AVIONICS RELIABILITY ANALYSIS

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Abstract

The U.S. Air Force is developing an Integrated Communications, Navigation, and Identification Avionics (aviation electronics) system with the acronym ICNIA for use in tactical aircraft. Designers of ICNIA as well as the Air Force need to be informed of the reliability of proposed designs. Hence, the Air Force contracted The Analytic Sciences Corporation (TASC) to develop a model of the ICNIA system and to develop algorithms for determining various system performance measures such as the system reliability. TASC developed the ICNIA model and developed a software package called MIREM to analyze ICNIA systems. Unfortunately, due to the complexity of ICNIA, the developers of MIREM were forced to incorporate several approximations in MIREM. In the report by Foley [2], we showed that these approximations can perform poorly in some artificially constructed examples. Their accuracy on realistic examples is unknown. We have developed and implemented two algorithms for analyzing ICNIA. The algorithms do not use any approximations and are computationally feasible on realistic sized examples. It is recommended that MIREM be modified to use the algorithms described in this paper.

Keywords and phrases

Reliability, fault tolerance, bounds on reliability, bounds on mean time until failure, avionics reliability.

1. Introduction

1.1. OVERVIEW

The U.S. Air Force is developing an Integrated Communication, Navigation, and Identification Avionics (aviation electronics) system with the acronym ICNIA for use in tactical aircraft. Design work is currently being done at both ITT and TRW.
Designers of ICNIA as well as the Air Force need to know the reliability of proposed designs. Hence, the Air Force contracted The Analytic Sciences Corporation (TASC) to develop a model of the ICNIA system and to develop algorithms for computing various performance measures such as the system reliability.

TASC developed a model of the ICNIA system and a software package known as MIREM which computes various performance measures. Unfortunately, due to the complexity of ICNIA, the direct ways of analyzing ICNIA were computationally impossible. Hence, the designers of ICNIA were forced to incorporate several approximations in MIREM to reduce the amount of computation to a reasonable level. In the report by Foley [2], we showed that these approximations may grossly overestimate the system reliability in some artificial examples. Their accuracy on realistic examples was unknown. By realistic examples, we mean the systems being developed by ITT and TRW.

We have developed two algorithms for analyzing ICNIA. The algorithms have been implemented and tested on several examples, including the ITT and TRW designs. The design details of the ITT and TRW systems are proprietary and can not be disclosed in this paper. The algorithms required little computational effort, even on realistic examples. In fact, the computational effort was so small that we always used WATFIV and the "//quickie job card" for small batch jobs of less than 20 seconds.

There is little literature devoted to the reliability of ICNIA. Veatch et al. [4] and Veatch [3] describe the ICNIA model and the mathematical basis of MIREM. Foley [2] describes some of the assumptions of the ICNIA model, points out the difficulties with MIREM’s approximations, and makes some initial suggestions for improving the algorithms analyzing ICNIA.

1.2. PERFORMANCE MEASURES OF INTEREST

There are two basic performance measures: the system reliability and the mean time until system failure. We assume that the ICNIA system is initially in perfect working condition. During the course of a mission, various components may fail until eventually the ICNIA system is unable to perform its tasks satisfactorily. Let $T$ be the length of time that ICNIA is working. The designers of ICNIA and the Air Force wish to be able to compute the system reliability

$$R(t) = P\{T > t\}.$$  \hspace{1cm} (1.1)

$R(t)$ gives the probability that the ICNIA system performs satisfactorily on a mission of length $t$ hours. Unfortunately, a simple closed form expression for the function $R(t)$ does not seem to exist. The best that can be done seems to be to have a computer program which computes a single number $R(t)$ when given the specifications of the system and the mission length $t$. 