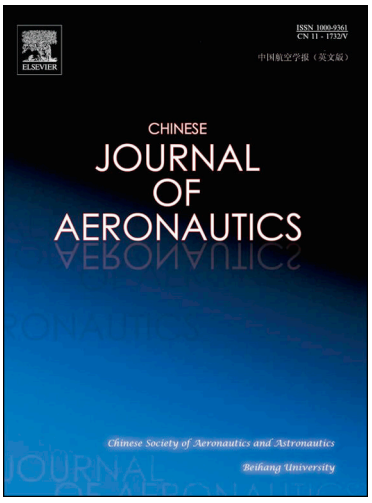
Accepted Manuscript



Review Article

A critique of reliability prediction techniques for avionics applications

Guru Prasad Pandian, Diganta Das, Chuan Li, Enrico Zio, Michael Pecht

PII: S1000-9361(17)30239-X
DOI: https://doi.org/10.1016/j.cja.2017.11.004
Reference: CJA 934

To appear in: *Chinese Journal of Aeronautics*

Received Date: 1 December 2016
Revised Date: 15 January 2017
Accepted Date: 20 February 2017

Please cite this article as: G.P. Pandian, D. Das, C. Li, E. Zio, M. Pecht, A critique of reliability prediction techniques for avionics applications, *Chinese Journal of Aeronautics* (2017), doi: https://doi.org/10.1016/j.cja.2017.11.004

A critique of reliability prediction techniques for avionics applications

Guru Prasad PANDIAN[a,*], Diganta DAS[a], Chuan LI[b], Enrico ZIO[c] , Michael PECHT[a]

[a]*Center for Advanced Life Cycle Engineering, University of Maryland, College Park, MD 20742, USA*
[b]*National Research Base of Intelligent Manufacturing Service, Chongqing Technology and Business University, Chongqing 400067, China*
[c]*Chaire System Science and the Energy Challenge-Fondation Electricite' de France, CentraleSupelec, Paris, France and Department of Energy, Politecnico di Milano, Milan 20133, Italy*

Received 1 December 2016; revised 15 January 2017; accepted 20 February 2017

Abstract

Avionics (aeronautics and aerospace) industries must rely on components and systems of demonstrated high reliability. For this, handbook-based methods have been traditionally used to design for reliability, develop test plans, and define maintenance requirements and sustainment logistics. However, these methods have been criticized as flawed and leading to inaccurate and misleading results. In its recent report on enhancing defense system reliability, the U.S. National Academy of Sciences has recently discredited these methods, judging the Military Handbook (MIL-HDBK-217) and its progeny as invalid and inaccurate. This paper discusses the issues that arise with the use of handbook-based methods in commercial and military avionics applications. Alternative approaches to reliability design (and its demonstration) are also discussed, including similarity analysis, testing, physics-of-failure, and data analytics for prognostics and systems health management.

Keywords: Avionics reliability; MIL-HDBK-217; Handbook-based methods; Physics of failure; Prognostics and health management

1. Introduction

The reliability property of a device (e.g., a component or system) relates to its ability to provide its required function for the period of time needed. There are various definitions available for reliability in both academic journals and English dictionaries. For our practical purpose, reliability is defined as the ability of a device to perform as intended (i.e., without any failure and within specified performance limits) for a specified time, in its lifecycle conditions[1]. From a quantitative point of view, reliability is typically evaluated as the probability that a device performs its function for a required period, under specified environmental and operational conditions. Reliability estimations are used to evaluate a design, compare design alternatives, trade off system design factors, support test planning, track reliability improvements (reliability growth), and organize maintenance and sustainment logistics.

The Military Handbook 217 (MIL-HDBK-217) has been developed to estimate the reliability of military electronic equipment and systems, based on a statistical approach. Point-estimate models are used, whose parameters are to be determined from field failure data. Since its introduction, this handbook has been constantly cited in reliability requirement contracts. It has also been updated about once every seven years, to address deficiencies and inaccuracies. The limitation of the handbook in designing an electronic assembly has been studied in the past and has been shown to out-burden on requirements of complete information of the board design which may not be practical in real time situations[2]. However, the last update to MIL-HDBK-217 was implemented in 1995, in reaction to a contract where a supplier found the models to be without any scientific foundation and the results to be highly inaccurate[3,4]. The updated version carries the same deficiencies from its predecessors and is being used even currently by military and aerospace industries in their reliability and contractual documents. In spite of the updates, about 50% of the 52 major defense systems reported in between 2006 and 2011 by the Department of Defense (DoD) Office of the Director, Operational Test and Evaluation (DOT&E) have failed to meet the required reliability levels[5]. Since the last update, there have been other handbooks such as GJB/Z 299 (Chinese version of the

Corresponding author: E-mail: gpandian@umd.edu