Validating the Electronic Combat Environment in Aircrew Training Devices

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ABSTRACT

Validating the electronic combat environment (ECE) in aircrew training devices (ATD) is a process that compares the operating parameters and performance of the electronic warfare (EW) portions of ATDs to the current intelligence assessment of threat weapons systems, documents the differences and assesses their impacts, and authenticates the representations and interactions. Real world threats are constantly evolving and EW reprogramming centers routinely update mission software to counter the developing threats. These changes and updates affect many different mission aspects regarding aircrew threat perceptions and reactions including detection, identification, and countermeasures effectiveness. This paper details the processes involved and illustrates the benefits of an ECE validation program for ATDs.

ABOUT THE AUTHORS

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INTRODUCTION

The importance of electronic warfare has increased in recent years as the Air Force becomes increasingly dependent on electronic sensors and communications systems, to include networks in establishing and maintaining air and space dominance. Accordingly, electronic warfare training, especially that which involves the use of simulation, poses unique challenges to the training community.

Combat Air Force units currently train on over 200 aircrew training devices across 23 weapon platforms, many of which have threat environments that have either not been validated in over 6 years or have never been validated at all. Intelligence agencies continually update threat databases and reprogramming centers routinely update mission software within the actual electronic warfare (EW) systems. Without an independent validation process, aircrew training devices (ATDs) are at risk of having inaccurate threat environments which may lead to negative or ineffective training and an increased risk of combat losses.

In addressing these challenges, Air Force Instructions (AFI) 36-2248 and 36-2251 define simulator validation as the process of comparing a training device's operating parameters and performance to the current intelligence assessment of the weapons and threat systems. It also includes evaluating the interaction between the weapons and threat systems.

AFI 36-2248 defines an ATD as a training device used to prepare aircrew members for the actual performance of flight duties. The AFI lists the categories of ATDs as Flight Simulators, Flight Training Devices, Aircraft System Trainers, and Other (for those that do not fall into the first three categories). The fidelity of these ATDs ranges from basic cockpit procedures training all the way to "flight-ready" mission qualification training. Increasingly, these ATDs are integrating mission planning systems with combat mission rehearsal capability. The challenge is to ensure this training is valid.

The Defense Modeling and Simulation Office (DMSO), now the Modeling and Simulation Coordination Office (M&S CO), defines verification as the process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications. It defines validation as the process of determining the degree to which a model and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model. Intended uses include training, mission rehearsal, and test and evaluation, each with its own unique requirements for accuracy and fidelity.

ECE VALIDATION

The Electronic Combat Environment (ECE) validation process spans the entire life cycle of the simulator. It validates the simulator's electromagnetic environment and ensures aircrews have accurate threat representations in stand-alone as well as Distributed Mission Operations (DMO) networked federations. Specific tasks for validating the weapons system and threat interactions include an extensive parametric database review of the ATD threat libraries and on-site evaluations to assess the accuracy of the ATD electronic warfare (EW) environment representation.

ECE validation focuses on the credibility and accuracy of the threat models compared with the actual threat system. A high-quality validation effort is, by necessity, a cradle-to-grave process that assesses the overall quality of threat system models and the threat environment within an ATD. It documents deficiencies and supports new acquisitions, upgrades, certification, decertification, and accreditation. ECE validation is not normally a software code validation, though identified discrepancies may assist in software development.

The process of validation includes authentication of all external threats and internal threat detection equipment and threat counter-countermeasures, including the interactions between the ATD's internal "ownship" systems and the external threat systems. Threats are human created/operated systems which potentially may

harm the ownship, including all weapon systems operated by potential adversaries (red/gray) and friendly (blue) forces. The evaluation encompasses validating the threat engagement parameters and performance (range, time, limitations, and capabilities). This includes threat sensor detection and tracking performance, and the threat system engagement timeline (Detect – Track – Engage – Weapon Fly-Out – Weapon Lethality). Along with validating threats, interaction with environmental factors such as weather and terrain, which include occulting (line of sight and weather/terrain masking) and radar clutter degradation is also evaluated.

Validation Processes

The validation of an ECE involves several processes. The first is threat parametric data verification. The parametric data include electromagnetic properties such as frequency, pulse repetition interval, dwell time, power, etc. plus physical characteristics of associated weapons pertaining to aerodynamic performance. The data also include associated weapon (missile, bullet) performance data such as fly-out models. The parametric review incorporates operational "mode-specific" cross checks within each system. Such data is perishable, as the threats are constantly evolving.

Before conducting the on-site evaluation of a device, the ECE validation team needs to perform a detailed analysis of the simulator's threat database and compare parametric values to current Defense Intelligence Agency (DIA) data such as the Electronic Warfare Integrated Reprogramming (EWIR) database, actual aircraft equipment, performance documents, and contract design specifications. Obsolete threat systems identified will be recommended for deletion from the simulator's database, new systems will be recommended for addition, and additional enhanced capabilities will be noted. Because of the different ways ECEs are produced, it may be necessary to reverse engineer the manufacturer's threat data.

Analyzing the simulator's threat database is an essential function that must be supported with sufficient time and resources. Any errors or omissions found in the data are corrected and sent back to the ECE manufacturer/developer for inclusion or updating of the ECE. This ensures the most up-to-date information is available before the on-site evaluation is started.

The subsequent on-site evaluation ensures, through operational testing, that parametric changes and updates have been made. This includes checking symbology, audio output, and affectivity of all electronic combat (EC) and electronic attack (EA) systems versus the threat spectrum. Current working knowledge of the operating characteristics of the ownship's defensive/surveillance systems simulated by the ATD is essential to the evaluation. Defensive systems include radar warning receivers (RWR), jammers and pods, towed decoys, expendables (chaff/flare dispensers), Electronic Support Measures (ESM) systems (like panoramic receivers), and sensor-fusion systems designed to improve aircrew situational awareness in the electronic environment. A working knowledge of such systems includes detailed design information involving both the hardware and software aspects and an understanding far more in-depth than typically described in handbooks, which have errors or lack the detailed description necessary to accurately interpret operation. An understanding of the threat systems' susceptibility to defensive tactics is also required.

After completion of the on-site evaluation phase of the ECE validation, an in-depth analysis is made of the data gathered. This analysis is extremely comprehensive in nature and may require several months to accomplish. If an adverse training impact is identified, the cause of this is reported and prioritized for correction by ATD developers and maintainers.

A formal report is generated at the completion of the initial parametric data verification phase, and another at the end of operational testing (on-site evaluation and data analysis phases). The data verification report details the corrections to the threat data libraries and documents the sources. Threat representation validation reports note differences between the DIA threat definition and the representative threat system and describe, in a general manner, the potential impact of those differences on training. The testing report details discrepancies found in the simulator's threat environment that vary from the real world. The report also discusses the instructor/operator station (IOS) and mission planning and production facilities used to control and create missions. The report presents written information detailing discrepancies between the simulator's threat environment and the actual threats. The purpose is to ascertain the differences between the real world and the simulation that will or could cause negative training.

The ECE validation process uses in-house electronics engineers, electronic warfare officers (EWO), operations analysts, and intelligence analysts. They require knowledge of surface and airborne threats and associated parametric data, electronic warfare,

modeling and simulation techniques and practices, aircrew training, test procedures, and acquisition. Due to the unique aspects of the validation mission, personnel require extensive training throughout their tenure to keep current with changes in threat systems, tactics, and simulation technology. Personnel who conduct the parametric data validation task could include intelligence specialists, operations research analysts, EWOs, especially those with technical degrees, and engineers. Personnel best suited for the on-site evaluation include EWOs, particularly if they have operational experience with the applicable defensive systems, and engineers.

Training Tasks

The ECE validation function must accommodate networked simulation and training operations along with stand-alone training. Technology has re-defined the standards for training through simulation, especially regarding electronic warfare. Today, bit-level realism and accuracy in simulating defensive avionics, such as RWR, is possible, and the training tasks defined are reflecting these new capabilities.

The type of training supported by the ATD will determine the degree to which threat behavior must reflect real-world operations. For mission rehearsal training or possibly even tactics development, particularly in a distributed environment, the tactical behavior is very important and will be driven by two factors: the physical properties of the threat (verified and quantified through the parametric review) and the operational doctrine simulated (e.g., nation specific for mission rehearsals). The specific operational doctrine is the most subjective portion of the validation process because of the limited amount of data in this area. Intelligence estimates, Air Force Aggressor personnel, and associated weapons school expert (intelligence and aircraft) involvement should be obtained.

The ATD users must provide a description of training objectives and tasks required to be supported by the threat simulation under validation. A means of measuring training effectiveness should also be applied because the most robust training system cannot be reliably evaluated without some form of measurable data. Examining the performance of threats and defensive avionic systems should be conducted with the stated training objectives and tasks as the framework for validation. In many cases, it will be necessary to meet with the users to clarify these training requirements and tasks. An EWO/operations research analyst is ideally suited for this task.

DMO

DMO is an Air Force readiness initiative to develop a fully integrated system of operational domains (live, virtual, and constructive) that will train combat and combat support forces in a realistic, fully integrated environment, from individual training through mission rehearsal. The ECE validation process must continually evolve to capture the capabilities allowed with this new technology. DMO has added a new level of complexity to threat validation because it permits simultaneous and multiple types of training tasks in large-scale, real-time environments. Because a networked simulation may have two, three, four, or more different ECEs involved, the interactions between these simulations must be validated, especially regarding the time-based correlation of "events" that occurs. For example, if ECE A fires a surface-to-air missile (SAM) at Entity B which is using ECE B, will ECE B see ECE A's launch and will it complete the engagement, or will ECE C interpret the SAM launch as a threat to Entity C and give its aircrew indications that they have been engaged?

If a single organization or government office can become the focal point for EW data distribution to all ATD systems, most entities should be modeled with the same correct parametric data, which should help improve interoperability between the various ECEs. Having a single focal point for ECE validation data should also improve the accuracy and fidelity of the threat simulations which, in turn, should increase the overall effectiveness and utility of DMO.

ECE VALIDATION BENEFITS

Historically, many aircrews have no real world experience or exposure to most threats. To them, what they see in the simulator becomes the "truth" because of the immersive nature of the training obtained in this device. This is exactly why a simulation must be thoroughly verified and validated. This will ensure the aircrews' experience with the diverse spectrum of threats, obtained in an ATD, accurately reflects the actual threats they may face in combat.

With the limited availability of flight training in a realistic threat environment, accurate threat representations in simulators have become increasingly important to ensure aircrews develop knowledge, and procedures to effectively recognize and defeat threats encountered in combat. ECE validation ensures that the simulation meets all the specified requirements and that it implements those requirements correctly in software.

It also ensures the audio and visual stimuli associated with ownship aircraft EW systems are accurately simulated in the ATD.

Intelligence agencies continually update threat databases. National agencies such as the Missile and Space Intelligence Center (MSIC), DIA, and National Air and Space Intelligence Center (NASIC) are always updating and revising their respective reports and analyses. EW reprogramming centers respond with updated mission software. As avionics become more robust computationally, these revisions are occurring more frequently than before. ECE validation can be the means to keep ATDs current with the pace of these EW data updates.

DMO significantly raises the bar. Virtual Flags, the Joint Forces Air Component Commander (JFACC) toolbox, and Air Operations Center (AOC) certifications also require accurate databases and threat behaviors. Mission rehearsal and tactics development require extreme accuracy in the threat databases used. With the increasing number of networked trainers, ECE validation will help ensure developers and maintainers keep these databases concurrent with requirements.

Robust new technologies and assets, such as the Airborne Laser (ABL), can be trained and evaluated in ATDs in a way they cannot in the real world. For example, the laser can be fired in simulation without fear of blinding personnel or sensors. In the same way, new EW technology and tactics can be tested and trained without expensive range time, as long as they and the environment are simulated accurately. Shooting down simulated tactical ballistic missiles (TBM) is far less costly than launching real world training targets. Accurate threat data will enable low observable platforms to train in ways that are generally impossible due to security concerns or are too expensive in the open air environments.

Though the evidence to date is anecdotal, based on feedback from combat aircrews, training in robust EC environments improves aircrew coordination, situational awareness, decision making, risk management, and communication. The benefits of training in a robust, realistic EC environment also include reduced probability of aircraft/aircrew loss and improved overall crew resource management (CRM).

Global Strike Task Force

With the emergence of DMO, threat validation will play a critical role in ensuring aircrews are prepared to encounter real world enemy threats and realistic Integrated Air Defense Systems (IADS) in any theater through mission rehearsal. Using accurate threat simulations will prepare aircrews facing lethal air defenses, increase aircrew confidence in their weapons system, and thus, reduce attrition. ECE validation will authenticate the threat databases of DMO networked strike aircraft simulators to ensure the accuracy of threats, IADS, and the ECE. This will ensure realistic aircrew training in EW reconnaissance, aircraft self protection, the destruction or suppression of enemy air defenses (DEAD/SEAD), and Global War on Terrorism (GWOT) scenarios. DMO simulation success will depend heavily on accurate and current models to simulate high value targets (HVT) such as enemy command and control (C2) systems, IADS, weapons of mass destruction (WMD), and TBMs. ECE validation will ensure onboard EW systems are accurately modeled to readily detect and counter these threats.

ATD THREAT VALIDATION HISTORY

The United States Air Force ECE validation program was originally called Simulator Validation (SIMVAL) because it performed operational performance validations on open air test and training range radar simulators long before the ATD evaluation function was added around 1984. In that respect, it validated the entire threat simulator; hence, it was called SIMVAL. At that time, Foreign Technology Division (FTD) (now NASIC) performed acquisition validation of the range simulators, while the Air Force Electronic Warfare Center (AFEWC) (later the Air Force Information Warfare Center - AFIWC) performed the operational validation. Both of these organizations fell under the Air Force Intelligence Command (AFIC) (later the Air Intelligence Agency - AIA). ATD threat validation support was added to the AFEWC mission and Air Force Regulation (AFR) 80-25 tasked AFIC/AIA to conduct ATD SIMVAL. Due to an administrative error during the transition from AFRs to AFIs, AFR 80-25 was rescinded.

In 1993, both the NASIC and AFEWC programs were scheduled to be cut, but AFIC reconsidered this based on customer requirements. As a result, the program was reorganized. AFEWC gave up the range simulator validation function to NASIC and concentrated on ATD Threat Environment Validation only. Since AFEWC no longer validated the entire simulator, they stopped using the term SIMVAL and instead used ATD Threat Validation.

With the advent of DMO, the ATD Threat Validation program was given the responsibility for validating the DMO threat environment. AFIWC provided personnel to the DMO Integrated Product Team (IPT) groups. Program Objective Memorandum (POM) initiatives stipulated funds for the AFIWC connection to DMO federations to enable long-haul validation efforts, but funding was not available. Without funding, AFIWC was forced to cut the ATD Threat Validation program.

In March 2003, AFI 36-2251 was rewritten to include the ATD SIMVAL mission. It states "SIMVAL will be accomplished throughout the life cycle of the Training System." However, no organization or unit was assigned the mission. Currently, no single office or agency has the ability or authority to hold ECE manufacturers/developers responsible for electronic combat database currency or threat performance.

SUMMARY

Combat Air Force units currently train on over 200 aircrew training devices across 23 weapon platforms, many of which have never had their threat environments validated or it has been over 6 years since they were last validated. Real world threats constantly evolve while EW reprogramming centers routinely update mission software residing within the EW systems. These changes affect the way aircrews detect, identify, and respond to threats. Without an ECE validation program, the threat systems in current training devices, as well as future devices such as the F-35 ATDs, will not be accurate, and negative training may result with potentially disastrous consequences. Additionally, with the increased emphasis and reliance on DMO and high fidelity simulators to offset the loss of flying hours, the credibility and accuracy of threat databases and IADS representations will play a critical role in the overall success of current and future training. Without an independent government-led validation process, Combat Air Force aircrews are faced with the risk of invalid training with the commensurate risk of increased combat losses. The ATD simulator validation mission must be revitalized.

ACKNOWLEDGEMENTS

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