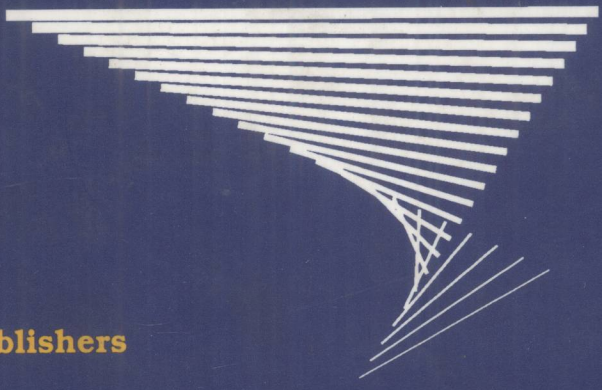
SYSTEM TEST and DIAGNOSIS



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by

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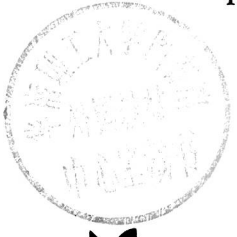

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SYSTEM TEST AND DIAGNOSIS

To our families
whose encouragement
has allowed us to
complete this project
at the expense of
all other demands.

Preface

This book is the culmination of nearly twelve years of research at ARINC Research Corporation into diagnostic modeling and its applications. When we first undertook these research areas, the field of system level test and diagnosis was in its infancy. During our research, we have been privileged to witness its evolution into a full science and partake in some extremely gratifying projects that have demonstrated capabilities previously unattainable. We have tried to codify and illustrate the new science which involves the combination of our research and work from many previous scientists and researchers, and from a multitude of scientific disciplines. In this book we touch on set theory, predicate calculus, artificial intelligence, multicriterion optimization, and several other disciplines to provide a coherent process of setting up diagnostic models. Throughout the process, the applications have driven the solutions, often forcing us to revise our basic assumptions and rederive the underlying theory. The results have been most gratifying, and we hope we have been able to convey them properly throughout this text.

This text is developed as a primary reference for diagnosis at the system level which is taken to be a complex enough collection of entities that we must rise above the myriad of details to accomplish some basic strategic objectives. We intend this book to be used by scientists and engineers building real systems with real test requirements. The text may also be used in a graduate level course on test and diagnosis. It is not recommended for undergraduates because of the multiplicity of disciplines that need to be firmly understood prior to their integration into a complete diagnostic process.

The book is organized into three parts. The first part provides motivation for careful development of the discipline. In the first chapter, we introduce the subjects of system test and diagnosis. We then provide a historical perspective in the second chapter and establish the problem of diagnosis and repair in the third.

The second part provides the tools necessary for analyzing system testability and computing diagnostic strategies. Chapter 4 reviews modeling

systems from the bottom up, and chapter 5 complements the discussion in chapter 4 by discussing modeling from the top down. In chapter 6, we develop the framework for analysis by defining the information flow model. This model will be used throughout the remainder of the book. In chapter 7, we develop a theory of fault isolation and introduce the detailed example to illustrate the application of the theory. We then expand the model analysis in chapter 8 to include assessing system testability, including the definition of measures and detailed analysis of the example introduced in chapter 7. Chapter 9 focuses on issues in verifying and validating the test architecture, including the model, algorithms, and specific tests. We conclude part 2 by discussing different architectures for system diagnosis and maintenance.

In the third part, we discuss advanced topics of diagnosis. Chapter 11 presents an architecture for inexact diagnosis that combines aspects of fuzzy logic, statistical inference, and neural networks. In chapter 12, we discuss a real problem of handling extremely large diagnostic problems. We present three distinct methods for reducing the problems to a manageable size. In chapter 13, we address issues associated with time sensitive diagnosis. Problems related to adaptive diagnosis and learning systems are addressed in chapter 14, and we conclude the book in chapter 15 with a discussion of the art of diagnosis.

Throughout parts 1 and 2, we provide individual case studies based on analyzing real systems that address specific issues raised in the body of the text. In part 2, we provide a detailed case study that is used throughout the book to make concrete the theory presented. This case study is based on a shoulder mounted missile system, but the details of the system have been modified to illustrate specific principles of test and diagnosis.

A work of this magnitude is not completed in a vacuum, and we provide a detailed list of references at the end of the book. We also recognize the many contributions of our friends and colleagues in helping to develop the theory and practice of system test and diagnosis. Specifically, we thank John Agre (Rockwell-Collins), Tony Ambler (Brunel University), Hal Balaban (ARINC), Rodney Bond (ElectroCom Automation), Rich Cantone (NRL), Larry Carpenter (ARINC), Broady Cash (ARINC), Paul Charbonnier (Aerospatiale), Brian DePaul (Northrop), Harry Dill (ARINC), Bernard Dugas (Dassault), Marie English (IEEE), Gene Esker (ARINC), Beth Gilreath-Jansto (ARINC), Sharon Goodall (University of Maryland), Jerry Graham (ARINC), Arnold Greenspan (AROS), Jerry Hadfield (ARINC), Chuck Hawkins (University of New Mexico), Leonard Haynes (Intelligent Automation), Mark Jeppson (Honeywell), Frank Johnson (ARINC), Bill Keiner (NSWC Dahlgren), Brian Kelley (Automation Software Development), Bill Kolb (ARINC), Jean-Luc Larraga (Aerospatiale), Jean-Paul Martin (Aerospatiale), Colin Maunder (British Telecom), Sherri Means (ARINC), Marty Meth (Weapon System Improvement Group, OASD), Les Orlidge (AAI),

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Finally, we wish to note with appreciation that much of the material in this book is drawn from previous publication of our work in many IEEE forums. We thank the IEEE for allowing us to use this material in preparing this book and reference the following publications (all © IEEE):

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CONTENTS

Part One: Motivation