

Excerpts from the course:

The Economics of Test and Testability

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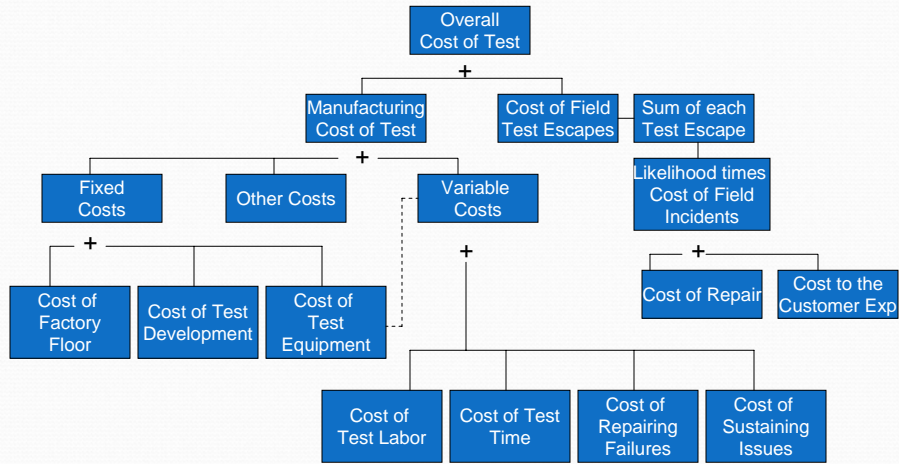
Will be presented in San Jose on Feb 11, 2010.
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System Test and DFT Economics

Cost of System Test Diagram

From Williams & Ambler: System Manufacturing Test Cost Model, ITC 2002

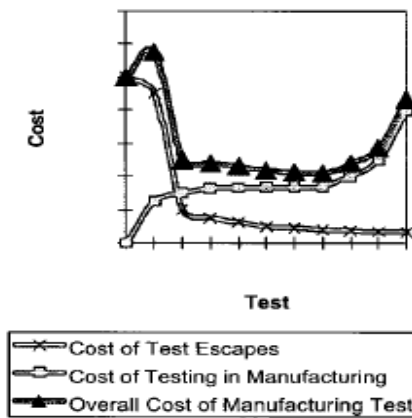


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Cost of Test

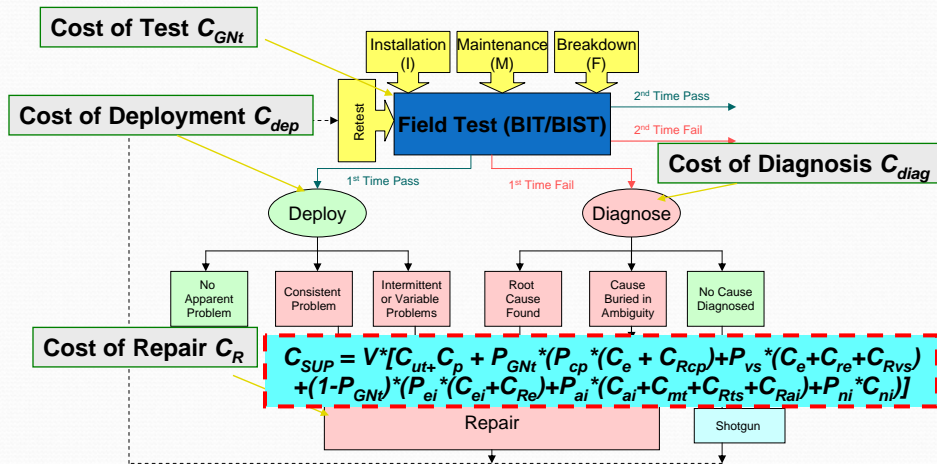
From Williams & Ambler: System Manufacturing Test Cost Model, ITC 2002



Field Support Test and DFT Economics

Cost of Support

Louis Y. Ungar, An Economic Model of Supportability Through Design for Testability, AutoTestCon, 2006



DFT Improvements

$$C_{SUP} = V * (C_{ut} + C_p + P_{GNT} * (P_{cp} * (C_e + C_{Rcp}) + P_{vs} * (C_e + C_{re} + C_{Rvs})) + (1 - P_{GNT}) * (P_{ei} * (C_e + C_{re}) + P_{oi} * (C_{di} + C_{mt} + C_{Rts} + C_{Roi}) + P_{ni} * C_m))$$

Factor	Description	DFT Improvements Possible
V	Volume	See components below as $V = I * M + F * (R_1 + R_2 + R_n)$
M	Number of Units undergoing regular Maintenance	None
F	Number of Units that breakdown	A more comprehensive test in production is possible on a testable unit, thereby reducing the requirement for more frequent maintenance.
(R ₁ + R ₂ ... R _n)	Number of times a unit needs to be retested – with R _n requiring the unit to be scrapped.	A more comprehensive test in production could have been prognostic and reduce the number of breakdowns The most likely reason for retest is low fault coverage. Better DFT will allow catching such "undetectable" or "undetected" faults and reduce the likelihood of having to scrap a unit.

Louis Y. Ungar, An Economic Model of Supportability Through Design for Testability, AutoTestCon, 2006

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DFT Improvements

$$C_{SUP} = V * (C_{ut} + C_p + P_{GNT} * (P_{cp} * (C_e + C_{Rcp}) + P_{vs} * (C_e + C_{re} + C_{Rvs})) + (1 - P_{GNT}) * (P_{ei} * (C_e + C_{re}) + P_{oi} * (C_{di} + C_{mt} + C_{Rts} + C_{Roi}) + P_{ni} * C_m))$$

Factor	Description	DFT Improvements Possible
C _{ut}	Unit cost of a test run	Through DFT, test times can be reduced.
C _p	Parts cost in repair	Better quality fault isolation prevents replacing good parts.
P _{GNT}	Percentage of units passing the Go/No Go test	This doesn't indicate whether the units that pass the test are in fact good. (See costs of escape.) On the other hand, with more comprehensive production tests likely in a testable system, we can expect a higher number of good units passing during installation and maintenance, thereby reducing the overall cost of test.
P _{cp} * (C _e + C _{Rcp})	Percentage of units passing that exhibits a consistent problem when installed in the system, the cost associated with dealing with this escape, and the cost of repairing it.	A unit that has passed the test and is still faulty indicates that the test was not sufficiently comprehensive. This occurs either because of test engineering mistakes or because certain faults are too difficult to address with the test. DFT can make it simpler for the test engineer to produce good test programs, and eases detection of elusive faults.
P _{vs} * (C _e + C _{re} + C _{Rvs})	Percentage of units passing that exhibit problems, but the symptoms vary and are unpredictable. Invoke escape costs, costs of having to rerun units and the cost of repairs.	Intermittent and variable faults that exist in a unit, which already passed the test indicates environmental, power or timing problems. Because many of the tests are focused on catastrophic faults, such as stuck-at-0 or -1 faults, actual faults can be missed. Through DFT, it is possible to expose such faults to external testers or internal Built-In Self Test circuitry.

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DFT Improvements

$$C_{cup} = V * [C_{ix} + C_p + P_{GNT} * (P_{cp} * (C_e + C_{Rcp}) + P_{vs} * (C_e + C_{re} + C_{Rvs})) + (1 - P_{GNT}) * (P_{ei} * (C_{ei} + C_{Re}) + P_{ai} * (C_{ai} + C_{mt} + C_{Rts} + C_{Rai}) + P_{ni} * C_{ni})]$$

Factor	Description	DFT Improvements Possible
$(1 - P_{GNT})$	Percentage of units that fail field test	Obviously, the cost associated with faulty units is greater than those associated with good units, it is our goal to get a higher percentage of good units from production. DFT at manufacturing test reduces this number, but there is not much we can do for units that break in the field.
$P_{ei} * (C_{ei} + C_{Re})$	Percentage of those units that failed the test that gave exact fault isolation information, times the cost associated with such diagnosis plus the cost of repairing them.	As these cost less to support than units that do not have exact fault isolation information, DFT techniques need to be employed to make more cases of diagnoses exact.
$P_{ai} * (C_{ai} + C_{mt} + C_{Rts} + C_{Rai})$	Percentage of failed units that that remains ambiguous of the root cause. Includes cost associated with administering the ambiguity, manual troubleshooting, repairing through troubleshooting and repairing ambiguous isolation	Ambiguity can create two types of cost factors. Either we choose to replace or repair all suspected causes or we take the time to further trouble shoot. Neither is a desirable option. The way to avoid this through DFT is to make sure the design lends itself to exact fault isolation.
$P_{ni} * C_{ni}$	Percentage of units that failed the test, but provide no isolation information, times the cost associated with such units.	Having no fault isolation information leaves us with few options. We have to guess (Shotgun). Often we will be wrong, thereby creating needless costs. Through DFT we can minimize situations like this and get more exact isolation.

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An Example Reduced Initial Volume

Units Installed (I)	200	200
Yearly Maintenance for 10 years (M)	2000	2000
MTBF = 5 years - Each unit undergoes repair twice per life time. With DFT a 10% improvement. (F)	400	360
Percent Retested (R1+...Rn)	30.0%	20.0%
Units Retested	780	512
	3380	3072

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An Example Reduced Test Cost

Total Initial Volume (V)	3380	3072
Percent of (I) passing	95.0%	95.0%
Percent of (M) passing	90.0%	92.0%
Percent of (F) passing	5.0%	2.0%
Percent Retested (R1+...Rn) Passing	80.0%	90.0%
Total Units Passing	2634	2498
Unit test cost (C _{ut})	\$50.00	\$40.00
	\$169,000.00	\$122,880.00

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An Example Reduced Support Cost

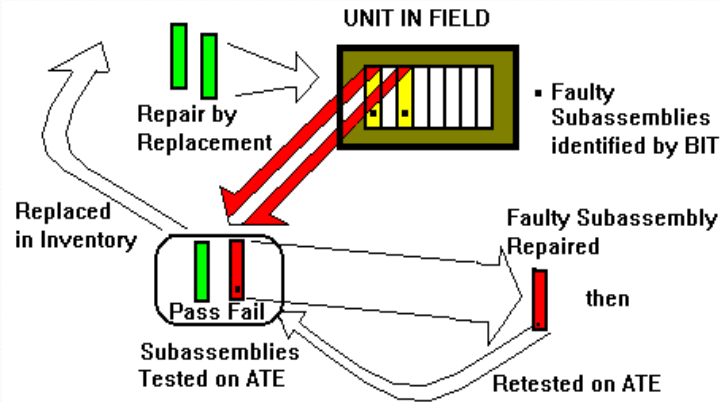
Test Costs - $V \cdot C_{ut}$	\$169,000.00	\$122,880.00
Consistent Problem Costs - $V \cdot P_{GNI} \cdot P_{cp} \cdot (C_e + C_{Rcp})$	\$3,694.77	\$2,437.50
Variable Problem Costs - $V \cdot P_{GNI} \cdot P_{vs} \cdot (C_e + C_{re} + C_{Rvs})$	\$3,489.50	\$1,726.56
Exact Isolation Costs - $V \cdot (1 - P_{GNV}) \cdot P_{ei} \cdot (C_{ei} + C_{Re})$	\$11,627.01	\$10,501.85
Ambiguous Isolation Costs - $V \cdot (1 - P_{GNV}) \cdot P_{ai} \cdot (C_{ai} + C_{mi} + C_{Rts} + C_{Rai})$	\$8,894.66	\$3,570.63
No Isolation Diagnosis Costs - $V \cdot (1 - P_{GNV}) \cdot P_{ni} \cdot C_{ni}$	\$1,492.00	\$574.00
Repair Costs - $V \cdot P_R \cdot C_p$	\$2,809.00	\$1,191.06
C_{SUP}	\$201,006.94	\$142,881.60
Savings		28.92%

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Traditional BIT In Field Service

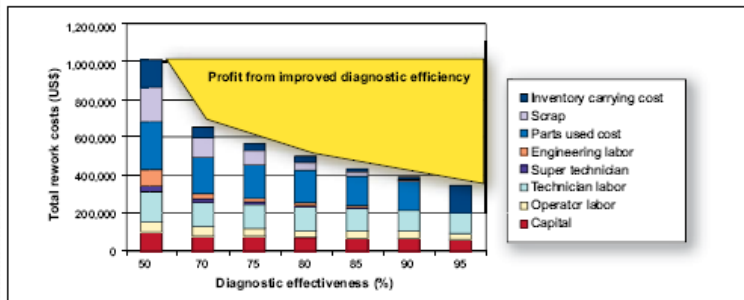


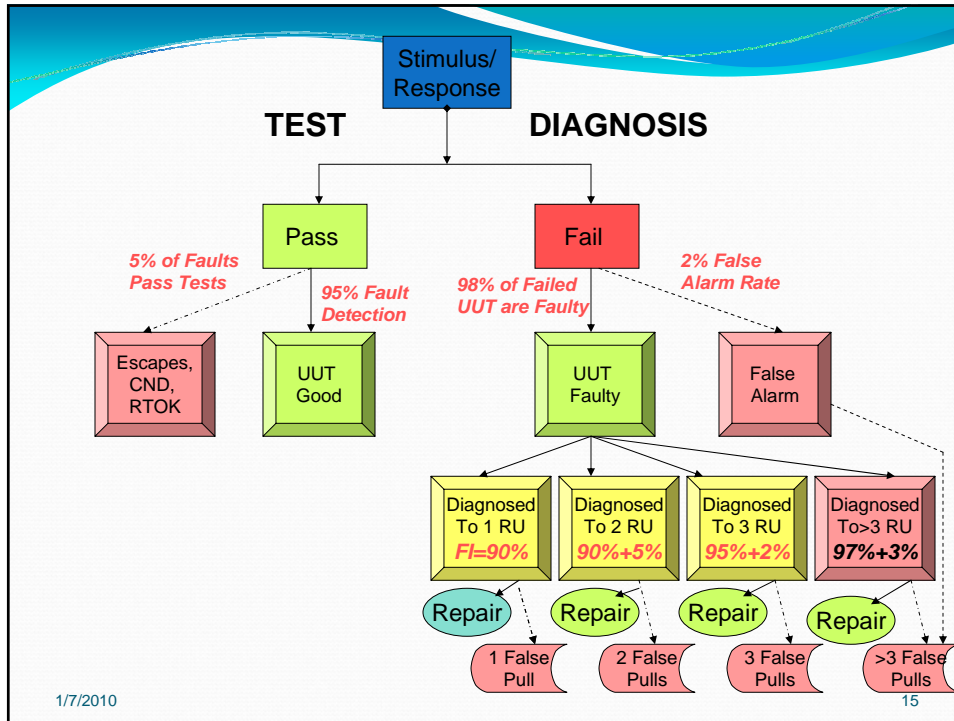
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BIST and Diagnostic Strategies Enhance Performance-Based Logistics (PBL)

EE Times Asia, July 16, 2007, "Save on field support costs with PBL Methods"
By Duane Lowenstein, Agilent Technologies, Inc.





Vertical Testability

- As a tolerance cone, BIT tests should have less stringent requirements than higher level tests in order to avoid "cannot duplicate" conditions.

