Utilizing current test strategies to drive diagnostics development, deployment and support through software tools
So Why Is it So Hard To Understand or Do we Just Make It Hard?

Answer on a student’s Geometry test

3. Find $x$.

Here it is
Using The Learning Organization Process to Improve

- External/Internal Disturbances
- Object of Interest
- Behavior
- Results
- Understanding
- Model
- Predict
- Measure
- Analyze
- Learn
- Knowledge
- Decide
- Act
-

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So Why Do We Test…….

- To Measure the Health of the Process
- To Reduce Risk of Variability
- To Identify Problems

Risk

Meet Spec

Verify Design

Ship Product that Works

Warranty Cost

Design | Validation | Manufacturing | Support
The Problem
How Much is Really at Risk?

Shipped Defect Rate Exposure

- 50% Coverage
- 60% Coverage
- 70% Coverage
- 80% Coverage
- 90% Coverage

Yield at Test Stage

0.0% 2.0% 4.0% 6.0% 8.0% 10.0% 12.0% 14.0%

75% 80% 85% 90% 95% 100%
Effectiveness

Fault Spectrum

Typical Test Strategy

Characteristics:
- Broad coverage at each test
- High level of redundant test
- Leakage of early defects caught later by test
- Fault coverage is unpredictable
Process Test Coverage Redundancy

- Insufficient
- Excess
- Cold Solder
- Marginal Joints
- Voids

- Excess
- Bridging
- Tombstone
- Misalignment

- Missing
- Gross Shorts
- Lifted Leads
- Bent Leads

- Polarity, Extra Part,
  - Non-Elec. parts
  - Bypass Caps, L’s
  - Lifted Power/Gnd

- Inverted
- Polarity

- Shorts
- Open

- Dead Part
- Wrong Part
- Bad Part
- Short/Open on PCB
- Functionally Bad

Solder

X-Ray

AOI

Correctness

CT

Functional

Electrical

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Example Design Coverage
ICT → AXI → AOI → Functional

Solder
- X-Ray: 66.6% Unique Coverage, 33.5% (FA)

X-Ray
- CT: 12.2% Unique Coverage, 51.1% (FA)

AOI
- 5.0% Unique Coverage, 2.8% (FA)

Electrical
- Correctness
- Functional

~10% NOT COVERED
Example of Coverage
Functional → AXI → AOI → ICT

Solder

X-Ray

44.0% Unique Coverage

AOI

41.2% Unique Coverage

Correctness

3.2% Unique Coverage

Functional

Electrical

0.9% Unique Coverage

2.9% (FA)

~10% NOT COVERED

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What is Needed
Coverage Mapping and What We Know

Process Test Coverage (Static) - Functional Test Coverage (Dynamic) -

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Coverage Mapping and What We May Know

Process Test Coverage (Static) - Functional Coverage (Dynamic) -
Coverage Mapping and What We Want to Know

Process Test Coverage (Static) - Functional Coverage (Dynamic) -

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The Answer

FAULT COVERAGE
Desired Production Test Process

Characteristics:
- Test in right place
- Minimize redundant test
- Effectively catch defects at origin
- Fault coverage is predictable

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What is Needed For Effective Test Strategies

• A common Framework for describing Test Strategies.
• Standardized documentation for test.
• Metrics to make test tradeoffs between test strategies (AXI, AOI, ICT, Functional, etc) for gaps and overlaps.
• Ability to simulate a Test Strategy as the product is being developed to feedback DFX input.
• A consistent, repeatable process throughout the product life cycle.

What is not needed is…….
• An automated way to develop test plans
• A tool to eliminate the need for test developers
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Test Optimization Software: Knowledge Transfer
Elements for a true Product Life Cycle Test Strategy

- Multiple design teams, multiple locations, using common design rules, common design tools for uniform test strategies.

- Transfer product designs, processes, test and repair knowledge in a predictable, repeatable manner to anyone anywhere.

- Model, simulate and predict test performance, quality, and cost drivers.

- Deliver manufacturing specifications without flying engineers everywhere.

- Have a common language for communicating product/process functionality.

- Consistent repair and diagnostic process with no variability, any time, any where and by anybody.
Example of Change
Using The Learning Organization Process to Improve

External/Internal Disturbances

Act

Decide

Learn

Knowledgex

Predict

X-Ray

AOI

ICT

Func

Effectiveness

Fault Spectrum

Results

Measure

Analyze

Behavior

Pass

Fail

Pass

Pass

80%

20%

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Original Manufacturing Flow
Complexity and Variability at Every Step

Pristine Yield = 0%
Pristine Yield = 43%

Yield = 0%

Yield = 67%
Yield = 78%
Yield = 86%
Yield = 96%

DT
Thru-Hole
SMT
MDA
SRU Assembly Cells
SRU Cell Test
LRU Assembly Cell
LRU Cell Test
ESS
Final System Assembly and Configuration
Final Assembly System Test
Ship

Repair
Diagnostics
Repair
Diagnostics
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1 Day
30 Mins
1 Day
2 Days
4 Days
6 Days

DIAGNOSE
RE-TEST
DIAGNOSE
RE-TEST
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Distribution of Defects by Symptom

Other
Placement
Wrong/Bad Parts
Solder/Workmanship

LRU
SRU
Redesigned Manufacturing Flow

Pristine Yield = 72%

Yield = 80%

Yield = 95%

Yield = 98%

Yield = 98%

Yield = 98%

SMT  Thru-Hole  XRAY  MDA  SRU Assembly Cells  SRU Cell Test  LRU Assembly Cell  ESS  LRU Cell Test  Final System Assembly and Configuration  Final Assembly System Test  Ship

Repair  Diagnostics  Repair  Diagnostics  Repair  Diagnostics

DIAGNOSE

RE-TEST 15 Mins

RE-TEST 30 Mins

RE-TEST 60 Mins

DIAGNOSE

DIAGNOSE

DIAGNOSE

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NDIA October  2006
What is the impact of Efficient Test and Effective Diagnostics?

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<td>Increase in quality and reduction in diagnostic and repair of products</td>
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<td>Increase productivity of production lines due to increased test capacity (20% * 200 units/yr * $20K/unit)</td>
<td>$.8 Million</td>
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<td>Savings in elimination of new tests and testers at SRU (at $500K) and LRU (at $1,000K) test cells* (($500K * 4 + $1,000 * 4) * 25%)</td>
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<td>Reduction in total cycle time due to increased quality and re-alignment of processes (5 days * $240/day * 960 units/year)</td>
<td>$1.15 Million</td>
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$2.62 Million First Year

5 year ROI

$16.3 Million
Conclusion
Leverage Points in the Product Life Cycle

80-90% of manufacturing cost determined before QUAL
90% of achievable first pass yield determined by QUAL
80% of potential profitability fixed at DEV
80% of MTBR determined before DEV

Current tools will allow you to leverage these advantages by:
- Eliminating Complexity and Variability
- Ensuring Efficient and Effective Test Strategies before release
- Developing Automated Diagnostics with little additional resources during development
- Using Test and Diagnostics as part of a learning organization throughout the total product life cycle to leverage Results!!
Questions???