

# iNEMI Statement of Work (SOW) iNEMI Board and Systems Manufacturing Test TIG iNEMI Functional Test Coverage Assessment Project

**Version # 1.0**

**Date 2-20-07**

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**Co-Project Leader: TBD**

**TC Coach: TBD**

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## Basic Project Information

### ***Purpose:***

The purpose of this project is to create a functional test coverage assessment method that enables reliable comparison of test coverage between different test environments, between test revisions, and between different assessors. Creating more consistency in functional test coverage assessment opens more opportunity to automate or standardize reports, enabling more informed decision making on issues pertaining to test.

### ***Background and Motivation:***

Coverage reports for structural test equipment (e.g., ICT, AXI, AOI) are relatively standardized due to the consistency of the test environment. For example, testing a resistor on one design is relatively the same as testing a resistor on another, completely different, design. Functional test equipment is more customized, including the hardware, software and test generation process. Due to this variability of the test environment, and the fact that functional test requires the board to perform its native functions during testing, determining whether a resistor value is correct in two differing designs is at least difficult, and could be impossible. Formulating a coverage assessment method for functional test must encompass the fact that the test environment differs, and yet still offer information that allows the coverage of the test to be comprehended and compared to other test stages or test revisions.

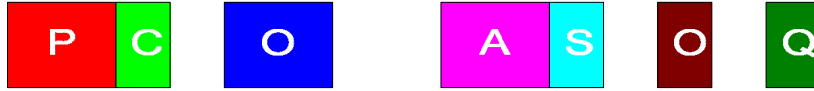
Given board size/density/speed constraints, obtaining acceptable test point access is becoming more challenging, placing an increasing burden on functional test to cover defects that might normally have been detected at MDA/ICT given higher test point access. Understanding how functional test can supplement upstream test stages becomes critical to implementing an end-to-end test plan.

Examples of the coverage spectrum, referencing PCOLA/SOQ for the structural test defect spectrum nomenclature, would look something like Figure 1. Functional test additions used in this example include F=Feature Testing, A=At-Speed Testing, I=In Parallel Testing, M=Measurement.

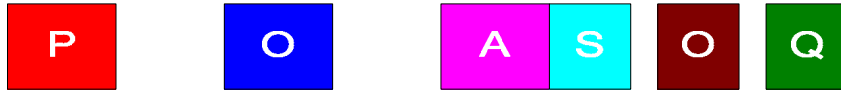
Coverage Rainbow



Hypothetical AOI Coverage



Hypothetical AXI Coverage



Hypothetical MDA/ICT Coverage



Hypothetical FT Coverage



Hypothetical System Test Coverage



Figure 1

Gaps in test coverage can be visualized as light shining through gaps in coverage capability, as shown in the AOI hypothetical coverage in Figure 2.

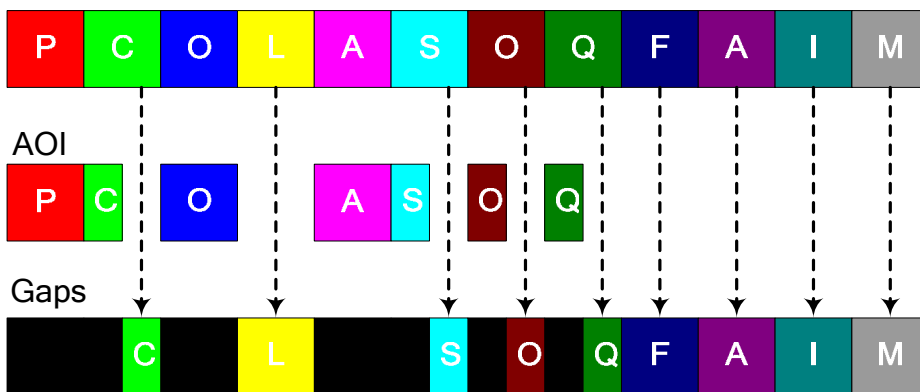


Figure 2

Using a common defect spectrum and stacking multiple test stages, coverage from all test stages can be compared, as shown in Figure 3, with the resulting test gaps in the entire test process indicated on the bottom.

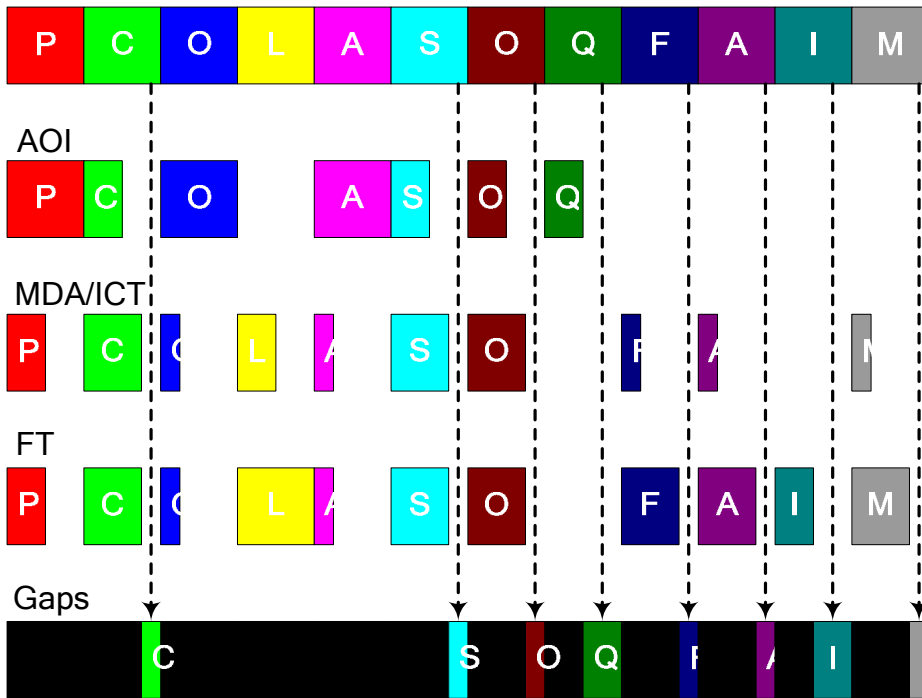


Figure 3

The diagram above is a graphical representation that can also be depicted in a Venn diagram of the defect universe and three test stages in Figure 4, where the black areas in Figure 3 are areas of the defect universe that are contained somewhere within the scope of any test stage in Figure 4.

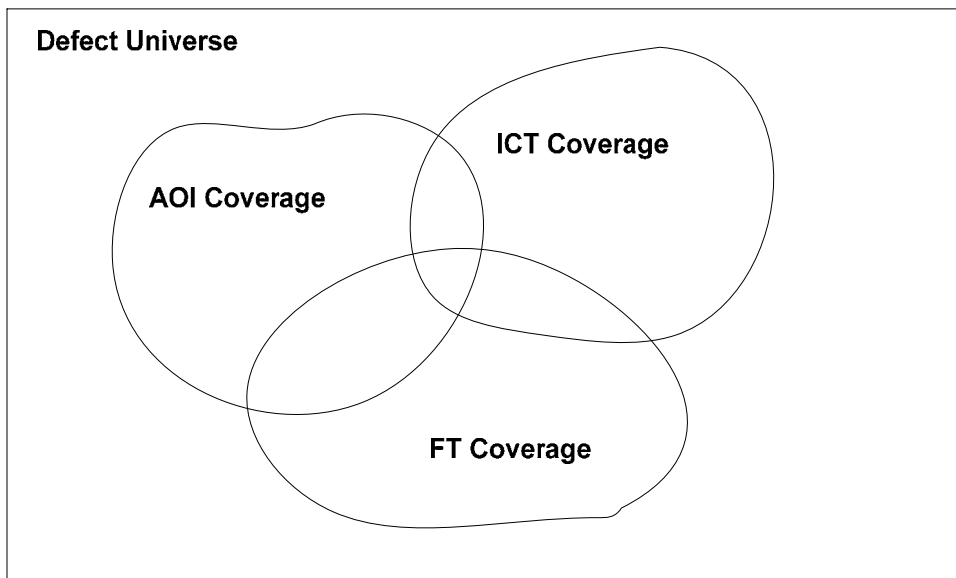


Figure 4

This is but one usage model for a functional test assessment method that leverages upon, and adds to, a structural defect spectrum and assessment method. More usefulness can be obtained by introducing confidence margin and weighting factors to allow reporting of how much you trust the assessment (confidence margin), or reporting of how important coverage on that particular defect is (weighting factor).

## **Scope of Work**

The effort can be divided into three stages:

- **Phase 1, Definition** – *Entry*, project acceptance. *Exit*, meet deliverable requirements and define Phase 2 entry requirements. *Timeline*, estimated to be Q2 '07.
  - Compile usage models of functional test coverage. Examples:
    - Meeting quality requirements...X% functional test coverage of all blocks, Y% coverage of critical blocks, max-rated speed testing of all interfaces, etc.
    - Comparing test revisions.
    - Comparing test environments to aid selection of test HW/SW.
    - Comparing test stages to determine test holes that must be caught at a later test stage.
    - Reusing test coverage assessments of design blocks that were reused.
  - Compile and distribute industry survey of functional test coverage usage.
  - Define terminology...examples: What is a functional block? How do test patterns determine test coverage?
- **Phase 2, Deliverables** – *Entry*, as defined in Phase 1. *Exit*, meet deliverable requirements and define Phase 3 entry requirements. *Timeline*, estimated to be Q4 '07.
  - Create list of deliverables from project to support usage models. Suggested deliverables include:
    - Compile a list of defects that encompasses structural faults referencing existing categorization methods, i.e., PCOLA/SOQ, PPVS, MPS or IPC defect categorizations.
    - Add functional test specific defects to structural defect list:
      - Feature, an aggregate, of any or all, of silicon, circuitry and SW.
      - At-speed, testing full range of functional speed from lowest to highest
      - In parallel, creating system stress by running tests in parallel.
      - Measurement, discrete measurement (voltage, current, dB, etc.) or CRC, BERR, etc.
      - Other potential items:
        - Diagnosability – can the fault be deduced from the error.
        - Gauge of system stress.
    - Define assessment methods (e.g., paper assessment, assessment by observation, fault injection).
    - Create confidence margin and weighting factors that allow emphasis for important assessment items.
    - Develop guidelines for assessing coverage and assigning confidence margin.
    - Develop reports that reflect usage models.

- **Phase 3, Application** – *Entry*, as defined in Phase 2. *Exit*, meet deliverable requirements. *Timeline*, estimated to be Q1 of '08.
  - Use unified defect list, assessment method, confidence margins, weighting factors and guidelines to solidify coverage assessment details then ensure the method fits the usage models.

### **Purpose of Project**

- The Functional Test Coverage Assessment Project aligns to the iNEMI Test TIG's 5-Year Plan by addressing the Lack of Test Coverage Methods in the Functional, System Test Gap Analysis. The project intends to standardize coverage assessment terminology and methods to fill this gap, and to make this information available prior to 2009.
- The Functional Test Coverage Assessment Project intends to create building blocks from which more efforts can be launched, and does not intend to entirely solve functional test coverage assessment issues.
- Benefits to participants, iNEMI members and the industry include:
  1. Participants and iNEMI members will be exposed to industry usage of functional test coverage assessments.
  2. Participants and iNEMI members will be exposed to industry methods of assessing functional test coverage.
  3. Participants and iNEMI members will obtain earliest release of terminology and methods that will lay the groundwork for more robust test processes at their respective companies, with the potential to improve cost of test.
  4. The test and manufacturing community will benefit from more robust, and intelligible, coverage assessment methods by allowing common terminology and methods. Adopters of these coverage assessment methods will enable industry partners to converse more easily about coverage assessment, and should enable more rapid understanding of coverage assessment reported by another party.
  5. The test and manufacturing community will benefit from having a foundation from which more functional test coverage progress can build.

### **Previous Related Work**

- Kenneth P. Parker, Apex 2003, "*A New Process for Measuring and Displaying Board Test Coverage.*"
- Stephen F. Scheiber, *Building a Successful Board-Test Strategy*. Butterworth-Heinemann, 1995. ISBN 0-7506-9432-7.
- "*TestWay (including PPVS fault mode).*" <http://www.aster-ingenierie.com>
- Kathy Hird, Kenneth P. Parker, Bill Follis, "*Test Coverage: What Does it Mean when a Board Test Passes?*" Proceedings of International Test Conference, 2002.
- Wouter Rijckaert, Frans de Jong, "*Board Test Coverage, The value of prediction and how to compare values,*" Proceedings of International Test Conference, 2003.

- Christophe Lotz, Peter Collins, Dominique Wiatrowski, “*Functional Board Test – Coverage Analysis: what does it mean when a functional test passes?*” European Board Test Workshop, 2006.
- “*Calculation of In Process DPMO and Manufacturing Indices for Printed Board Assemblies,*” IPC-9261 June 2000 (see Appendix A – Defect Classification).
- Charles Robinson, Amit Verma, “*Optimizing Test Strategies During PCB Design for Boards with Limited ICT Access.*”

**Participants (Upon official project acceptance and membership closure)**

- List all participants and their managers. Strive to include representatives of all facets of the industry, including customers, suppliers, and manufacturers.
- State role and expected contributions of each project team member.
- List any known background IP for each participant.

**Project Plan (Project Plan is being developed)**

**Schedule with Milestones**

|                                 | Q1 | Q2     | Q3     | Q4     | Q5     | Q6     | Q7     | Q8     |
|---------------------------------|----|--------|--------|--------|--------|--------|--------|--------|
| <u>Phase 1 - Definition</u>     |    |        |        |        |        |        |        |        |
| Create SOW Document             |    | Red    |        |        |        |        |        |        |
| Submit SOW document             |    | Red    |        |        |        |        |        |        |
| Project Approved/Rejected       |    | Red    |        |        |        |        |        |        |
| Phase 1 Exit Req's defined      |    | Yellow | Yellow |        |        |        |        |        |
| Definitions                     |    | Yellow | Yellow | Yellow |        |        |        |        |
| Usage Models                    |    | Yellow | Yellow | Yellow |        |        |        |        |
| Phase 2 Entry Req's Defined     |    |        | Green  |        |        |        |        |        |
| Phase 1 Exit Req's Met          |    |        | Green  |        |        |        |        |        |
| <u>Phase 2 - Deliverables</u>   |    |        |        |        |        |        |        |        |
| Revise SOW Document for Phase 2 |    |        | Red    |        |        |        |        |        |
| Phase 2 Exit Req's Defined      |    |        | Red    |        |        |        |        |        |
| Phase 2 Deliverables Creation   |    |        | Yellow | Yellow | Yellow | Yellow |        |        |
| Phase 3 Entry Req's Defined     |    |        |        |        |        | Green  |        |        |
| Phase 2 Exit Req's Met          |    |        |        |        |        | Green  |        |        |
| <u>Phase 3 - Application</u>    |    |        |        |        |        |        |        |        |
| Phase 3 Entry Req's Defined     |    |        |        |        |        | Red    |        |        |
| Revise SOW Document for Phase 3 |    |        |        |        |        | Red    |        |        |
| Deliverables Meet Usage Models  |    |        |        |        |        | Yellow | Yellow | Yellow |
| Phase 3 Exit Req's Defined      |    |        |        |        |        |        |        | Green  |
| Phase 3 Exit Req's Met          |    |        |        |        |        |        |        | Green  |

## **Phase 1 – Detailed Information**

- **Create SOW Document, SOW Submission, and Project Approval/Rejection**

- Resources

- Formation group to create prior to official project acceptance.
- iNEMI Technical Committee to review and recommend acceptance or rejection of the project.

- **Phase 1 Exit Requirements Defined**

- Resources

- Formation group to create prior to official project acceptance. If project is accepted and further definition is required, the final project group will complete Phase 1 exit requirements.

- **Definitions**

- Resources

- Subtask leaders will determine effort required and request team member participation, if necessary, to complete subtask. Final project team to review definitions and provide final approval.

- Materials and Processes

- Identify the materials to be used. Standard materials should be used whenever possible. Use of standard materials reduces costs, improves yields, and assures the widest applicability of results within the industry. Justification should be provided if non-standard materials are to be used.
- Describe any processes to be used, including applicable standards and specifications. Use of standard processes reduces costs, improves yields, and assures the widest applicability of results within the industry. Use of any non-standard processes must be justified.
- Any specific suppliers or technologies required and reasons for the requirement.
- In cases where custom components are necessary, state which project participant is responsible for assuming this cost.

- **Usage Models**

- Resources

- Subtask leader will determine effort required and request team member participation to complete task.

- Materials and Processes

- Industry survey will be created to solicit a wide sampling of industry usage of functional test coverage assessments.
- Means of distribution? Materials and resources required?

## ***Phase 2 – Detailed Information (Defined at exit of Phase 1)***

- **Task 1 – Task n (include the following information for each task in a separate bullet list)**
  - Resources
    - A detailed list of the resources needed and expenditures expected for the project, including human resources, money, and equipment.
    - List of committed resources from participating companies.
    - State source of funding for any components, assembly, design, and testing needs. Alternatives include participant donation, iNEMI direct funding, and supplier donation.
  - Materials and Processes
    - Identify the materials to be used. Standard materials should be used whenever possible. Use of standard materials reduces costs, improves yields, and assures the widest applicability of results within the industry. Justification should be provided if non-standard materials are to be used.
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    - Any specific suppliers or technologies required and reasons for the requirement.
    - In cases where custom components are necessary, state which project participant is responsible for assuming this cost.
  - Testing Procedures
    - State anticipated number of parts to be tested. Use discrimination in choosing samples for failure analysis to maximize ROI.
    - Use IPC 9701 0-100C as baseline ATC unless justification can be given for alternate test parameters.
    - For test vehicle design and fabrication, it is recommended that reference components that have been ATC tested on previous projects be used to provide a baseline and facilitate comparison of results between projects.
    - Explain design protocol. Use standard design practices and commonly used software to reduce costs and widen applicability of results.
    - At what stages testing will be done and time needed.

## ***Phase 3 – Detailed Information (Defined at exit of Phase 2)***

- **Task 1 – Task n (include the following information for each task in a separate bullet list)**
  - Resources
    - A detailed list of the resources needed and expenditures expected for the project, including human resources, money, and equipment.
    - List of committed resources from participating companies.

- State source of funding for any components, assembly, design, and testing needs. Alternatives include participant donation, iNEMI direct funding, and supplier donation.
- Materials and Processes
  - Identify the materials to be used. Standard materials should be used whenever possible. Use of standard materials reduces costs, improves yields, and assures the widest applicability of results within the industry. Justification should be provided if non-standard materials are to be used.
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  - Explain design protocol. Use standard design practices and commonly used software to reduce costs and widen applicability of results.
  - At what stages testing will be done and time needed.

### ***Project monitoring plans***

- How will you ensure open lines of communication among participants?
  - Conference call every 2 weeks.
  - Form sub-teams to enable localized communication of sub-team details.
  - Offline email.
  - Face-to-face meetings twice per year at convenient industry events (e.g., APEX).
- Planned teleconference schedule
  - Every 2 weeks.
- Request progress reports as tasks are completed
  - Subtask leader will present to full team for approval and subtask closure during closest biweekly meeting. Status reported in distributed meeting notes and available for status rollup.

- Dates of technical reviews (2 per year) and progress reports and what they will contain
  - Dates TBD, most likely corresponding with iNEMI event.
  - Content:
    - Running record of subtask results upon closure or short summary with directions to more details.
    - Task schedule indicating closed items.
    - Risk analysis of pending items.
    - Notes of opportunities outside the scope of the current project

### ***Outcome of the project***

- Phase 1 Success Criteria
  - SOW document submitted and project approved.
  - Project team formed and industry representation is sufficient (as measured by what?).
  - Industry survey completed.
  - All Phase 1 exit criteria met and Phase 2 entry criteria defined.
- Phase 2 Success Criteria (TBD)
- Phase 3 Success Criteria (TBD)
- List all deliverables
  - Pending Phase 2 definition
- State which project results will be shared, with whom, and by what means

**NOTE: All changes to SOW must be approved by the TC (version control)**