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Reliability:
A Look at Four Decades of Reform Within the Department of Defense

Larry Crow, Ph.D.
Crow Reliability, Madison, Alabama

Developing weapon systems in the Department of Defense (DoD) is a particularly challenging task for many reasons. The most obvious and well known difficulties are that the systems will almost always push the state of the art in technology, there are always schedule constraints and the need to deploy as soon as possible, and of course, budget considerations. What is not so obvious to many people is the especially difficult challenge of meeting reliability requirements. DoD data over the period 1997 to 2006 show that a very low percent of DoD systems attained their reliability requirements during an Operational Reliability Demonstration Test at the end of the program. Systems that fail to meet the reliability requirements during this test are either deployed with the low reliability or subjected to a reliability improvement program as an attempt to increase the reliability of the system. Both alternatives are costly.

Key words: Reliability; DoD acquisition reform; demonstration tests; reliability growth.

An unreliable weapon system has a clear impact on the war fighter and will always have a major impact on lifecycle sustainment costs. Because of this situation there have been many studies of DoD reliability practices over the past several years by the National Academy of Sciences and the Defense Science Board.

As noted by the most recent (2007–2008) Defense Science Board Task Force addressing reliability, we need to put the problem in historical perspective so we will have a better understanding of what it is we need to do. That is: What policies work and what policies do not work? Are we repeating past mistakes? What are proven historical DoD reliability best practices? To get an understanding of the answers to these questions and the various DoD approaches in the past, we need to go back about four decades.

Era 1969 to 1980

During this period the main DoD guidance document on reliability was Mil Std 785 A released on March 28, 1969 and entitled "Reliability Program For Systems and Equipment Development and Production." The DoD policy during this period was to only specify a reliability requirement and subject the system to an Operational Reliability Demonstration Test at the end of the program. Depending on the number of failures during the test, the system either passed the test or failed the test. Unfortunately, in the earlier part of this era most programs failed their Operational Reliability Demonstration Test. The situation improved with the use of reliability growth testing. Beginning in the 1960s companies such as General Electric (GE) were taking a different approach to reliability testing than the DoD demonstration test method. Instead of waiting until the end of a development program and subjecting the system to a fixed reliability demonstration test, why not test the system earlier, and incorporate corrective actions when reliability problems were discovered. This approach not only improved the reliability but J. T. Duane of GE was also able to show empirically that the reliability improvement trend had a predicable learning curve pattern. This observation is called the Duane Postulate.

This predicable pattern could be used for reliability management and J. D. Selby and S. G. Miller of GE recommended reliability growth management to the DoD in the early 1970s. At the same time (1972) the author, at the Army Materiel Systems Analysis Activity (AMSAA), showed that the Duane postulate could be expanded and formulated into a statistical framework, called the Crow (AMSAA) model. This model provided the necessary groundwork for valid statistical methods

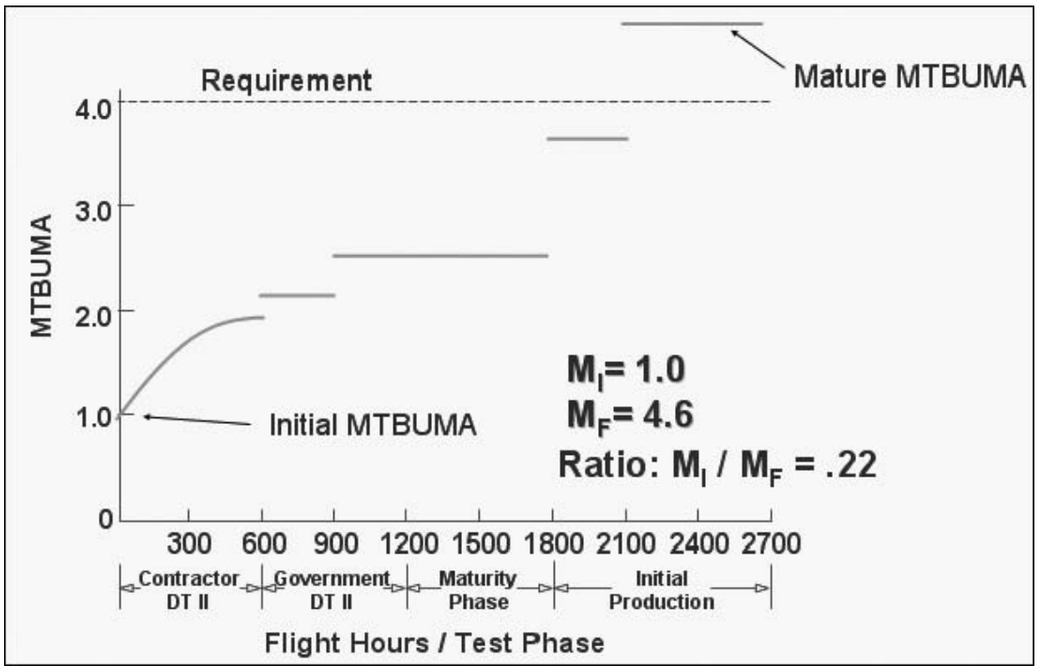

Figure 1. The Blackhawk helicopter reliability growth measured in meantime between unscheduled maintenance action (MTBUMA) per flight hours per test phase

to evaluate the current mean time between failures (MTBF) of a system while the reliability is improving during reliability growth testing.

This first major DoD application of reliability growth was on a U.S. Army program, the Blackhawk helicopter (1972–1978). The Blackhawk had a reliability requirement for mean time between unscheduled maintenance action (MTBUMA) of 4 hours. When the Blackhawk was first tested the MTBUMA was 1 hour. If this was the usual demonstration test, the system would have failed. Instead, the system was subjected to reliability growth testing where the reliability was improved and the Crow (AMSAA) model was used for assessment of the progress. This process increased the Blackhawk MTBUM from 1 hour to 4.6 hours, exceeding the requirement. For this system the initial MTBUMA was 22 percent of the final value actually attained, with an improvement of 4.6, *Figure 1*.

During the 1970s reliability growth was applied to many major systems within all the services, for example, the Army's M1 Abrams main battle tank, the U.S Navy's Tomahawk Weapon System, and the U.S. Air Force's F16 Fighter aircraft. With the success of this new approach to DoD reliability the Joint Logistic Commanders in 1976 directed that a new Mil Handbook be written. This document, "Reliability Growth Management," MIL Handbook 189, was released in 1981. In the meantime the DoD made no changes in its reliability policies. However, each service did make policy changes which made reliability growth and reliability engineering a best practice through various regulations and documents such as the Army's 702-3, the Air Force R & M 2000, and the Navy Willoughby Templates Best Practice NAVSO P-6071.

A lesson that was loud and clear was that the old practice of simply specifying a reliability requirement, not requiring upfront reliability design engineering, and then subjecting the system to a demonstration test was a failed and flayed approach. A demonstration test is a go-no go management test. On the other hand reliability growth testing is an engineering tool where failure information is used to improve the system reliability.

The use of reliability growth and test-analyze-and-fix (TAAF) testing became widespread within the DoD to complement and, in some cases such as the Blackhawk helicopter, a substitute for formal reliability demonstration testing. Despite the success of reliability growth there was still concern by many reliability experts within the DoD that it was rewarding contractors for sloppy initial designs. This concern was addressed in 1980.

Era 1980 to 1998

In 1980 the DoD released Mil Standard 785 B, "Reliability Program for Systems and Equipment

Development and Production." This revision contains fundamental changes from Mil Std 785 A. The document states that "Increased emphasis has been placed on reliability engineering tasks and tests. The thrust is toward prevention, detection and correction of design deficiencies, weak parts, and workmanship defects." Mil Standard 785 B consisted of reliability tasks in three main areas: management, design, and testing. The management and design tasks were directed toward increasing the reliability of the initial design, and reliability growth was now a complementary reliability best practice task to further increase the reliability toward the requirement. The goal of DoD reliability policies from 1980 until the mid to late 1990s was to achieve good reliability by focusing on reliability fundamentals during design and manufacturing rather than merely setting numerical requirements and testing for compliance toward the end of development. DoD data shows that during this period the reliability growth best practice increased the initial reliability MTBF by an average factor of about four times, similar to the results of the Blackhawk helicopter. Most of the systems used in the First Gulf War were developed using reliability growth testing, Mil Std 785 B, and other design best practices, and as the results showed, these systems were generally very reliable during this conflict.

DoD policy changed again in 1998.

Era 1998–present: Acquisition reform

In 1998 DoD implemented Acquisition Reform. The DoD noted that "DoD's transition to a Performance-Based Business Environment, maximizing the use of commercial items and practices, is a key step toward achieving civil military integration." The consequence of Acquisition Reform on reliability was that now the only reliability requirement was that the system passes an operational test at the end of the development program. Reliability growth testing and upfront design reliability engineering were no longer best practices and were not required. Mil Std 785 B was cancelled, although Mil handbook 189 is still active. This is basically the same approach taken by the DoD in the early 1970s which did not work then and is clearly a major factor affecting the low percent of systems passing reliability operational tests today. Unfortunately, the DoD had repeated history in terms of its policy and direction regarding reliability. This policy is not likely to change. However, some good news is that there are pockets within the DoD development community that never gave up key reliability best practices and reliability growth. This is particularly true of aviation systems, both fixed wing and rotary. A big part in effectively addressing this issue is recognizing that DoD has gone full circle over the past four decades and learning from the experiences in between. For example, although Mil Standard 785 B provided a structure for reliability engineering, we know today that many of these tasks were actually not that effective. We can do better. Therefore, issuing a new Mil Standard 785 B-like document is not the answer. The Defense Science Board Task Force addressing reliability has noted this issue in its report and steps are already underway in the DoD to attempt to correct this problem by issuing a new industry-government reliability standard with a more modern approach, and implementing comprehensive reliability training programs. Although we have made a full circle in policy, DoD now has an opportunity to provide leadership in the reliability community in order to improve the number of systems passing operational reliability demonstration tests.

Dr. Larry H. Crow is president of CRR. Previously Dr. Crow was VP, Reliability & Sustainment Programs, at the Illinois Institute of Technology Research Institute, which became Alion Sciences. From 1985 to 2000 Dr. Crow was director, Reliability, at Bell Labs Advanced Technology Systems (later named General Dynamics ATS). From 1971–1985, Dr. Crow was chief of the Reliability Methodology Office at the U.S. Army Materiel Systems Analysis Activity (AMSAA). He developed the Crow (AMSAA) reliability growth model, which has been incorporated into U.S. DoD handbooks, and national & international standards. He chaired the committee to develop Mil-Hdbk-189, Reliability Growth Management and is the principal author of that document. Dr. Crow is a fellow of the American Statistical Association, and the Institute of Environmental Sciences and Technology. He is a Florida State University Alumni Association Distinguished Alumnus and the recipient of the FSU "Grad Made Good" Award for the Year 2000, the highest honor given to a graduate by Florida State University. E-mail: Crowrel@knology.net ❑