

# ACHIEVING MISSION REHEARSAL OBJECTIVES EMPLOYING MISSION-ORIENTED SIMULATOR DEVELOPMENT

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## ABSTRACT

The key to facilitating an "adequate" Mission Rehearsal capability lies in the training system itself. The challenge to the military and the simulation industry is to judiciously and cost-effectively apply today's technology to create the simulated aircraft and mission environment fidelity required to meet Mission Rehearsal performance objectives. Traditional development concepts, however, may be inadequate. We are no longer concentrating on training specific tasks, but rather are now involved with complex performance objectives such as tactical awareness, interpretation, anticipation, and prioritization; crew and combined team coordination; and tactical decisionmaking. The criteria for such objectives are not readily definable and in actuality can vary from crew to crew and situation to situation. Consequently, a system to meet such objectives cannot be easily specified. *This paper addresses the challenge imposed by Mission Rehearsal performance objectives and fidelity requirements and discusses an effective solution to supplement traditional specifications: Mission-Oriented Simulator Development. This concept, demonstrated on the AH-64 Combat Mission Simulator, provides techniques incorporating military and developer teamwork to assess and refine the evolving system throughout the development cycle, based on the user's evolving "mission" requirements.*

## INTRODUCTION

Potentially one of the most significant applications of today's simulation technology is the employment of advanced training systems to allow our aviator attack teams to practice and be critiqued in real-world operations before actually performing those operations. In the theatre world, a dress rehearsal aims to assure a successful coordination of roles on opening night by requiring the actors to perform on stage, in full costume, and under the stress imposed by a critical review group. Similarly, Mission Rehearsal aims to assure that the complex coordination of an operation will be *precisely executed by synthetically exposing the aviators to the stress of real-world workloads imposed by aircraft complexities, unfamiliar terrain and cultural features, environmental factors, and hostile interaction by a geographically specific intelligent threat. The obvious outcome of a poor dress rehearsal is a correspondingly poor performance and a disgruntled audience. A poor or "inadequate" Mission Rehearsal, however, can lead to much graver consequences.*

The key to facilitating an "adequate" Mission Rehearsal capability lies in the training system itself. The challenge to the military and the simulation industry is to judiciously and cost-effectively apply today's technology to create the simulated aircraft and mission environment fidelity required to meet Mission Rehearsal performance objectives for today and in the future, having the ability to change with the mission requirements.

Wiggers, et al.<sup>[1]</sup> describe Mission Rehearsal as "Tactical forces/crews conducting trial performances, to which all factors, including an appropriate level of uncertainty, have been realistically applied to a situation with the intent of preparing for a specific mission." Wiggers also described three other related training categories which, when combined with Mission Rehearsal, form a hierarchy of mission training which leads towards a successful execution of a mission. These include mission preparation, mission preview, and combat mission training. A significant difference between

the various categories is that combat mission training and mission rehearsal must provide the total combat workload imposed on the crew by the complexity of today's aircraft and tactical environment, including appropriate levels of mission uncertainty. In addition, mission rehearsal must provide the fidelity to represent specific missions, including specific aircraft configurations, specific real-world visual and sensor imagery, and specific real-world threats. Also of *significance is the involvement by tactical forces/crews which associates team performance as an essential and critical element of mission rehearsal.*

## MISSION REHEARSAL PERFORMANCE OBJECTIVES

The combat missions assigned to today's aviation units require high levels of proficiency in a large repertoire of individual, crew, and team skills. Today's helicopter aviator must not only be an excellent pilot able to fly nap-of-the-earth and effectively conduct air-to-air combat but also be accomplished in avionics, communications and navigational skills, and doctrine. He must be a threat expert, able to evaluate at a moment's notice what course of action to take when encountering an aural or visual cue. He must also be a master of his weapon systems and of the employment capabilities of all weapon systems that are available to him under a combined team role. The fact that the aviator or aviation crew, through progressive training, has become proficient in the operation of a particular aircraft before participating in a mission rehearsal does not preclude the need for full-fidelity aircraft and weapon systems simulations at the mission rehearsal level. On the contrary, since the aircraft and its systems are primary contributors to the aviation crew's workload and performance potential, lessening or altering that workload for mission rehearsal would reduce the effectiveness of the rehearsal.

George, et al.<sup>[2]</sup> noted that skilled human performance is often characterized in terms of overt observable behavior, but in fact, that performance primarily involves unobservable processing of information which results sometimes, but

not always, in observable behavior. These authors have described the following four classes of information processing, and these must be supported by a mission rehearsal system:

### 1. Individual and Team Procedures

The operations required of the members of the tactical team are usually segmented in sequences of activities involving corresponding sets of tactical functions. Standard procedures are developed to form the framework for organizing each function in the sequence of required operations. Each procedure tells each individual in the team what he must do, when he must do it, and in what order, but equally important, it tells each team member what each other team member will do. Procedures are memorized and applied as more or less fixed sequences of actions, but they are predicated on two other important processing capabilities, recognition and anticipation.

### 2. Recognition

The aviation team member must recognize and discriminate among an almost infinite variety of patterns of information in deciding what they require of him and in anticipating their potential impact on him, on the team, and on the mission. The simplest recognition skills relate to the events and conditions under which specific procedures must be applied, modified, or terminated. The most complex involve discriminating among patterns of information about the terrain, the weather, threats, friendly elements, and the deployment and behavior of both friendly and hostile forces. Each of these levels of recognition and discrimination requires practice, first in making accurate assessments of their meaning, and second, in discriminating among dynamic events in real time while performing other procedures, maneuvers, and tactics under time pressure and stress.

Recognition skills are not only crucial to tactical proficiency, but they are especially difficult because of the number of information sources available, the amount of information to be processed, limits in the time available, and, perhaps most important, limits in the quality and the completeness of the information usually available in combat operations. Recognition and discrimination must almost always be accomplished with fleeting, fragmentary, and frequently conflicting information. Much of the crew's information arrives by way of radio and sensor systems which may be influenced by weather, jamming, and other incidental and intentional effects. Information received through direct vision is also subject to limits imposed by weather, camouflage, the use of cover and concealment on both sides of the conflict, and by the need to perform recognition tasks at maximum range with minimum cues.

In team operations much of the information needing to be recognized and discriminated is in the performance of other members of the team and of the other tactical elements being supported by, or providing support to, the operation. Skilled performance requires that each team member know and do the right things at the right time, and that each also know what to expect of the others - what they should do and what they probably will do.

### 3. Anticipation

The most important task of an aircrew is to "stay ahead" of the aircraft and the situation. Success in tactical operations requires skill in anticipating the behavior of other crew and team members, and of other friendly and hostile elements on, over, and around the battlefield. Detailed mission planning anticipates all likely contingencies and prepares the crew to respond effectively to them, but some events

and circumstances having potential impact on the crew and its mission are unanticipated, requiring rapid reorientation and response. While implementing appropriate levels of uncertainty is recognized as a key element of mission rehearsal, the methodology for employing uncertainty is widely debated. When allowed by time, an attractive approach would be to have the team first become proficient in performing the mission without unanticipated events or circumstances and then practice the mission with the addition of various less-anticipated disruptions which could potentially occur.

### 4. Interpretation

The information available to a crew in planning sessions, briefings, from their past experience, and in the events and activities occurring during mission operations provides the basis for the selection of courses of action to be employed in accomplishing the assigned mission. Before a course of action can be initiated, the mass of available information must be evaluated, prioritized, interpolated, and extrapolated in accordance with tactical doctrine and experience. This includes determining, at various points in the mission, if the next planned course of action can be employed or if an alternate plan should be pursued.

It should also be noted that because the aviator has an added dimension of height above terrain, he must perform with three distinct differences from ground-based elements; George, et al.<sup>[2]</sup>, have stated:

*The amount of information the aviator has to process is larger due to aircraft complexity, and because of his larger picture of a complex battlefield environment; the processing of that information must be accomplished much more quickly due to the high mobility of the aircraft and its threats; and when operating at low altitudes, the accuracy of his split-second tactical decision-making must be correct the first time.*

This means high workloads under stressful conditions, near information overload with time as a critical variable. An error in decision making or situational awareness can result in quickly aborting the mission or catastrophe.

As noted by Wiggers, et al, Mission Rehearsal not only trains the mission crews but also serves as an acceptance test of the mission. More specifically it is a determination of whether or not the team can successfully perform the mission with the anticipated combat workloads and associated stress factors. Accordingly, a Mission Rehearsal device must provide complex information processing settings in which the crew's performance can be realistically evaluated.

The level of simulator fidelity required is the simulation sophistication necessary to supply information needed in practicing tasks performed in a specific mission. For the aviator this means that the simulator must be concurrent with his aircraft's total mission/tactical capabilities; that it flies and interacts with the environment as expected in the real world, and perhaps most importantly, that the simulator encourages the aviator to think and react as though he were in the mission environment.

## THE CHALLENGE OF MISSION REHEARSAL

The goal of the aviation training community is to apply available technology to allow crews to obtain combat proficiency before they encounter actual combat. Although Mission Rehearsal performance objectives are complex and demanding, they will be achievable in the near future by employing currently available technologies and advanced

technologies presently being developed and refined. High-fidelity simulations have been integrated with interactive threat algorithms to allow generic combat mission training in the AH-64 Combat Mission Simulator (CMS)<sup>[9]</sup>. High-fidelity networking has been demonstrated to allow aviator team training objectives to be accomplished at a generic mission level<sup>[4,5]</sup>. Large-scale networking of selective-fidelity devices has been implemented<sup>[6]</sup> and gateways are being developed to allow the force elements of these networks to operate with aviators in high-fidelity networks. In addition, large-scale Force Level Simulation (FLS) is being developed to accurately represent specific threat forces, including their doctrine, tactics, and mission and their command, control, and communications structure. Advanced computer image generation techniques are being developed to support the real-world visual and sensor image requirements of Mission Rehearsal by providing terrain imagery derived from Digital Mapping Agency (DMA) data as well as other map and chart sources. This terrain will be enhanced by data extracted from aerial and satellite photography and will be merged with detailed cultural and threat modeling developed from reconnaissance photos and intelligence reports. Development programs are also in place to allow the generation of universal, correlated databases for visual, FLIR, and radar imagery (Project 2851), and for refining techniques to quickly provide such databases (Rapidly Reconfigurable Database Generation).

The challenge to the military and the simulation industry is to judiciously and cost-effectively apply current and emerging technologies to create the simulated aircraft and mission environmental fidelity required to meet Mission Rehearsal performance objectives. There is, however, a significant potential problem in applying traditional simulation development concepts to meet this challenge. Simulation technologies have become capable of supporting performance objectives beyond those derived from the tasks involved in system operation and fundamental tactical operations, permitting practice in the workloads, complexities, and uncertainties typical of real-world tactical operations. Traditional guidance for simulator development has been the simulator specification which describes the characteristics of the aircraft, its systems, and its operating environment as they are expected to be perceived and interpreted by the crew being trained. It is difficult, however, to specify detailed mission training performance except in general terms because for the most part there is limited analytical data to define the required performance. This leads to the potential for a program to appear to be successfully implemented throughout most of the development cycle, yet near the end of the program it could be discovered that, as qualified crews begin to operate the device or devices, the essential characteristics of the mission and task environments become more clearly understood, dictating more detailed and more accurate interpretations of the intent of the specification. In fact, it may be found that the simulation could meet the specification requirements without meeting the mission needs of the user.

#### MISSION-ORIENTED SIMULATOR DEVELOPMENT

The concept of Mission-Oriented Simulator Development is intended to address the concern over meeting the user's needs, especially in complex, mission-oriented devices. The concept evolved through Army/Industry teamwork on the AH-64 Combat Mission Simulator (CMS) and is considered to be a key factor leading to the mission effectiveness of the AH-64 CMS. This concept is applicable to supplement the specification on all simulation development programs and is essential in dealing with the complexities of Mission Rehearsal.

The mission-oriented simulator development process begins with a review of the missions, the tactical capabilities of the systems being simulated, and the training objectives derived from those missions and capabilities. Where necessary, specific mission training objectives are expanded to identify their demands for specific simulator capabilities. Mission scenarios are developed and implemented to exercise these capabilities as they evolve from concept to design, and finally to implementation in the hardware-software integration process. Deficiencies and their likely causes are noted and addressed, and as modifications are implemented they are evaluated in turn. The result is the development of a system which meets specifications and which is optimized to support the user's requirement for combat proficiency.

The basic concept of mission-oriented development is the utilization of a small team (mission team) or teams of highly qualified individuals to assess every aspect of a system (or subsystem) from the viewpoint of the user. Such assessments should be conducted at each stage of the simulator's development and implementation. To be applied as an effective development tool, however, this basic concept must include follow-up activities by the mission team, specifically in resolving problems recognized during each mission assessment.

Much of the process involves physical tests of the system under development, but it also includes a series of dedicated mental exercises. Conducting a representative combat mission with the available system equipment is an example of the first type of testing, but the second must be applied before actual systems are available. For example, design reviews are often conducted at subsystem levels. To supplement these individual reviews, mission evaluations must be applied by a team which conceptually integrates the various designs and then assesses the system by visualizing its operation relative to meeting mission objectives.

The selection of the mission team members is critical in ensuring successful mission-oriented simulator development. The goal is to team key individuals to create an extensive combined knowledge-base encompassing the mission, the aircraft systems, and the simulation systems. Accordingly, it is essential that the team collectively possess the following expertise and it is desirable, where possible, to have crossovers of such expertise among team members.

First and foremost, there must be comprehensive and accurate knowledge of the system's mission, including the intended threat. Such knowledge can only be obtained through discussions with the customer and the user. Obtaining a detailed understanding of the system specification is a prerequisite to conducting such discussions, not a substitute. The team must also have access to a constant flow of information from the command channels on any and all changes that are taking place or expected to take place on the mission or aircraft. Whenever possible, the user should have a mission expert on the team.

Second, there must be knowledge of the systems being simulated and of their operation. Today's military aircraft incorporate sophisticated, state-of-the-art systems which are integrated to provide versatile maneuverability, precise navigation, long-range target recognition, identification and acquisition, and extremely accurate weapons delivery. Somewhat as a consequence of evolving near the limits of technology, these systems often have highly individualized operational characteristics which are very significant in the split-second decision-making environment imposed on the aircrews in actual combat. To facilitate advanced training for such aircraft, high-fidelity simulators, such as the AH-64 CMS, employ simulations, stimulations, and emulations

which rival in complexity the actual systems being replicated. Simulation designers must have detailed knowledge of each aircraft system since the simulated system must not only perform as well as the aircraft system but must also interface with a simulated environment and be capable of performing simulator-unique functions not generally considered in the aircraft system design (e.g., freeze, rapid initiation, record/replay, etc.). The mission team must have a detailed knowledge of the aircraft systems and their operation through access to documentation, discussions with system developers, test pilots, and aircrews, and when possible, through hands-on experience.

With knowledge of the intended mission and of the operation of the actual system, the team can assess the operation of the simulated system. However, the role of the mission team also includes helping to isolate and resolve system inadequacies. Thus, the team must have a detailed knowledge of simulation, both of the specific system design being evaluated and of simulation techniques in general.

George, et al.<sup>17</sup> have provided a detailed analysis of Mission Oriented Simulator Development, as it pertains to advanced mission training devices. This analysis was supported with numerous examples of important applications of the concept throughout the AH-64 CMS development cycle. These authors noted that the simulator's training mission must have first priority at each point in the development cycle, to ensure that the evolving designs are progressing towards a system that will successfully support its training objectives. Early testing allows early identification of mission deficient areas, thus minimizing the cost and schedule impacts involved with implementing required corrective actions.

Mission-Oriented Development can be readily applied to Mission Rehearsal by assessing the associated missions relative to performance objectives rather than to training objectives. The teaming of mission, aircraft, and simulation knowledge will be essential in providing the highly qualified guidance needed to subjectively and cost-effectively address the many issues that will arise relative to achieving Mission Rehearsal performance objectives. A long list already exists containing issues which may be addressed with varying levels of technology and cost. The ideal or adequate solution for each issue, however, may remain questionable well into the development cycle. The list includes such issues as:

- system/subsystem fidelity levels
- scene quality and database fidelity levels
- database generation time
- threat force database and modeling fidelity
- prioritization of multiple user needs
- performance of joint operations interface (high-fidelity and low-fidelity networks)
- extent of Mission Rehearsal control functions
- uncertainty modeling and control
- commonality of Mission Rehearsal and Mission Planning assets
- level of built-in security provisioning to support unknown future scenarios

Mission teams can be employed during requirements analysis to formulate a best estimate of required and achievable goals. Subsequently, as each program evolves, Mission-Oriented Simulator Development should be employed to provide assessments of how the system is progressing towards meeting the desired mission performance objectives, and to provide appropriate corrective recom-

mendations in instances where the development is deviating from meeting those objectives.

## CONCLUSIONS

Today's simulation technologies are evolving to a level which in the near future will allow the development of systems to support aviator Mission Rehearsals. However, applying these technologies to cost-effectively address the complex performance objectives associated with Mission Rehearsal poses a significant challenge. In addition, there exists a potential for inadequate or inappropriate applications of technology, since many of the detailed characteristics of the performance objectives cannot be readily defined or specified. Mission-Oriented Simulator Development has been shown to be an effective technique to supplement a specification to assure that a complex mission training device fully meets the needs of the user. Military and industry teams can also employ this concept to help achieve the complex performance objectives of Mission Rehearsal devices.

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