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

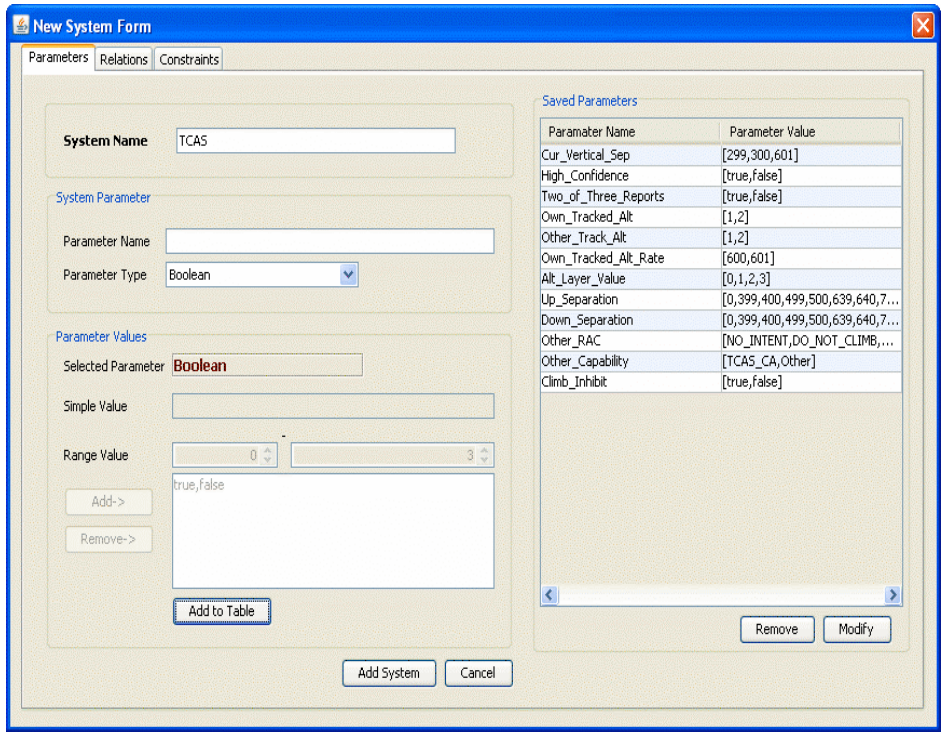
- Flight Vehicle engine failure modes – compare w/ existing tests
- Flight Vehicle engine upgrade –combinations of flight mode fac comparison with existing tests

- 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/existin
- 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 combinati coverage and extend as needed
  - ability to adopt CT partially or gradually