SAVE OUR SIMULATORS (SOS): A DISTRESS CALL FROM AN OPERATIONAL USER

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ABSTRACT

This paper discusses some of the problems experienced by operational users in their efforts to obtain maximum training benefit from Advanced Flight Simulators. The major shortcomings of simulation training identified here are not the result of state-of-the-art technology limitations. In fact, many of the training difficulties encountered by simulator users today may have been avoided if greater attention had been given to defining Mission and Task Requirements during simulator design. This suggested emphasis on Mission indicates a change of mind-set is needed that focuses on explicit operational requirements as well as the more conventional technical approach. After analysis of typical simulator training problems, it is concluded that simulation training could benefit substantially through greater consideration to front-end analysis during simulator design, and by providing training personnel with well designed instructional programs that includes an objective Performance Measurement System.

INTRODUCTION

Training aircrews in such complex tactical mission areas as Air Combat Maneuvering (ACM) has always been difficult at best. This is largely because of the dynamics and complexity of these mission environments: Multiple interrelationships among numerous systems must be perceived and managed, plus the need, during critical phases, to process substantial information and respond to manifold task requirements.

Until recently, this "higher order" training was only possible during actual aircraft operations, with the built-in limitation of not being able to adequately interject sophisticated threat systems into specific training missions, as well as the lack of a means to repeatedly practice complex mission tasks.

Background and Discussion

Simulators have been around for quite some time, and most of us (military aircrews) have learned to fly utilizing a certain amount of synthetic flight training. They have until very recently been designed primarily for instruction in such areas as:

- Standard Operating Procedures (SOP)
- Emergency and Irregularity Procedures
- Instrument Flight Procedures
- Weapons System Operational Procedures.

Procedures oriented training was, therefore, about as much as we could expect from available simulation design capability.

However, the near revolution in computer technology has changed this.

Driven largely by advancements in informational display technologies, simulators are now capable of providing for "Higher-order" mission related training previously not possible.

In view of such advances we would assume that operational training personnel would be welcoming these devices with open arms. Unfortunately, this is not the case. Indeed, many 'customers' of these advanced training devices hold them in low esteem. But, why is this so? What exactly is the problem? And what, if anything, can be done to improve this low customer acceptability?

"Various significant problems in operating this air combat simulator have become manifest. Among these include: inadequate implementation of instructional design features; poor design of the operation (features) of demo and debrief equipment and procedures . . . .and demonstration creation process lengthy and difficult to perform."(1)

The above statement was extracted from a formal qualitative review of a recently introduced Full Mission Flight Simulator designed to support Navy fighter training. A close look at these and other similar problems reveals that (1) they are endemic to the recently introduced class of advanced flight simulators designed to instruct in complex mission areas, and (2) these problems are largely operational, vice technical in nature.

In addressing these "operational" difficulties, this paper attempts to pinpoint significant problem areas and their underlying causal factors which are resulting in low customer acceptability. Additionally, a new conceptual approach for viewing advanced simulation systems is suggested, as well as a discussion of the possible application of this conceptual framework in subsequent design and/or modifications to these sophisticated training systems.

It should be emphasized that it is not the intention of this treatment of simulation design to single out and criticize any individual group or place anyone in bad light. By candidly discussing certain operational difficulties and suggesting a possible course of action it is hoped that a dialogue can be established between operational users and the siumlator design community in order to improve overall mission performance of these important training systems.

Problem Statement

While it was orginally believed that most simulator shortcomings were either the result of technological limitations or to a lesser extent funding constraints, a recent problem analysis conducted by the author revealed that many major systems deficiencies fall substantially outside these categories. Our major difficulties, it seems, do not stem from these areas - our technology is maturing nicely and considerable funding appears to be available for adequate design - but stems largely from the absence of a coherent "mission logic" to drive the cognizant simulator design. Moreover, since this conventional design process usually commences with design specifications which remain largely technical, inadequate focus is provided for many critical mission requirements. Consequently, important mission considerations during the conceptual design phase are either superficially addressed or totally ignored.

A comprehensive analysis of simulator problems brought to light the following fundamental areas where significant efforts should be directed.

- A change of mind-set appears to be needed to move from an exclusive technical focus to a broader view which fully embraces mission requirements and instructional design requirements as well.
- A mechanism is needed to spotlight critical mission areas, thereby bringing to bear appropriate resources so that enhanced training can be conducted to improve performance in these critical regions.

Although many of our advanced full mission simulators are experiencing certain technical difficulties, most of these are either being corrected or corrective action is being contemplated. On the other hand, the difficulty of many of these same devices to adequately instruct in important mission areas for which they are designed, poses a more serious problem because it strikes at the very heart of the conventional design process. For example, a recently installed full mission flight simulator for West Coast Navy fighter training exhibits the following "mission related" deficiencies which, it appears, should have been addressed during the original design process.(2)

Mission Area	Deficiency
One vs. One Tactics (1vs1)	o Only two models used for Wide Angle Visual (WAVS) presentation. Need additional aircraft models to simulate full threat spectrum.
Missile Envelope	o Air-to-air threat missiles are not simulated. Need reasonable inventory of threat missile systems.
Missile	o Missile firing light source lacks accurate fidelity. Need improved visual presentation.
SAM Defense	o SAM does not fly profile. Also need an expanded inventory of "real world" SAM threat systems.
Advanced ACM Tactics	o Capable of only 1vs1. Need expanded capability to include 1vs2, 2vs1 at minimum.
Low Altitude ACM	Inadequate ground growth. Need visual method to determine altitude in simulation of 'real world' conditions.
Overland ACM	o System is locked into an overwater mode. Need both land and water.
Basic Problem Scenarios	o System unable to run desired scenarios due to unreliability and inadequate design attention to this area.
	o System record feature limited to 1 hour. 3-hour minimum needed to cover all desired scenarios.
Engagement Geometry Analysis	o Threat bogey cannot be scenarioized (directed) to demonstrate classical adversary maneuvers. Need capability to provide this important training requirement
Sortie Debrief	o System employs wholly inadequate performance measurement system.

A somewhat different system also utilized for fighter tactics training exhibits similar shortcomings:(1)

- Inadequate instructional design features. Demo and debrief systems inadequately designed and difficult to use.

- o Adaptive maneuver logic (of threat aircraft) varies in performance.
- o Demo create process involves a lengthy procedure and is thus difficult to perform.
- o Debrief printouts difficult to understand and of limited usefulness.

It appears from the foregoing that although technology plays a part, a significant number of identified problems clearly reside in the category of "insufficiently defined mission and training requirements."

STRUCTURED APPROACH TO FORMULATING SIMULATOR DESIGN CRITERIA

The means of translating appropriate "mission logic" into full mission simulator design features suffers from a clear, well defined process. The need, for instance, of having an unambiguous and comprehensive understanding of the cognizant mission prior to addressing conceptual design options is self-evident. While it would be naive to suggest that design teams do not design with the overall mission in mind, experience has shown that these same teams are not provided with, and thus do not adequately address, critical mission requirements as part of the conceptual design process. Approaches have been utilized in the past to attempt to understand and document mission driven training requirements, yet an acceptable methodology unfortunately is not evident. (The ISD model is a movement in this direction but significant shortcomings exist for many purposes beyond curriculum development, due to its inability to adequately analyze the cognizant mission: Most of the methodology is directed to specifying tasks and behaviors.) One possible method, suggested here, is presented in the interest of stimulating dialogue with a goal of eventually establishing a structured approach to advanced simulator design. This proposed scheme, presented in the broadest of brush strokes, follows a straightforward logic process outlined below (and graphically displayed in Figure 1). A more detailed description of each element of the scheme follows in subsequent paragraphs.

Structured Approach to Simulation Design

- o Conduct a formal Mission Analysis, structuring the mission to include functional sequencing, scenarios, task requirements and performance objectives.
- o Perform an Instructional System Requirements Analysis in order to select appropriate instructional methods for selected mission objectives.
- o Utilizing a systematic approach, conduct a Priority Analysis by assigning priorities to specific mission and operator task areas; spotlighting candidate simulation design features which will realize the greatest training payoff.

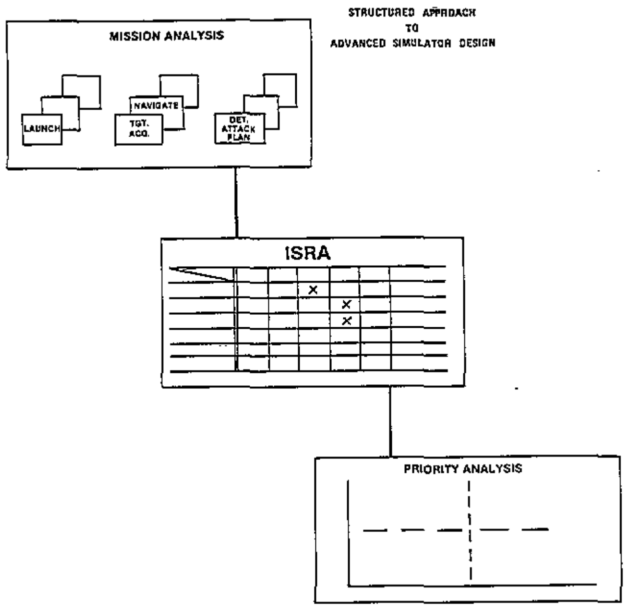

Figure 1

Mission Analysis

A selected operational mission is formally analyzed by following the logic process depicted in Figure 2. Although space does not permit a detailed examination of the methodology, the following outlines the important steps.

- o The process of analyzing a cognizant military mission commences with a coherent - albeit generic - mission statement. A mission statement describes, in broad terms, the purpose of a warfare-specific operation.
- o Functional mission hierarchies are constructed next to identify mission elements, specifying broad mission tasks, and depicting relationships.
- o Overall mission objectives are then specified for appropriate mission elements identified in the step above. Objectives are needed to understand broad performance requirements of the scrutinized mission.

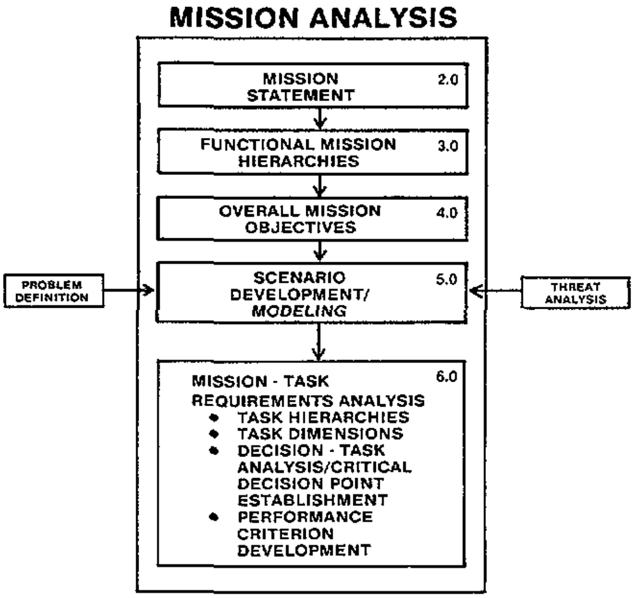

Figure 2

- o Scenarios are developed to explore threat-imposed constraints, mission profiles, tactics, critical mission segments and broad resource needs to successfully carry out the intended operation. Functional sequencing, scenario tree analysis, and P_K (Probability of Kill) equations are the three common analytical techniques utilized in this step.

- o Mission-task requirements, the last step in the process, constructs task hierarchies, specifies task dimensions, identifies critical decision points and relative task loading, and suggests task performance criteria in an attempt to fully understand detailed requirements of the mission.

Instructional System Requirements Analysis

An analysis of training requirements driven by the previously outlined technique for analyzing the mission, is designed to specify appropriate training tracks and training objectives and relate these to candidate training methods. A convenient means to conduct this analysis is to create a matrix as shown in Figure 3. As indicated, this rather straightforward analytical technique specifies mission objectives (derived from the aforementioned mission analysis) on the horizontal axis vs. candidate training methods along the vertical axis. Note the ACM portion of the fighter mission, selected for this example, is decomposed to a level sufficient for analysis and is arranged in a systematic sequence. Finally, for each mission objective, candidate methods of training are identified by X-ing in appropriate boxes. For this paper we are concerned primarily with simulation, although this technique, being generic, appears to be suitable for a wide range of instructional needs.

Priority Analysis

After candidate training methods are identified, determining candidate design areas based upon the examination of critical mission requirements is considered the next logical step. This suggested process or methodology is outlined below.

- o Select an appropriate mission objective (or phase) where simulator training is suggested from the aforementioned matrix.

- o Determine relative importance of this mission phase utilizing expert interviews and conventional scaling techniques (a one-to-ten scale appears appropriate).

- o Decompose selected mission phase into its component tasks (task hierarchy).

- o Arrange related tasks into groups or modules.

- o Examine overall difficulty of these task modules by determining aircrew task loading during this phase of the mission as follows:*

  -Tasks performed individually in sequence - low rating (1-3)

  -Multiple tasks performed simultaneously under relaxed time conditions - medium rating (4-6)

  -Multiple tasks performed simultaneously under increased time compression - high rating (7-10)

- o Plot mission importance vs task difficulty on conventional graph as shown in Figure 4.

- o Superimpose demarcation lines on the graph forming four equal quadrants.

Mission objective/task modules plots which fall in the upper right quadrant represent the highest priority areas where design efforts should be focused and where maximum

*The previous mission analysis, having identified critical decision points and task loading will aid this analysis considerably.

INSTRUCTIONAL SYSTEMS REQUIREMENTS ANALYSIS MATRIX

	MISSION OBJECTIVES (ACM) / CANDIDATE TRAINING METHODS	TARGET ACQUISITION			EVALUATE TACTICAL SITUATION			MANEUVER AGAINST THREAT				NEUTRALIZE THREAT	
		ESTABLISH EFFECTIVE RADAR PROCEDURES	ACQUIRE TARGET	VISUAL I.D. TGT	DETERMINE THREAT CAPABILITIES	EVALUATE RELATIVE TACTICAL POSITION	DETERMINE ATTACK PLAN	EMPLOY APPROPRIATE ENGAGEMENT GEOMETRY MODELS	ACHIEVE OFFENSIVE POSITION	MAINTAIN ENERGY	RECOGNIZE LAR	DELIVER WEAPON	EVALUATE RE-ATTACK
ACFT OPS	CONVENTIONAL ACFT OPERATIONS	x	x	x			x	x	x	x	x	x	x
ACFT OPS	RANGE SUPPORTED ACFT OPERATIONS	x	x	x			x	x	x	x	x	x	x
SIMULATION	FULL MISSION SIMULATION	x	x	x			x	x	x	x	x	x	x
SIMULATION	OFT	x	x								x	x	
SIMULATION	CPT						x						
SIMULATION	PTT				x	x	x		x		x	x	
GROUND TRAINING	CAI	x			x			x		x	x		
GROUND TRAINING	TAPE /SLIDE /VIDEO	x			x					x			
GROUND TRAINING	PROGRAMMED TEXT	x			x								
GROUND TRAINING	PLATFORM	x			x								

Figure 3

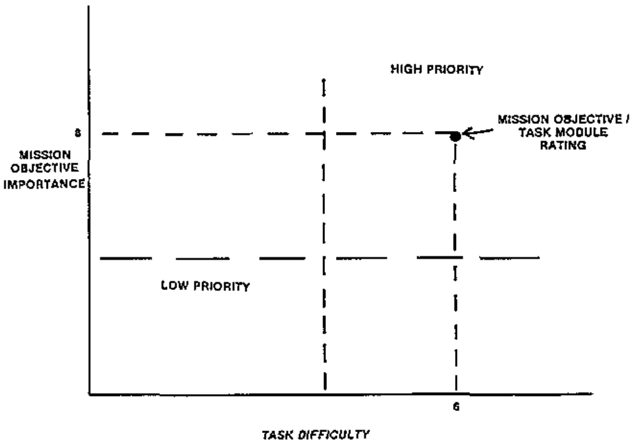

Figure 4

mission effectiveness will most likely be achieved. Conversely, plots which fall in the lower left quadrant represent the lowest priority rating suggesting not more than a modest investment in resources is needed. An example to illustrate the above scheme follows.

From the Instructional Requirements analysis matrix (created in part from the previous mission analysis): (1) it is determined that the mission objective "Determine Attack Plan" is a candidate for advanced simulation training; and (2) from expert interviews it is then decided that this mission objective's relative importance rating is 8. This number is plotted along the Y axis of the graph (Figure 4). (3) The mission phase is then decomposed into its component tasks and a task module Determine Appropriate 1V1 Tactics to Achieve Advantage is identified (Figure 5). (4) Determining the difficulty of this task module is then attempted by examining task loading for this mission phase.

In this hypothetical case multiple tasks need to be performed but under relaxed time conditions (largely because this objective occurs prior to engagement); thus a difficulty rating of 6 is assigned. This number is then plotted along the X-axis (see Figure 4). Where these two numbers intersect represents the relative desirability rating of providing instruction for this mission-related task module utilizing advanced simulation technology. Note in this example it is considered "highly desirable" to utilize advanced simulation systems to train in this area.

The foregoing structured approach is intended to provide a convenient means of specifying and selecting areas where concentrated efforts can achieve the greatest

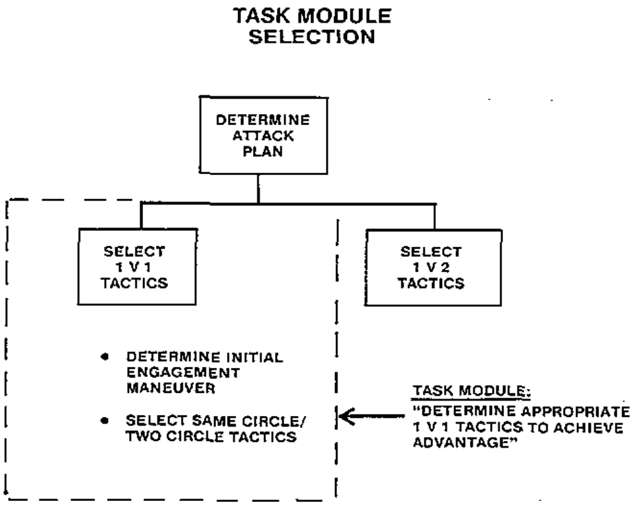

Figure 5

training return-on-investment. In other words, of all of the mission areas that are possible to simulate today, where should we be directing our attention? Clearly, our attention, followed by our resources, should first be directed at the most difficult/most important mission areas. In this way, training systems can be designed that speak directly to critical operational needs. Finally, it is the author's opinion that as our high-technology training systems begin to focus on critical operational needs, their acceptability as well as their utilization rates will show substantial improvements.*

INSTRUCTIONAL DESIGN FEATURES

The most obvious instructional design feature an advanced simulator could possess is a formal curriculum designed to achieve specific training objectives while utilizing the subject device. Unfortunately, this is so obvious that, paradoxically, it has been often overlooked. Numerous instances can be cited where expensive, advanced flight simulators were delivered to the fleet without a supporting syllabi. Fortunately, steps are being taken to rectify this situation and it appears now that most cognizant individuals agree on a need for a supportive instructional program complete with performance feedback for these modern training devices.

*It is recognized that ultimately this priorization analysis must find a logical resting place, such as a direct aid to selecting generic design features of the system under analysis. Additional work is needed in this area and formal support for this and similar efforts is strongly encouraged.

Significant difficulties, however, remain in deciding who should be responsible for curriculum development: prime contractors, squadron personnel (i.e., users) or training specialists. These questions become moot when these devices are viewed from a systems perspective. This view holds that complete instructional systems are needed in this age of complex mission requirements driven by high technology.

For advanced simulators this "training system" could include such operational items as:

- Conventional system hardware and supporting computer software
- Operational training curriculum
- Performance measurement system
- Training management system.

There remains an unfortunate tendency - possibly due to a less than clear view of the "systems approach" - to treat only the first step as sufficiently worthy of the design team's attention. If we can at least tentatively agree that as sophisticated instructional devices, full mission simulators ought to come equipped with a structured training program, (which has the added benefit of requiring contractors to more fully consider operational training problems and requirements) then an important related condition presents itself. How can critical mission objectives be translated into formal curriculum designed to enhance training effectiveness in today's complex mission areas?

To answer this question we must first briefly outline the ISD process and then show how the previous priority scheme can be utilized for the design of enhanced training programs.

Curriculum Development

Development of a training program for advanced flight simulators should clearly follow the ISD (Instructional System Development) process, which provides a systematic and scientific methodology for

- o Identifying tasks that (operators) must perform
- o Specifying the hierarchy of training objectives
- o Developing procedures and schedules for training in the performance of identified tasks.

The ISD model, although providing for improved professionalism in instructional system design, lacks a mechanism specifically designed to spotlight critical mission areas and concomitant priority training requirements. Thus, such critical areas as operator decision-task requirements are largely neglected in present ISD treatments.[3]

Mechanism to Aid in Development of Enhanced Training Products

To aid in the development of enhanced training products, a mission-focused priority scheme for identifying critical mission areas and thus important training requirements is considered essential. The previously outlined "structured approach" is considered a candidate means to accomplish this task.

The process of focusing in on critical mission and training needs commences as before with a formal analysis (Figure 2) of the cognizant mission. The Instructional System Requirement Analysis matrix (Figure 3) then provides a convenient means to identify candidate instructional methods appropriate to the specified mission objectives. From this matrix, we can see for instance, that the mission objective "determine threat capabilities" can be addressed by utilizing any or all of the following training methods:

- Part task trainer
- CAI
- Stand-alone tape/slide/video
- Programmed text
- Platform.

A possible way to determine the most appropriate instructional strategy is to conduct a Priority Analysis to determine relative importance of this mission area. This analysis, explained in detail in the previous section, examines appropriate mission objectives and its component tasks from the standpoint of importance and task difficulty.

When plotted on the Priority Analysis Graph (Figure 4), Mission Objective/Task Modules which fall in the high priority quadrant should drive the development of an instructional system commensurate with this priority. High priority areas may, therefore, require the development of a composite training system embracing the following areas:

o Aircraft operations complete with detailed scenarios

o Simulation training events designed to prepare for specific aircraft operation scenarios.

o Part-task trainer designed to instruct in critical decision-task areas.

o Computer-aided instruction designed to develop requisite background information.

Thus the composite training system concept extending beyond the compartmentalized view of stand-alone training systems, proposes, utilizing the "Structured Approach", to (1) focus on critical mission areas, and (2) integrate various instructional devices (and instrumented ranges) and curriculum into a coherent, goal oriented process whereby enhanced training indeed becomes a reality.

SUMMARY

It appears self-evident that a clear view of mission objectives, tasks, and candidate training methods coupled with a priority scheme is needed in any successful design effort for advanced simulation systems. Indeed, these concepts are finding favor among more and more individuals such as Cream[4] who encourages a task rating system for use in selecting actual simulator design features.

Whatever priority or rating system is adopted, providing design teams with appropriate "mission logic" coupled with a mechanism to focus attention and resources on those areas promising the greatest training return-on-investment appears to be the critical task at hand. No longer can we afford to build high technology systems exclusively from a technical specification document. Technical know-how must be translated into mission capability by making technology respond specifically to critical mission needs. Otherwise we will remain in our current predicament of fielding technical systems that at best only achieve sub-optimum levels of mission performance throughout the system's life-cycle. Thus future distress calls from the operational community will become an increasingly regular and tragic occurrence.

ABOUT THE AUTHOR

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Graduating from Navy Flight Training in 1965, CDR. Smith spent 14 years on active duty in various assignments flying the F-8 Crusader, accumulating over 2400 hours in type. His major fleet assignments included Officer-in-Charge, Light Photographic Squadron Sixty Three Detachment One (VFP-63 Det 1) deployed in USS Constellation, as well as numerous squadron level department head positions.

When not performing his Naval Reserve duties, Mr. Smith in civilian life is employed as an Airline Pilot and, in addition, is involved in work relating to Mission and Operational Analysis.

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