Case Study #1

A Contract Manufacturer (CM) performed this case study [1]. This CM produces many large, highly complex boards. Their reasons for performing this case study were:

- Their customers continue to demand ultra-high reliability with tight schedules and budgets.
- High node count is driving fixture cost and weight up, lead time out, and reliability down.
- Product complexity of this magnitude results in lower test yields, reducing test throughput.
- Future assemblies will go beyond the node-count limits of the current in-circuit test system.

Table 1 describes the evaluated board and tests.

Number of Components	2,240, including: - 1,705 Discrete Analog Devices - 137 Resistor Packages - 148 Digital ICs (27 with Boundary-Scan)
Number of Solder Joints	24,223
Number of Electrical Nodes	5,659
Simplified In-Circuit Probe Reduction	54% (from 5,659 nodes to 2,602 nodes)
X-Ray Inspection	New
Full In-Circuit Test	Production-Tuned
Simplified In-Circuit Test	New

Table 1 – Case Study #1 Evaluated Board Size and Case Study Tests

This case study compared a fully-probed in-circuit test on a conventional high node count test system with a combined x-ray/in-circuit test strategy, using the simplified in-circuit (i.e. lower probe count) test. In addition, the manual visual inspection performed on this board with the full in-circuit test was removed, as the x-ray inspection replaced it's fault detection. The full in-circuit test had been in use and tuned to the production process prior to this study. Both the x-ray inspection and simplified in-circuit test were new to the production process at the time of this study. The evaluation was performed on 25 to 150 boards, depending on the parameter measured.

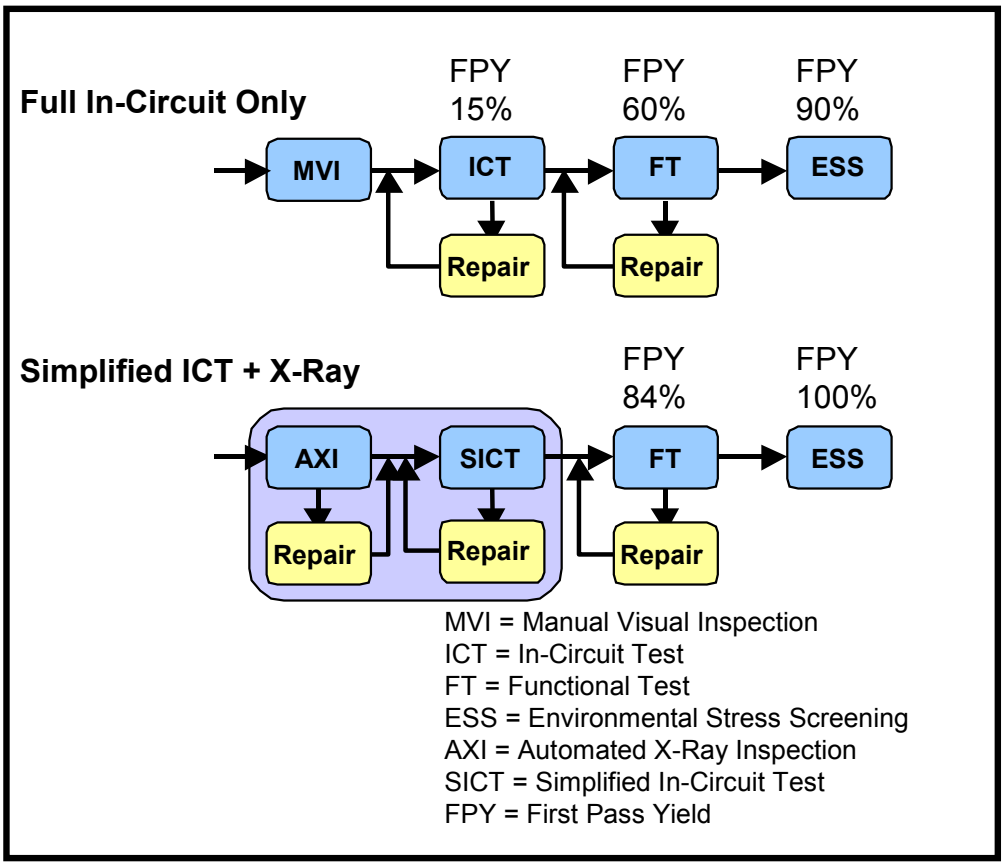

Figure 1 - Case Study #1 Yield Measurements

Figure 1 shows the results of this case study. Adding x-ray inspection, while reducing in-circuit test probing, increased first pass yield at functional test from 60% to 84%. While the 60% yield at functional test may appear low, this is because the size and component count of the board afford many more defect opportunities. This actually compares favorably to other case study yields.

This evaluation removed virtually all solder defects from the functional test failures when using x-ray inspection and simplified in-circuit test.

Implementing this test strategy also removed all test failures at environmental stress screening (ESS). This suggests that it may be possible to remove ESS when implementing the combined x-ray inspection and simplified in-circuit test strategy.

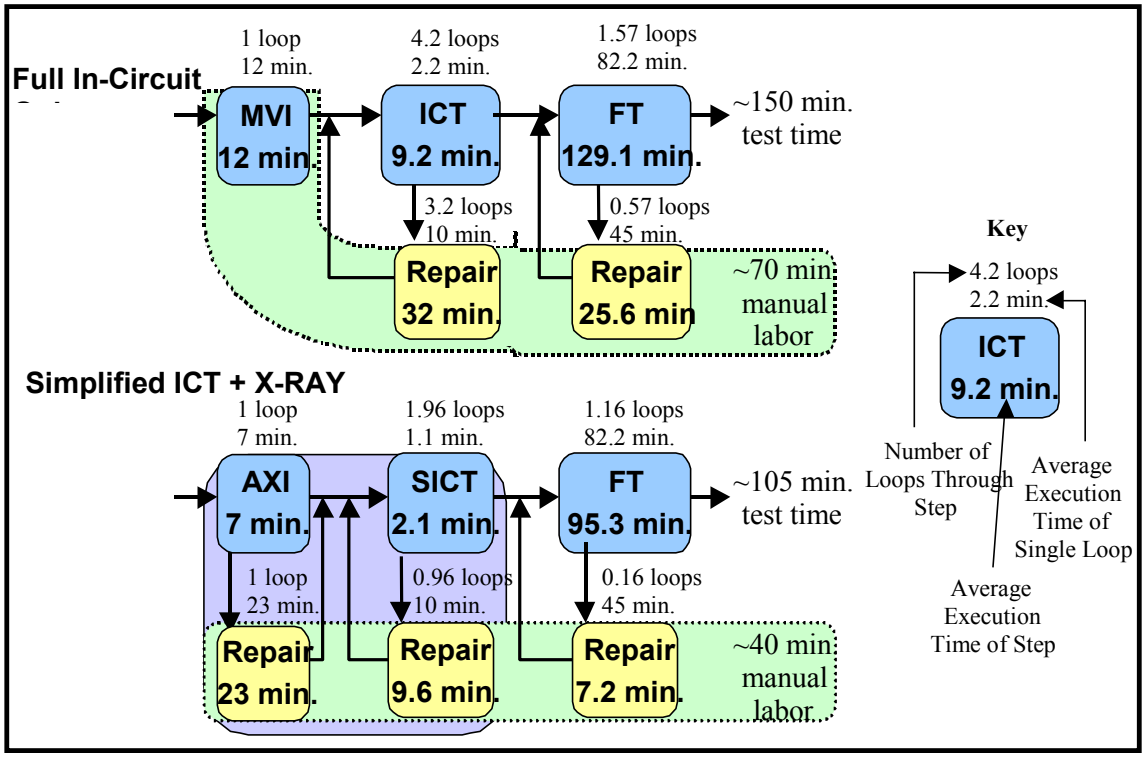

Figure 2 - Case Study #1 Measured Test and Repair Times Per Board

In addition to test yields, this study monitored test and repair times per board, as shown in Figure 2. The test time for each step included any retest required on each board for that step. For example, the conventional high node count in-circuit test time averaged 2.2 minutes per execution. In this study, the evaluated boards entered this repair loop an average of 3.2 times. This resulted in an average of 4.2 tests on the in-circuit test system. Therefore the average test time for this test step was 9.2 minutes (2.2 minutes per execution X 4.2 loops).

This study measured an average test time savings of 45 minutes per board, and a 30 minute reduction in manual labor.

Reducing fixture probe count was also a prime motivation for this evaluation. Table 2 shows the results. In addition to the reduced probes, cost, weight, and build time, one difference noted dealt with fixture shorts. Because of the large number of test probes (over 5659) and the twisted pair wiring used in the traditional long-wire fixture, pressure from the wires forced small wire-wrap tails to intermittently contact other fixture probes or their wire-wrap tails. Because of this, the full in-circuit test fixture had a significant problem with fixture shorts. With the simplified in-circuit test fixture (less probes and single wires instead of twisted pair), no fixture shorts were detected. The long wire fixture program also required more maintenance, as wire capacitance changed with each fixture modification.

Full In-Circuit Test	Simplified In-Circuit Test
♦ 5,659 Signal Nodes	♦ 2,602 Signal Nodes (54% Probe Reduction)
♦ Traditional Long-Wire Fixture	♦ Short-Wire Fixture
♦ 6 Week Build Time	♦ 2 Week Build Time
♦ $37,000	♦ $22,000
♦ 248 Pounds	♦ 148 Pounds
♦ Significant Fixture Shorts	♦ No Fixture Shorts

Table 2 – Case Study #1 Fixture Comparisons

Case study #1 demonstrated the following:

- Adding x-ray inspection, while simplifying the in-circuit test, improved functional test yield from 60% to 84%.
- Combining these two test methods also eliminated all environmental stress screening failures.
- Overall test time per board (i.e. test cell throughput) was reduced by 45 minutes (150 vs. 105 minutes).
- Manual labor was reduced by 30 minutes per board (70 vs. 40 minutes).
- In-circuit test time per board was reduced by over 7 minutes (9.2 vs. 2.1 minutes).
- In-circuit test became much more efficient, sending an average board through the repair loop 0.96 times instead of 3.2 times.
- The automated process test bottleneck was reduced by over 2 minutes (9.2 minutes at full in-circuit test vs. 7 minutes at x-ray inspection).
- Fixture probe-count, cost, weight and construction time was significantly reduced.

[1] Stig Oresjo, Agilent AwareTest xi Software Intelligent Test Technology, Agilent Technologies Publication Number 5968-9936E, 2000.