Overview of:
Reliability Growth: Enhancing Defense System Reliability

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Committee on National Statistics

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Thanks to our sponsors

- Thanks for inviting me for the first dissemination of this report. This is an ideal group to discuss the panel's recommendations.

- Both the chair and the other local panel member wanted to be here but were unable to.

- Thanks to AT&L and DOT&E for supporting this and other related work at the National Academies.

- Please interrupt whenever something is unclear.

Initial Charge

- The Committee on National Statistics initially received funding from DOT&E and AT&L to look into Reliability Growth Models, what they are and are not useful for, and how they can be improved. Nice, focused study.

- At the first meeting it was decided to expand the charge to include reliability growth more generally --- to look into design for reliability, reliability testing, and also the administration of reliability growth, including the development of requirements, the content of RFPs and proposals, and the communication between contractors and DoD and other oversight issues.

Panel Roster

The following people served as panel members:

Arthur Fries (chair), IDA   Bill Meeker, Iowa State University
Peter Cherry, SAIC (retired)   Nachi Nagappan, Microsoft
                                                     Research
Rob Easterling, Sandia (retired)   Michael Pecht, University of
                                                     Maryland
Elsayed Elsayed, Rutgers   Ananda Sen, University of Michigan
Aparna Huzurbazar, Los Alamos   Scott Vander Wiel, Los Alamos
Pat Jacobs, NPGS

Ernest Seglie, DOT&E (retired) unpaid consultant
Mike Cohen, CNSTAT - study director

What We Did

First, we had the initial meeting at which the charge was revised.

Then we had a large workshop:

Speakers:

Frank Kendall, AT&L

Michael Gilmore, DOT&E

Andy Monje, OSD

David Nicholls, RIAC

Paul Shedlock, Raytheon

Tom Wissink, Lockheed Martin

Lou Gullo, Raytheon

Guangbin Yang, Ford

Shirish Kher, Alcatel-Lucent

Workshop Speakers (continued)

- Martha Gardner, General Electric
- Mike Cushing, AEC (retired)
- Bud Boulter and others from AFOTEC
- James Woodford, US Navy
- Karen Bain, NAVAIR
- William McCarthy, OPTEVOR
- Patrick Sul, DOT&E
- Paul Ellner, ATEC
- Nozer Singpurwalla, George Washington University
- Don Gaver, NPGS
- Steve Brown, Lennox International

Subsequent Meetings

- And then we had three meetings of just the panel in executive session.

- The report was late which I apologize for but the sponsors never complained, which I greatly appreciate.

Structure of Report

- Summary
- Chapter 1 -- Charge
- Chapter 2 – Perspective from Industry
- Chapter 3 – Reliability Metrics
- Chapter 4 – Reliability Growth Modeling
- Chapter 5 – Design for Reliability
- Chapter 6 – Reliability Testing
- Chapter 7 – Developmental Test and Evaluation
- Chapter 8 – Operational Test and Evaluation
- Chapter 9 – Software Reliability Growth
- Chapter 10 – Conclusions and Recommendations
- Appendices – Recommendations in related reports, Workshop agenda, Recent history, MIL HDBK 217, Bios

Recommendations (1-4)

- **Rec. 1: Analysis of alternatives should include an assessment of relationship between system reliability and mission success, and between system reliability and life-cycle costs.**

- **Rec. 2: Need for a technical report justifying reliability requirements, including the linkage between reliability and life-cycle costs, and feasibility, measurability, and testability, and this should be reviewed by a panel of experts.**

- **Rec. 3: Any proposed changes to reliability requirements should be approved by at least the service component acquisition authority. Part of consideration should be impact on mission success and life-cycle costs.**

- **Rec. 4: Need for an outline reliability demonstration plan to be included in RFP that shows how system will be tested by DoD and how it's reliability is expected to improve. This should also be reviewed by a panel of experts prior to use in an RFP.**

Recommendations (5-8)

- **Rec. 5: Reliability should be a key performance parameter.**
- **Rec. 6: All proposals should specify the design for reliability techniques that the contractor will use during system design. There should be a line item for the costs of DFR techniques.**
- **Rec. 7: All proposals should include an initial plan for system reliability and qualification as well as a description of the reliability organization and reporting structure. This should be regularly updated – an up-to-date assessment of what is know by the contractor about hardware and software reliability at the component , subsystem, and system level.**
- **Rec. 8: System developers should use modern DFR techniques, particularly physics of failure methods, to support system design and reliability estimation. MIL-HDBK-217 and its progeny have grave deficiencies.**

Recommendations (9-12)

- **Rec. 9: For software systems and subsystems, all proposals should specify a management plan for software development and that the contractor will provide DoD will full access to system architecture, metrics being tracked, and archived log of the management of system development. (failure reports, time of incidence, time of fix)**

- **Rec. 10: Validity of assumptions underlying application of reliability growth models should be carefully assessed. Reliability growth models should not be used to forecast substantially into the future. Exception – early in system development**

- **Rec. 11: Contractors should specify an initial reliability growth plan and the outline of a testing program to support it, recognizing that they are preliminary. Cost, level of test, size, schedule, etc.**

- **Rec. 12: Contractors should archive and deliver to DoD all data from reliability testing and other related analyses. Also include all failure reports, times of failure, and times of resolution.**

Recommendations 13-16

- **Rec. 13: Expert panels to review designs of accelerated test plans, and models linking accelerated to typical use.**
- **Rec. 14: For all software systems and subsystems, DoD should mandate that the contractor provide DoD with access to automated software testing capabilities to enable DoD to conduct its own automated testing.**
- **Rec. 15: DoD should mandate the assessment of the impact of any major changes to system design on the existing plan for DFR and reliability testing.**
- **Rec. 16: DoD should mandate that contractors specify to their subcontractors the range of anticipated environmental load conditions that the system needs to withstand.**

Recommendations 17-20

- **Rec. 17: DoD should ensure that there is a line item in all acquisition budgets for oversight of subcontractors compliance with reliability requirements.**

- **Rec. 18: DoD should mandate that proposals include appropriate funding for DFR and testing in support of reliability growth and that awarding of contracts will take that into consideration. Changes after award require approval at a high level.**

- **Rec. 19: Prior to delivery of prototypes to DoD for DT, the contractor must provide test data supporting a statistically valid estimate of system reliability consistent with the operational reliability requirement.**

- **Rec. 20: Near end of DT, there should be full-system, operationally relevant test during which the reliability performance of the system will equal or exceed required levels. Needed to go forward.**

Recommendations 21-25

- Rec. 21: DoD should not pass a system that has deficient reliability to the field without a formal review of the resulting impacts on mission success and life-cycle costs.

- Rec. 22: Collect post-deployment reliability data for all fielded systems to support various feedback loops.

- Rec. 23: After a system is in production, changes in suppliers or manufacturing or assembly, storage, etc. needs review that it won't affect system reliability.

- Rec. 24: DoD should create a database with (1) outputs – reliabilities at various stages of development, (2) inputs -- variables that describe the system and the testing conditions, and (3) system development processes used to support analysis. Also for major subsystems.

- Rec. 25: Need additional technical expertise in: (a) reliability engineering, (b) software reliability engineering, (c) reliability modeling, (d) accelerated testing, and (e) the reliability of electronic components.

Some methodological concerns not covered in recommendations

- Using reliability growth for intermediate targets – there is noise on both sides -- the targets and the estimates – that has to be accommodated.
- How hard estimating system reliability is, especially early in development.
- Reliability growth models are typically only a function of time and not test environment or test scenarios.
- Combining reliability across tests – this is a serious problem especially if test scenarios differ, which they almost always will --- there have been a few attempts to do this but very hard research problem. DT/OT gap one example of this.

Wrapping Up

- **DOT&E and AT&L have put in place excellent guidance and other materials pointing us in the right direction.**
- **The recommendations are pointing us further down a road that they have already outlined.**
- **We hope that this will prove useful. There was strong unanimity on the part of the members for all content.**
- **The panel members were a joy to work with. A continuing relationship with many of them would be worthwhile to consider.**
- **I have a report brief for you as a handout and I would be happy to mail out to anyone here a free copy of the report, which should be ready in a few weeks.**

To get a free copy of (unedited) book, search for title at:

www.nap.edu

or go to:

http://www.nap.edu/catalog/18987/reliability-growth-enhancing-defense-system-reliability

To get the final, edited book mailed to you free of charge, e-mail me at:

mcohen@nas.edu.