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RTO AGARDograph 300

Flight Test Techniques Series – Volume 17

Electronic Warfare Test and Evaluation

(les Essais et l'évaluation du matériel de guerre électronique)

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edited by

H. Banks
R. McQuillan

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Electronic Warfare Test and Evaluation

(RTO AG-300 Volume 17)

Executive Summary

Control and exploitation of the electromagnetic spectrum has become as much a part of modern warfare as air superiority or dominance of the sea lanes. Electronic Warfare (EW) is the mission area responsible for establishing and maintaining a favorable position in the electromagnetic domain. Test and evaluation (T&E) of those devices used on modern military aircraft to prosecute this critical mission area requires the use of a wide range of test techniques and analytical methods to assure users of the readiness of EW systems to meet the challenges of the combat environment. Actual in-flight testing comprises a relatively small portion of the EW T&E process. As a result, the reader will find that the concentration in this document is far broader than "flight test" - ranging from laboratory efforts to establish the system performance baseline through complex ground-based simulations and finally the limited verification accomplished in the open-air range environment.

This document is intended as an introductory text dedicated to EW systems test and evaluation. While other volumes in the Flight Test Techniques Series have provided limited coverage of EW system testing, they have been generally aimed at a broad view of T&E and have not resulted in a singular focused handbook on EW test techniques.

While the primary goal of this document is to introduce the novice to a disciplined approach to EW testing, it will also serve more experienced testers and program managers as a concise reference for the EW test process and test resources. It begins with an overview of the test process in the context of the roles and missions expected of EW systems. Subsequent chapters provide examples of test requirements for major categories of EW systems. The final chapters focus on descriptions of specific types of test resources and how they can be linked to simulate predicted operational conditions. A catalog of some useful EW Test Facilities is included in an annex to this document.

Les essais et l'évaluation du matériel de guerre électronique

(RTO AG-300 Volume 17)

Synthèse

Le contrôle et l'exploitation du spectre électromagnétique font partie intégrante de la guerre moderne au même titre que la supériorité aérienne ou la domination des voies maritimes. La guerre électronique (EW) est la fonction opérationnelle destinée à établir et à maintenir une position favorable dans le domaine électromagnétique. Les essais et les évaluations (T&E) des dispositifs permettant aux aéronefs militaires modernes de réaliser cette mission essentielle font appel à une large gamme de techniques d'essais et de méthodes analytiques pour assurer aux utilisateurs la disponibilité des systèmes EW malgré les difficultés posées par l'environnement de combat. Aujourd'hui, les essais en vol ne représentent qu'une proportion relativement faible du processus EW des essais et évaluations. Par conséquent, le lecteur trouvera dans ce recueil des documents dont le champ d'intérêt dépasse celui des « essais en vol », allant des travaux effectués en laboratoire pour établir une base de référence pour l'évaluation des performances des systèmes, aux simulations au sol complexes et, enfin, aux vérifications limitées effectuées à l'extérieur, sur les zones d'essai.

Ce document est un texte préliminaire consacré aux essais et aux évaluations des systèmes EW. Bien que d'autres volumes dans la série sur les techniques des essais en vol aient proposé un traitement limité des essais des systèmes EW, ils ont, le plus souvent, donné une description assez générale du T&E, sans aboutir à un manuel consacré aux techniques d'essai du matériel EW.

Si ce document a pour objectif principal de présenter au débutant une introduction à une approche rigoureuse des essais EW, il servira également d'ouvrage de référence succinct pour les responsables de programme et les ingénieurs d'essais plus expérimentés. L'ouvrage commence par un aperçu du processus d'essai dans le cadre des missions et des rôles prévus pour les systèmes EW. Les chapitres qui suivent fournissent des exemples de spécifications d'essai pour les grandes catégories de systèmes EW. Les derniers chapitres sont axés sur des descriptions de moyens d'essai spécifiques et les possibilités d'association afin de simuler les conditions opérationnelles prévues. Un catalogue d'installations d'essais EW intéressantes est inclu en annexe à ce document.

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Preface

Most students of Electronic Warfare (EW) would declare its beginning to be about 1936. Many would say that the golden years of EW were in this early period leading up to and continuing through World War II. Little was spoken of EW's contribution in those early days, and frequently clear evidence of the EW systems effectiveness was lacking. Today, EW is a recognized requirement for nearly every weapon system. But clear judgements of its effectiveness remain elusive. This is the burden left to the tester. Test and Evaluation processes must be devised to rigorously establish the effectiveness and military worth of the EW system. These processes must be able to predict and then create the complex electromagnetic environment expected to occur in actual warfare.

The past decade has seen an enormous increase in the use and importance of the "electronic battlefield." The cat and mouse game of detection and evasion through the use of the electromagnetic spectrum has become the dominant feature of modern air warfare. A basic grounding in test methods and processes is essential to today's test pilots and flight test engineers.

Today's tester makes judicious use of a plethora of models, simulations, and hardware-in-the-loop test facilities prior to and during the more realistic open-air range and installed system test facility events. Analysis of data derived from each of these test opportunities leads to the overall evaluation of the EW system. This volume will introduce the concept of the EW Test Process and subsequently show how it is applied in each class of test facility and to each major division of EW systems.

Foreword

While other volumes in the Flight Test Techniques Series have provided limited coverage of Electronic Warfare (EW) system testing, they have been generally aimed at a broad view of test and evaluation (T&E) and have not resulted in a singular, focused handbook on EW test techniques. This volume has as its sole focus the processes, techniques, facilities, and goals of T&E of modern EW systems. Much of the world of EW remains shrouded in secrecy, and detailed descriptions of some test resources, test results, and EW techniques cannot be presented herein. However, this volume can fulfill its desired goal of serving as a comprehensive introduction to the practice of EW test.

The first section provides a historical perspective of EW system development, an overview of EW systems, and basic motivations for T&E. The reader will quickly realize that the development and eventual qualification of EW systems is heavily reliant on the use of ground-based test and evaluation resources. Since EW system performance is substantially scenario dependent, much of the testing must be accomplished in a combat representative electromagnetic environment. These high density and wildly dynamic conditions can only be offered to the tester through the application of complex models, simulations, and analytical processes.

Sections 2, 3, and 4 of this document examine the motivation for testing each of the three primary classes of EW systems; Electronic Support Systems, Electronic Attack Systems, and Electronic Protect Systems. Examples of test objectives, measures of effectiveness and performance, and test resource utilization are discussed. Section 5 introduces architectural considerations for EW Systems and discusses how various architectures may affect the test approach.

The EW Test Process, defined in Section 1, is based on an organized application of test resources including measurement facilities, models, simulations, hardware-in-the-loop facilities, installed system test facilities, and open-air ranges. Sections 6, 7, and 8 provide a discussion of how and when each of these test resource categories should be considered for inclusion in the test program. A catalog of some useful EW Test Facilities is included in the annex of this document.

Finally, some lessons learned in the T&E of EW systems have been collected in Section 9. While the specific issues depicted by these anecdotes may not be present in some future test program, the general nature of the lessons may be useful in avoiding costly mistakes.

Overall, this document will help the novice EW tester become familiar with the major elements of EW developmental and operational testing. More experienced testers will find the document to be a helpful reference source with a concise description of both test processes and test resources throughout the US and Europe. For those individuals with broader responsibilities in the acquisition, operations, or sustainment of EW systems, this volume will be a useful introduction to the potential for gaining in-depth understanding of EW system functionality and performance through the disciplined application of the EW test process.

Acknowledgements

The complexity and breath of application of modern EW Systems is such that any comprehensive overview requires the knowledge and insight of a great many individuals. The authors wish to recognize the efforts of several of those who contributed either directly or indirectly to the information presented in this volume. Mrs. Stassi Cramm and Mr. Dave Carroll of the U.S. Air Force Electronic Warfare Test Directorate at Edwards Air Force Base are recognized experts in the field of Modeling and Simulation and were solely responsible for the preparation of Section 6. Mr. Bill Flothmeier, Mr. Scott Hanssen, Mr. Doug Johnson, Mr. Lance Stevenson, and Mr. Gus Pignataro of the Naval Air Warfare Center, Weapons Division at Pt Mugu, California, shared their expertise in various areas in the formulation of Sections 2 and 3. Mr. Harry Franz was instrumental in collating the lessons learned in Section 9. Mr. Roland Graves was very helpful in detailing the EW capabilities at the NATO Consultation, Command, and Control Agency in The Hague, The Netherlands. Madame Francoise-Elisabeth Etling, chef du bureau information économique, of DGA was instrumental in informing the authors of the extensive EW Test and Evaluation resources available in France. Electronic Warfare test facilities within the United Kingdom form an important resource for NATO. Mr. Dave Burleigh and his cohorts at DERA, Farnborough, UK, were most cooperative in providing information on their facilities and processes for inclusion in this document. Herr Galleithner of Deutsches Zentrum fur Luft und Raumfahrt (DLR), Herr Dr. Hetzner and Herr Walsch of Daimler-Benz Aerospace (DASA), and Herr Dr. Schober and Herr Elvermann of WTD-81 provided the authors with an in-depth understanding of EW test resources in Germany.

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Acronyms, Symbols and Abbreviations

AI	Airborne Intercept
AOA	Analysis of Alternatives
AAA	Anti-Aircraft Artillery
ARMs	Anti-Radiation Missiles
DECM	Defensive Electronic Countermeasures System
DT&E	Development Test and Evaluation
DSM	Digital System Model
DOA	Direction of Arrival
ERP	Effective Radiated Power
EMI	Electromagnetic Interference
EMI/EMC	Electromagnetic Interference and Electromagnetic Compatibility
EA	Electronic Attack
ECCM	Electronic Counter Counter Measures
EP	Electronic Protection
ES	Electronic Support
EW	Electronic Warfare
FCR	Fire Control Radar
HITLs	Hardware-in-the-Loop facilities
HPM	High Power Microwave
IR	Infrared
ISTFs	Installed System Test Facilities
IC	Integrated Circuit
LPF	Low Pass Filter
LWS	Laser Warning System
MFs	Measurement Facilities
MMI	Man-Machine Interface
MOE	Measures of Effectiveness
MOP	Measures of Performance
MDS	Minimum Detectable Signal
MWS	Missile Warning Set
MDF	Missile Data File
M&S	Modeling and Simulation
OFP	Operational Flight Program
OAR	Open Air Ranges
OT&E	Operational Test and Evaluation
PTC	Planned Test Conditions
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RCS	Radar Cross Section
RIL	Reduction in Lethality
RIS	Reduction in Shots
RTC	Reference Test Condition
RWR	Radar Warning Receiver
SOJ	Stand-Off Jammers
SMA	Sub Miniature A
SAMs	Surface-to-Air-Missiles
SILs	Systems Integration Laboratories
SUT	System Under Test
T&E	Test and Evaluation
TSPI	Time Space Positioning Instrumentation
UV	Ultraviolet
UDF	Users Data File
VV&A	Validation, Verification & Accreditation

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14. Abstract

The past decade has seen an enormous increase in the use and importance of the "electronic battlefield." As a result of the continuing growth in this area, this volume has been prepared to serve as an introductory reference to the process of testing and evaluating Electronic Warfare Systems. Electronic Warfare (EW) is the mission area responsible for establishing and maintaining a favorable position in the electromagnetic domain.

Test and evaluation (T&E) of those devices used on modern military aircraft to prosecute this critical mission area requires the use of a wide range of test techniques and analytical methods to assure users of the readiness of EW systems to meet the challenges of the combat environment. Actual in-flight testing comprises a relatively small portion of the EW T&E process. Today's tester makes judicious use of a plethora of models, simulations, and hardware-in-the-loop test facilities prior to and during the more realistic open-air range and installed system test facility events. Analysis of data derived from each of these test opportunities leads to the overall evaluation of the EW system.

This volume will introduce the concept of the EW Test Process and subsequently show how it is applied in each class of test facility and to each major division of EW systems. The reader will find that the concentration in this document is far broader than "flight test" - ranging from laboratory efforts to establish the system performance baseline through complex ground-based simulations and finally the limited, but vitally important, verification accomplished in the open-air range environment.

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