

RTCA, Inc.
1150 18th Street, NW, Suite 910
Washington, D.C. 20036

Formal Methods Supplement to DO-178C and DO-278A

Copies of this document may be obtained from

RTCA, Inc.

Telephone: 202-833-9339

Facsimile: 202-833-9434

Internet: www.rtca.org

Please visit the RTCA Online Store for document pricing and ordering information.

FOREWORD

This report was prepared by RTCA Special Committee 205 (SC-205) and EUROCAE Working Group 71 (WG-71) and approved by the RTCA Program Management Committee (PMC) on December 13, 2011.

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;
- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity, and efficiency;
- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and
- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders.

Since the RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

This Page Intentionally Left Blank

TABLE OF CONTENTS

FM.1.0	INTRODUCTION	1
FM.1.1	PURPOSE	2
FM.1.2	SCOPE	2
FM.1.3	RELATIONSHIP TO OTHER DOCUMENTS	2
FM.1.4	HOW TO USE THIS DOCUMENT	2
FM.1.5	DOCUMENT OVERVIEW	3
FM.1.6	CHARACTERISTICS OF FORMAL METHODS	3
FM.1.6.1	<i>Formal Models</i>	3
FM.1.6.2	<i>Formal Analysis</i>	4
FM.1.7	FORMAL METHODS AS A VERIFICATION TECHNIQUE	5
FM.2.0	SYSTEM ASPECTS RELATING TO SOFTWARE DEVELOPMENT	7
FM.3.0	SOFTWARE LIFE CYCLE	9
FM.4.0	SOFTWARE PLANNING PROCESS	11
FM.4.3	SOFTWARE PLANS	11
FM.5.0	SOFTWARE DEVELOPMENT PROCESSES	13
FM.6.0	SOFTWARE VERIFICATION PROCESS	15
FM.6.1	PURPOSE OF SOFTWARE VERIFICATION	15
FM.6.2	OVERVIEW OF SOFTWARE VERIFICATION PROCESS ACTIVITIES	17
FM.6.2.1	<i>Considerations for Formal Methods</i>	17
FM.6.3	SOFTWARE REVIEWS AND ANALYSES	17
FM.6.3.1	<i>Reviews and Analyses of High-Level Requirements</i>	18
FM.6.3.2	<i>Reviews and Analyses of Low-Level Requirements</i>	19
FM.6.3.3	<i>Reviews and Analyses of Software Architecture</i>	20
FM.6.3.4	<i>Reviews and Analyses of Source Code</i>	21
FM.6.3.5	<i>Reviews and Analyses of the Outputs of the Integration Process</i>	22
FM.6.3.6	<i>Reviews and Analyses of the Formal Analysis Cases, Procedures, and Results for Requirements, Architecture, and Source Code</i>	22
FM.6.4	SOFTWARE TESTING	22
FM.6.5	SOFTWARE VERIFICATION PROCESS TRACEABILITY	23
FM.6.6	VERIFICATION OF PARAMETER DATA ITEMS	23
FM.6.7	FORMAL ANALYSIS OF THE EXECUTABLE OBJECT CODE	23
FM.6.7.1	<i>Principles of Coverage Analysis When Using Formal Methods</i>	28
FM.6.7.2	<i>Reviews and Analyses of the Formal Analysis Cases, Procedures, and Results for the Executable Object Code</i>	30
FM.7.0	SOFTWARE CONFIGURATION MANAGEMENT PROCESS	33
FM.8.0	SOFTWARE QUALITY ASSURANCE PROCESS	35
FM.9.0	CERTIFICATION LIAISON PROCESS	37
FM.10.0	OVERVIEW OF CERTIFICATION PROCESS	39
FM.11.0	SOFTWARE LIFE CYCLE DATA	41

FM.11.1	PLAN FOR SOFTWARE ASPECTS OF CERTIFICATION	41
FM.11.3	SOFTWARE VERIFICATION PLAN	41
FM.11.6	SOFTWARE REQUIREMENTS STANDARDS	41
FM.11.7	SOFTWARE DESIGN STANDARDS	42
FM.11.8	SOFTWARE CODE STANDARDS	42
FM.11.13	SOFTWARE VERIFICATION CASES AND PROCEDURES	42
FM.12.0	ADDITIONAL CONSIDERATIONS	43
<i>FM.12.3.5</i>	<i>Coverage Analysis When Using a Combination of Formal Methods and Testing</i>	43
ANNEX FM.A	– PROCESS OBJECTIVES AND OUTPUTS BY SOFTWARE LEVEL IN DO-178C	45
ANNEX FM.B	ACRONYMS AND GLOSSARY OF TERMS	57
ANNEX FM.C	PROCESS OBJECTIVES AND OUTPUTS BY ASSURANCE LEVEL IN DO-278A	59
APPENDIX FM.A	COMMITTEE MEMBERSHIP	A-1
APPENDIX FM.B	FREQUENTLY ASKED QUESTIONS AND DISCUSSION PAPERS	B-1

LIST OF FIGURES

FIGURE FM.6-1	LEVEL A SOFTWARE VERIFICATION PROCESSES.....	16
FIGURE FM.6-2	POSSIBLE VERIFICATION PATHS FOR EXECUTABLE OBJECT CODE WITH RESPECT TO SOURCE CODE AND REQUIREMENTS.....	28
FIGURE FM.B.1-1	SOFTWARE LIFE CYCLE FOR UNIT PROOF	B-8
FIGURE FM.B.1-2	PROOF PROCESS	B-13
FIGURE FM.B.1-3	OVERVIEW OF REQUIREMENT ARTIFACTS.....	B-19
FIGURE FM.B.1-4	SIMPLIFIED DISPLAY SYSTEM ARCHITECTURE	B-20
FIGURE FM.B.1-5	WINDOW MANAGER TOP LEVEL SOFTWARE MODEL	B-24
FIGURE FM.B.1-6	ANALYSIS PROCESS	B-25

LIST OF TABLES

TABLE FM.A-1	SOFTWARE PLANNING PROCESS.....	46
TABLE FM.A-2	SOFTWARE DEVELOPMENT PROCESSES.....	47
TABLE FM.A-3	VERIFICATION OF OUTPUTS OF SOFTWARE REQUIREMENTS PROCESS	48
TABLE FM.A-4	VERIFICATION OF OUTPUTS OF SOFTWARE DESIGN PROCESS	49
TABLE FM.A-5	VERIFICATION OF OUTPUTS OF SOFTWARE CODING & INTEGRATION PROCESSES	50
TABLE FM.A-6	TESTING OF OUTPUTS OF INTEGRATION PROCESS.....	51
TABLE FM.A-7	VERIFICATION OF VERIFICATION PROCESS RESULTS	52
TABLE FM.A-8	SOFTWARE CONFIGURATION MANAGEMENT PROCESS.....	53
TABLE FM.A-9	SOFTWARE QUALITY ASSURANCE PROCESS.....	54
TABLE FM.A-10	CERTIFICATION LIAISON PROCESS.....	55
TABLE FM.C-1	SOFTWARE PLANNING PROCESS.....	60
TABLE FM.C-2	SOFTWARE DEVELOPMENT PROCESSES.....	61
TABLE FM.C-3	VERIFICATION OF OUTPUTS OF SOFTWARE REQUIREMENTS PROCESS	62
TABLE FM.C-4	VERIFICATION OF OUTPUTS OF SOFTWARE DESIGN PROCESS	63
TABLE FM.C-5	VERIFICATION OF OUTPUTS OF SOFTWARE CODING & INTEGRATION PROCESSES	64
TABLE FM.C-6	TESTING OF OUTPUTS OF INTEGRATION PROCESS.....	65
TABLE FM.C-7	VERIFICATION OF VERIFICATION PROCESS RESULTS	66
TABLE FM.C-8	SOFTWARE CONFIGURATION MANAGEMENT PROCESS.....	67
TABLE FM.C-9	SOFTWARE QUALITY ASSURANCE PROCESS.....	68
TABLE FM.C-10	SOFTWARE APPROVAL PROCESS.....	69
TABLE FM.B.1-1	REDUNDANCY MANAGEMENT SOFTWARE VERIFICATION RESULTS...B-7	
TABLE FM.B.1-2	WINDOW MANAGER REQUIREMENTS FORMALIZED IN CTL	B-23
TABLE FM.B.1-3	WINDOW MANAGER ANALYSIS DATA	B-26

This Page Intentionally Left Blank

FM.1.0 INTRODUCTION

Formal methods are mathematically based techniques for the specification, development, and verification of software aspects of digital systems. The mathematical basis of formal methods consists of formal logic, discrete mathematics, and computer-readable languages. The use of formal methods is motivated by the expectation that, as in other engineering disciplines, performing appropriate mathematical analyses can contribute to establishing the correctness and robustness of a design. For example, formal methods, because of their mathematical basis, are capable of:

- Unambiguously describing requirements of software systems.
- Enabling precise communication between engineers.
- Providing verification evidence such as consistency and accuracy of a formally specified representation of software.
- Providing verification evidence of the compliance of one formally specified representation with another.

Formal methods are also capable of demonstrating properties of software systems such as:

- Freedom from exceptions.
- Freedom from deadlock.
- Non-interference between different levels of criticality.
- Worst case execution time.
- Bounds on stack size during execution.
- Freedom from unintended function.
- Correct synchronous or asynchronous behavior.

Since the publication of DO-178B, advances and experience have been gained in formal methods, their application, and tools. This supplement provides guidance for applicants and certification or approval authorities to facilitate the use of formal methods.

The adoption of formal methods into an established set of processes for development and verification can be an evolutionary refinement rather than an abrupt change of methodology. The extent to which formal methods are used to satisfy the objectives of DO-178C can vary according to aspects such as preferences of the program management, choice of techniques, and availability of specialized resources. Formal methods might be used in a very selective manner to partially address a small set of objectives, or might be the primary source of evidence for the satisfaction of many of the objectives concerned with development and verification.