Introducing Combinatorial Testing in a Large Organization: Experience Report

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Problem: Is combinatorial testing practical for real world high assurance software?

Approach: Eight pilot projects, over two years, applying combinatorial testing in Lockheed Martin (LM), one of the world’s largest aerospace firms.

Lockheed Martin/NIST Cooperative Research and Development Agreement

**Objective 1.** Investigate applicability of CT in a variety of application areas, including system, software, and hardware testing.

**Objective 2.** Determine effectiveness of CT for improving fault detection.

**Objective 3.** Study potential for reducing test cost or overall lifecycle cost by finding errors earlier in the process.
Application Areas: eight pilot projects

• Flight Vehicle Mission Effectiveness (ME) – compare w/ tests from statistical analysis tool

• Flight Vehicle engine failure modes – compare w/ existing tests

• Flight Vehicle engine upgrade – combinations of flight mode fact comparison with existing tests

• F-16 Ventral Fin Redesign Flight Test Program – application to problem analysis (system-level evaluation rather than software testing)

• Electronic Warfare (EW) system testing – evaluating and extending existing tests

• Navigation Accuracy, EW performance, Sensor information, and Radar detection

• Electromagnetic Effects (EMI) Engineering – compare w/ existing tests

• Digital System Command testing – testing file functions with multiple parameters
Software tools

- NIST & U. of Texas Arlington: ACTS
- Air Academy Associates: SPC XL, DOE KISS, DOE PRO XL, DFSS MASTER
- Phadke & Associates: rdExpert
- Hexawise: Hexawise tool

Results and Evaluation

Positive results - Demonstrated the ability to reduce test cost in a variety of areas; teams found many tools practical
  - Roughly 20% cost reduction
  - 20% - 50% better test coverage

Mixed results – Reluctance of many engineers to adopt new methods; some teams did not identify significant improvements

Lessons learned – Most critical factors affecting adoption: availability of education and training for the new method; clear demonstration of value.
Recommendations

• Develop and improve education and training materials

• Incorporate combinatorial methods into DoD guidance and industry standards; best practices

• Expand internal company guidance – developing a community of practice

• Greater availability of tools to support combinatorial testing – improved usability; matching tool to problem

• Modify approaches to using combinatorial testing –
  • integrating combinatorial testing with other test practices – measure combinatorial coverage and extend as needed
  • ability to adopt CT partially or gradually