

## 14D - "The Papers of Downs and Tractenberg"

### Presenters

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### Session Summary

**Tractenberg - Summary & Conclusions** - The Jelinski-Morande, Shooman, and Muss software reliability models all predict that the software error detection rate is a linear function of the detected errors. The basic differences among the models are that the error gates are, respectively, in terms of calendar-time, manpower, and computer-time. The models are simple to use for estimating the number of errors still part of the tested software.

Tractenberg showed by simulation that, with respect to the number of detected errors:

- 1) Testing the functions of a software system in a random or round-robin order gave linearly decaying system-error rates
- 2) Testing each function exhaustively one at a time gives flat system-error rates
- 3) Testing different functions at widely different frequencies gives exponentially decaying system error rates, and
- 4) Testing strategies which result in linear decaying error rates tend to require the fewest tests to detect a given number of errors.

**Downs** - A major aim of Downs' approach was to allow the assessment of the effects of different testing (and debugging) strategies in different situations. Musa subsequently quoted these different approaches in his publications. Downs showed how you can use the techniques developed to estimate, prior to the commencement of testing, the optimum allocation of test effort for software that was non-uniformly executed in its operational phase. He also discusses the application of statistical models in cases where the data environment undergoes changes. Finally, he presents two models to assess the effects of imperfections in the debugging process.

The main objective of his paper was to present an approach to the problem of modeling software testing in which the mathematical requirements for relaxing the various assumptions can be clearly seen. The second objective of his paper was to demonstrate the number of possible applications of models of this type. One obvious application is the prediction of software performance (in the reliability sense) after testing is completed and the software commences its operational phase. In particular, the differences in operational reliability resulting from the implementation of different testing strategies can be predicted.

RAMS Downs also investigated the issues associated with random vs. biased testing. He stated that an ideal approach to structuring tests for software reliability takes the following into consideration:

- 1) The execution of software takes the form of execution of a sequence of paths, 'c', the actual number of paths affected by an arbitrary fault, is unknown and can be treated as a random variable.
- 2) Not all paths are equally likely to be executed in a randomly selected execution [operational] profile.

According to Downs, very little is known about the nature of the random variable of the number of paths affected by an arbitrary fault. "This problem is not easy analytically and is made more difficult by the fact that there is very little information available relating to the type of distribution which should be ascribed to [the number of paths]". (Obtained from Michael R. Lyu Ph.D., Technical Staff, AT+T Laboratories).

### About the Presenter – Dave Dwyer

**Dave Dwyer**, Principal Software Engineer, BAE Systems. Over the last 38 years at BAE Systems, Dave has worked both as a reliability engineer and as a software engineer. He is an adjunct member of the faculty at Rivier College, where he taught a graduate course in Software Reliability. Before working at BAE Systems, he was a flight instructor at the University of Illinois for 3 ½ years. He has a BS in Physics (Providence College, 1963), an MSEE (Northeastern University, 1980) and a MSCS (Rivier College, 1999). He has presented several papers on Software and Hardware Reliability including "Improvements in Automated Reliability Growth

Plotting and Estimations” – 2009 RAMS, “Software Reliability Estimations/Projections, Cumulative & Instantaneous” - 2004 RAMS, “Reliability Test Planning for One Shot Systems” - 1987 RAMS, “Hardware Reliability Growth Estimations and Projections – What is Valid and What is Not”, ASQ NEQC 56th Conference, October. 18, 2006 and “Sweaty Days = Shorter Runways”, June 1972 Private Pilot Magazine.