td>3.6 min</td>
</tr>
<tr>
<td>Capacity</td>
<td>302,400</td>
<td>643,404</td>
<td>84,000</td>
</tr>
<tr>
<td>Utilization</td>
<td>0.165</td>
<td>0.078</td>
<td>0.595</td>
</tr>
<tr>
<td>Equipment Cost</td>
<td>$99,206</td>
<td>$23,313</td>
<td>0</td>
</tr>
<tr>
<td>Fixture Cost</td>
<td>0</td>
<td>$15,000</td>
<td>$110,000</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>$4,134</td>
<td>$1,554</td>
<td>$7,143</td>
</tr>
</tbody>
</table>
Case Study - Outputs

Current Strategy

ICT Yield 92.0%
Defects: 5,558

FT Yield 98.0%
Defects: 1,390

ST Yield 99.7%
Defects: 382

Defects: 263

Proposed Strategy

AXI Yield 90.5%
Defects: 5,558

ICT Yield 98.8%
Defects: 806

FT Yield 99.7%
Defects: 202

ST Yield 99.9%
Defects: 55

Defects: 38
Case Study - Outputs

**CURRENT STRATEGY**
Annual Yield related Costs: $ 647 K
(Scrap, Repair, Diagnostic, Field return, re-test)

Annual Equipment related Costs: $ 156 K
(Operator, Code, Maintenance, Equipment, Fixture,)

**PROPOSED STRATEGY**
Annual Yield related Costs: $ 280 K
(Scrap, Repair, Diagnostic, Field return, re-test)

Annual Equipment related Costs: $ 190 K
(Operator, Code, Maintenance, Equipment, Fixture,)
Case Study - Outputs

**CURRENT STRATEGY**

Annual Yield related Costs
+ Annual Equipment related Costs
\[ \text{\$ 803 K} \]

**PROPOSED STRATEGY**

Annual Yield related Costs
+ Annual Equipment related Costs
\[ \text{\$ 470 K} \]

**Total Savings (annual) due to the introduction of AXI**
\[ \text{\$ 333 K} \]
Case Study - Conclusion

• Test Cost Model demonstrated savings when adding AXI into the current strategy.

• Outputs of the model where validated against real data from manufacturing and field.

• The utilization of actual data in the model will drive accuracy onto the calculations.
Model Limitations

• The list of package types and their defect levels are not representative of all package types currently available in industry.

• In this test cost model we are assuming a 100% diagnostic yield

• This model will not accurately represent results when multiple test stages are used in a complementary manner.
Model Limitations

Stage 1
- Test Access: 60%
- Test Coverage: 100%

Stage 2
- Test Access: 40%
- Test Coverage: 100%
Model Limitations

Stage 1

100 defects

100% Coverage
60% Access

Faults detected

60

Stage 2

40 defects

100% Coverage
40% Access

Faults detected

40

60 + 40 = 100 defects

100% Coverage

Actual Coverage
Model Limitations

Stage 1

100 defects

100% Coverage
60% Access

Faults detected

60 defects

Stage 2

40 defects

100% Coverage
40% Access

Faults detected

16 defects

0 defects

60 + 16 = 76%

Coverage Calculated by Test Cost Model
Future Work

• The creation and linkage to a DPMO database.
• On-going validation of field related costs with actual warranty costs after a strategy has been selected.
• Enable automatic sensitivity analysis features into the test cost model.
• Enable production capacity analysis features into the model.
Conclusion

- The model is intended to be used by engineers or managers that are responsible for making decisions on test strategies for their company.

- Standardization of the economic analysis of production test strategies will bring consistency to the overall approach for determining the financial impact of various test techniques.

- The model is available to industry (free of charge) on the NEMI website at the following URL: http://www.nemi.org/projects/ba/test_strat.html