AN AIR TRANSPORTABLE PROGRAMMABLE AIR-TO-AIR COMBAT SIMULATOR

RICHARD J. HEINTZMAN
United States Air Force
Aeronautical Systems Division
Wright-Patterson Air Force Base, Ohio

INTRODUCTION

The demand for increasing use of flight simulators within the military has led to requirements for broader application and more efficient utilization.

The use of mobile simulators is by no means new to either the Air Force or Navy. Both services have used such devices effectively for years; the Air Force units being mounted in railcars and the Navy units being trailerized for highway transportation.

Current mobile simulators are limited to instrument flight simulation. The Air Force during the 1960s added visual attachments; however, this effort was unsuccessful. Recent advancements in mini-computers, microprocessors, and in computer image generation (CIG) make mobile simulators in general and visual mobile simulators in particular more feasible.

Aerial combat simulation is potentially a high payoff application of mobile simulation. This paper attempts to define a minimal cost, low-risk approach to Air Transportable Programmable Air-to-Air Combat Simulators (ATPAACS).

POTENTIAL REQUIREMENT

For years, various organizations have alluded to requirements for a mobile air-to-air combat simulator. The operational advantages of such a simulator are obvious. This is especially true if one assumes that such a simulator has the flexibility to be reprogrammed to simulate various types of aircraft and if the device is capable of computer simulation of an adversary. This would allow a single cockpit device to fly one-on-one against a preprogrammed threat. Since the proportion of the flying training syllabus devoted to aerial combat may be rather small, and not warrant dedicated aerial combat simulators, the mobile simulator is very attractive. It is also highly attractive as a tool to send to the field to update pilots in the latest tactics to be used against threat aircraft. It allows a pilot to learn specific enemy tactics and the preferred countertactics to be used in one-on-one engagements. The countertactics may be changed as enemy tactics change. It can be used to provide familiarization training with the performance characteristics of threat aircraft.

GOALS

The primary goal is to define an air-to-air combat simulator which is air transportable. Ideally, it should fit into a C-130 aircraft without exceeding its weight limitation for inter-theater shipment. The simulator should have a full field of view (FOV) display (limited only by aircraft configuration) with one high resolution aircraft image input and a horizon reference. As a minimum, it should have kinesthetic cueing to include g-suit, g-seat, and buffet systems. The aerodynamic simulation should be accurate and should be easily reprogrammable to represent different aircraft. An "iron pilot" (interactive computer pilot) program to fly a reprogrammable adversary aircraft using appropriate tactics should be included. The time required to set up and tear down the simulator should not exceed eight hours and four hours respectively.

APPROACH

Various approaches have been studied including both optical and screen displays, camera/model, CIG, opaque projector image generators, one or two cockpits, and various methods of providing kinesthetic cue simulation. Several basic conclusions were reached. Large optical displays would not be practical. A dome type screen which was inflatable would best meet the display and transportability requirements. Kinesthetic cueing would include g-suit, g-seat, and buffet systems. Cockpit motion would not be practical due to siting and size constraints, setup and teardown time requirements, the impracticality of using motion inside a dome, and the problems involved with mounting a nonrigid dome on a motion base. Details of the proposed cockpit are provided below.

Cockpit. The cockpit would be simplistic with instrumentation, systems, and controls limited to those necessary for air-to-air combat. A goal would be to provide a convertible cockpit configuration with removable instruments, panels, and controls to facilitate changes to represent different aircraft configurations. Such configuration changes would be effected at depot level. Such changes could include sidearm controllers and high g seating configurations.

Kinesthetic Cue Simulation. Kinesthetic cue simulation would include an active g-suit system to provide sustained g-cues, g-seat with active lap belt to provide both onset and sustained acceleration cues, and a seat buffet system to provide additional aircraft performance cues. Other methods for providing kinesthetic cueing would be considered during the development phase of the program.

Operator/Instructor Area. An operator/instructor area would be provided which would stress use of the latest instructional aids and cathode ray tube (CRT) type terminals to provide feedback to the operator/instructor and to provide a means for the instructor to brief and debrief pilots.

Image Generation. There are several alternatives available for generating the image of the opposing aircraft. They include CIG, camera/model systems, and an opaque projector system. The CIG approach is the most flexible since the three-dimensional aircraft image is digitally stored and may be changed with software alone. This approach, however, provides the least realistic aircraft image. A camera/model system provides a more realistic image but is less flexible and less reliable. The opaque projector system would involve projecting the image from a highly illuminated gimballed model to the screen with relay optics. This simple, reliable technique provides image resolution exceeding that of the human eye but is still less flexible than CIG, requiring physical model changes with the opaque projector. One problem that must be overcome is that the low light efficiency of the system may result in a dim display.

Display. The key element in any air-to-air combat simulator is the visual display. An extremely large field of view is required. Two basic approaches to providing such a FOV have been investigated. The first approach uses an inflatable dome similar to those used to protect radar antennas. Such a dome should be at least 16 feet in diameter with a 20-foot diameter preferred. The layout in Figure 1 shows an 18-foot dome. The input to the display would be either a television or opaque projector. If the opaque projector is determined to be impractical, hardened monochrome television projectors are available which would be ideal for mobile use. The background display would be provided by a point light source projector using spherical transparencies to provide horizon, sky, and ground plane for attitude and heading reference. The second approach investigated was a combination helmet-mounted sight and a helmet-mounted display. This approach would provide an unlimited FOV for the pilot with a minimum amount of hardware. It involves feeding video information including the threat aircraft and horizon and background into the helmet display and controlling position of this imagery with positional information for the helmet sight. The disadvantages of this approach are the limited instantaneous FOV of current helmet displays and the interaction between information displayed on the helmet and the cockpit structure and instruments. Current systems have an instantaneous FOV of only 25 - 40 degrees and only input imagery to one eye. The limited FOV would require more than normal head movement by the viewer. Initial indications, at this time, are that the dome display is more practical and may be lower in cost.

Radar. Radar simulation would be limited to airborne targets which would be generated digitally using conventional techniques.

Computer. The heart of the mobile air-to-air simulator would be the computer. Currently available mini-computers are extremely compact and could readily handle the simulation required. Initial indications suggest the use of two central processors and peripherals including a teletype and at least two magnetic discs. For those computations that do not require reprogramming, such as integration, linear function interpolation, g-seat, and control loading systems, the use of microprocessors should be considered. It is anticipated that with proper shock mounting and environmental protection it would not be necessary to provide hardened computer equipment.

Simulator Enclosure. The goal of this program would be to have the simulator in two enclosures, each with maximum dimensions of 8 ft X 8 ft X 20 ft. This would allow the simulator to be transported in either a C-130 or C-141. Modifications of standard electronic shelters with built-in environmental control equipment would probably be used to insure compatibility with International Standards Organization (ISO) transportability requirements. It may be desirable to include an auxiliary power unit to assure that adequate stable power is available for the simulator. Figure 1 shows a preliminary layout of the simulator with the two enclosures butted together for operation. A wall at one end of the instructor/console section is removed prior to assembly. A section of the enclosure at the cockpit area is removable to allow inflation of the spherical dome. An air lock is included to allow the pilot to enter the cockpit enclosure with the dome inflated.

Training Considerations. To take maximum advantage of the mobile simulator concept and to provide current training, the simulator must provide training against the tactics used by threat aircraft and permit relatively rapid tactics changes. Threat aircraft performance is an important part of

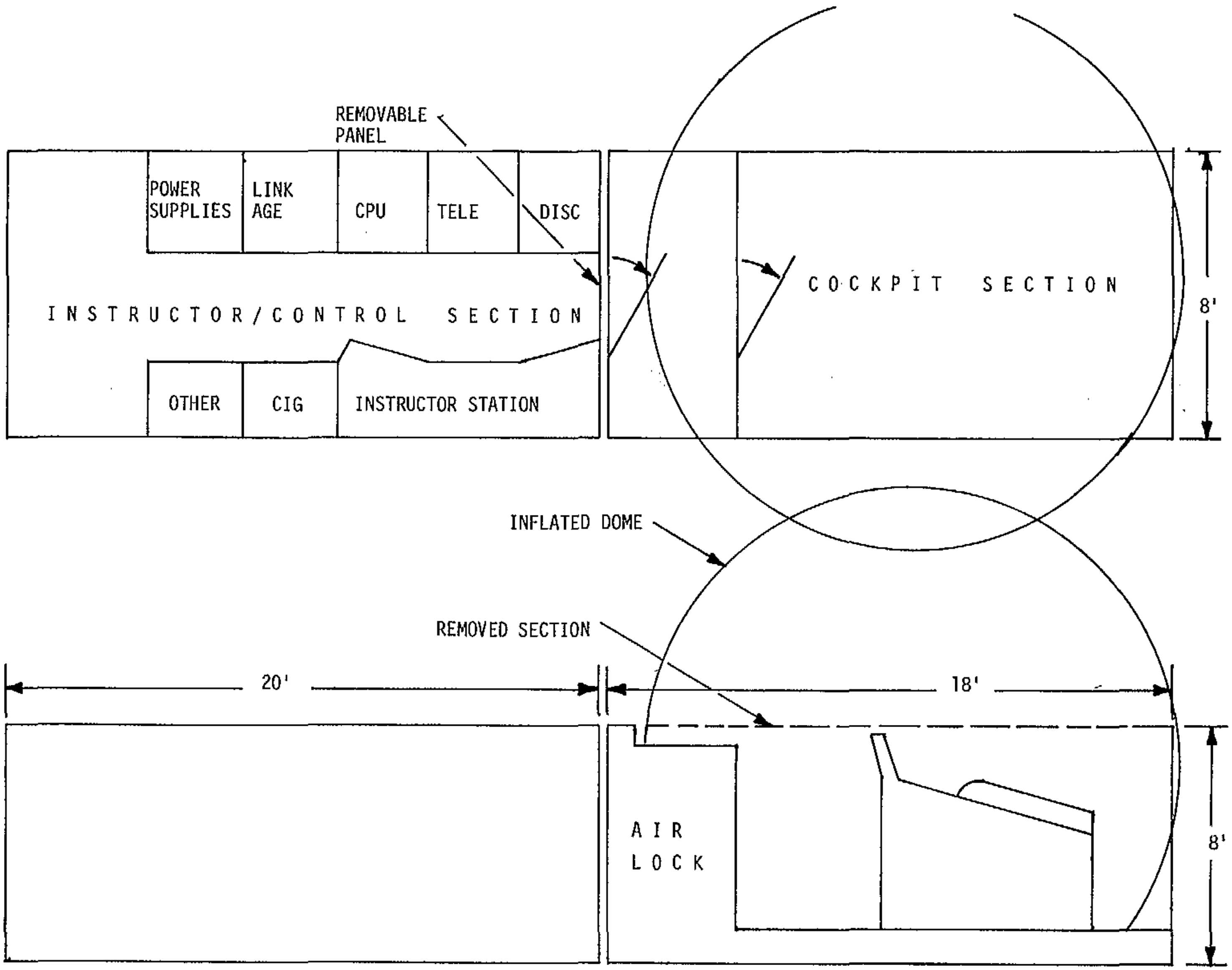

Figure 1. Proposed Layout - Air Transportable Programmable Air-to-Air Combat Simulator

the training to be provided, but it is the threat tactics, not aircraft performance, which are most subject to modification. The interactive target, or "Iron Pilot" should exhibit threat tactical considerations or should permit the instructor to provide such inputs from the console. The limitations of this simulation to one-on-one engagements limits tactical training to one-on-one situations but effective training can still be performed. Data on threat tactics is available from a variety of sources including intelligence organizations, the Tactical Fighter Weapons Center, AFM 3-1 "Tactical Fighter Weapons Employment," and the F-5 "Agressor" Squadrons. The tactics employed in a given situation depend strongly on the number of "friendlies" and adversaries involved. To provide tactical training with or against multiple aircraft, the simulation of multiple aircraft should be considered.

LOGISTICS CONCEPT

Field maintenance would probably be limited to removal and replacement of cards/modules. A 30 to 90 day spares kit would be carried along with each mobile trainer to ensure simulator availability. Repair would be accomplished at depot level. The simulator design will have to consider vibration, humidity, and extremes of heat and cold to be encountered during continuing moves. Design tradeoffs will be made between built-in test equipment (BITE) or separate supporting test equipment. The need for a self-contained power source or use of locally available power source will be traded off against the total weight and volume transportability considerations. Storage space for technical orders, spares kit, test equipment, and power source, if required, would become part of the simulator enclosure/shelter. Consideration of the need for maintenance, supply, and instructional areas may require the use of expandable simulator enclosure/shelters. Air transportation to support movement of the simulators will have to be provided with a priority commensurate with the need for the training.

SUMMARY

A mobile air-to-air combat simulator is feasible with today's technology. Advancements in computer and simulation technology make such a simulator not only feasible but practical. Further study work should be conducted in order to best define the approach. The expertise of several governmental/industrial groups seems applicable especially in areas such as inflatable structures, Bare Base concepts, and iron pilots.

ABOUT THE AUTHOR

MR. RICHARD J. HEINTZMAN is Chief of the Visual and Electro-Optical Branch, Simulator Division, Deputy for Engineering, Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio. He is currently responsible for the engineering aspects of Air Force visual flight simulation engineering development programs. In the past, he was Program Manager for the Simulator for the Air-to-Air Combat Advanced Development Program and was Project Engineer on the development of various Air Force visual flight simulation devices. Mr. Heintzman holds a B.S. degree in mechanical engineering from Bradley University, Peoria, Illinois.