EW TRAINING IN THE FLIGHT SIMULATOR

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INTRODUCTION

The development of sophisticated, radar controlled antiaircraft weapons and the development of warning and countermeasure devices to allow aircraft to fight and survive against those weapons have changed the whole nature of air warfare. Now, warning and countermeasures devices are considered an integral part of the aircraft's armament, and training in the proper use of these devices is in turn an integral part of aircrew training.

With the reduced availability of fuel, and the resulting drive to move more and more aircrew training into simulators, there has been increased interest in the addition of realistic Electonic Warfare (EW) environments in new and existing flight simulators. It is the purpose of this paper to discuss the ways in which EW capability is and can be applied to these flight simulators and the way it interfaces with the other simulator subsystems.

Several general requirements characterize the specifications being generated in this field:

- The EW simulator must generate a threat environment, with groups of threat emitters (fixed and moving) at preprogrammed locations in the flight simulator's gaming area.
- Threats must be triggered by "movement" of the simulator into the vicinity of threats in the gaming area.
- The EW displays in the simulator cockpit must accurately reproduce what the students would see and hear if they were really in the situation being simulated (including equipment anomalies).
- The operation of all receiver and countermeasure controls must be accurately reflected in the EW environment displayed.
- The EW environment must be consistent with the other elements of flight environment presented to students in the simulator.
- Instructors should be able to use and program the EW simulation, using only the skills required to fly and fight in the simulated environment.

While the techniques described are applied particularly to flight simulators, the same basic approaches are equally applicable to Command Information Center (CIC) Room Simulators and Armour Crew Trainers.

TWO BASIC APPROACHES

Two basic approaches to the application of EW to flight simulators are used: Signal Injection and Emulation. In the first approach (Signal Injection) actual RF or video signals are injected into the input ports of operational type receivers or video processors, as shown in figure 1. These signals are generated with the exact characteristics that the real signals would have if they were received

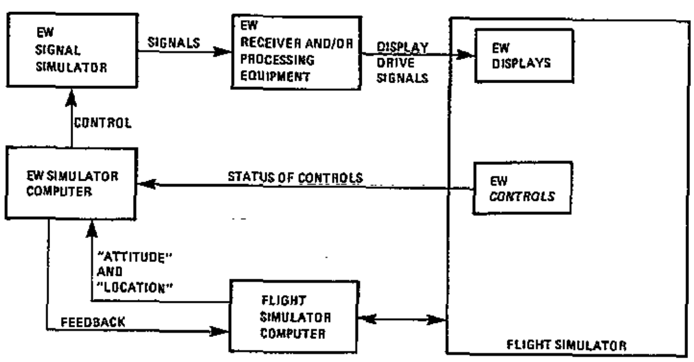

Figure 1. Signal Injection EW Simulation

by the operational equipment under combat conditions – with the aircraft in the attitude and location (relative to the simulated target) that the simulator shows at that moment. To achieve this, a computer controlling the EW simulator reads the status of the receiving and ECM equipment represented in the trainer, and the simulated location and attitude of the trainer in its gaming area. It then computes the exact signal parameters which would be seen by the receiver or video processor at that moment. The EW simulator is then commanded to generate those signal parameters – simulating many signals, each with the proper pulse and scan characteristics, signal strengths, direction of arrival, and (if applicable) RF frequency. This, of course, causes the receiver or video processor to generate the proper output signals to the displays which are presented to the student or students being trained in the flight simulator.

Signal injection is in many wrys the simplest type of EW Simulation to add to a simulator, because the actual receiver or processing equipment used in operation is driving the displays the student sees in front of him. This means that the display characteristics are precisely correct – including any peculiarities in the way the actual equipment presents its data, and any systematic performance anomalies which the student will see later when he uses the same equipment in the real aircraft.

In the second approach (emulation) as shown in figure 2, no actual signals are generated and no operational equipment is used (except perhaps the actual displays). Rather, a computer calculates the data that would be present on the operator's displays if the aircraft represented by the trainer were in the simulated position and attitude of the trainer in its gaming area.

At first glance, this seems to be a more simple approach, but now all of the little "quirks" of the operational equipment displays must be reproduced in order to preclude a negative training effect. It is a fairly simple task for a computer to place alphanumeric characters or lines on a cathode-ray tube (CRT) screen; but when these must jitter around in different ways as a function of signal density and relative location (as is the case in some real equipment), the task becomes more formitable.

SCENARIOS

In both Signal Injection and Emulation, threat scenarios are stored in the EW simulator computer. These scenarios comprise large numbers of threats located at various, appropriate positions throughout the gaming area. Any of these may be moving. The platform simulator is "flown" through this gaming area, and as threats are encountered, they are displayed to the student(s) in the simulator. As the simulator's "position" comes closer to the threat signal "location," the threat signal may change modes and the simulator will be "fired upon" if it gets into an appropriate position relative to the threat. The EW computer will analyze the effects of countermeasures applied at all stages in this process, determining if the threat will fire – and if it does, whether or not it hits the simulated aircraft. Damage assessment, or "near miss" information will be fed back to the platform so this can be applied (if appropriate) to other systems in the simulator. For example, a near miss could require the visuals to show a burst or an undetonated missile flying past in the appropriate direction.

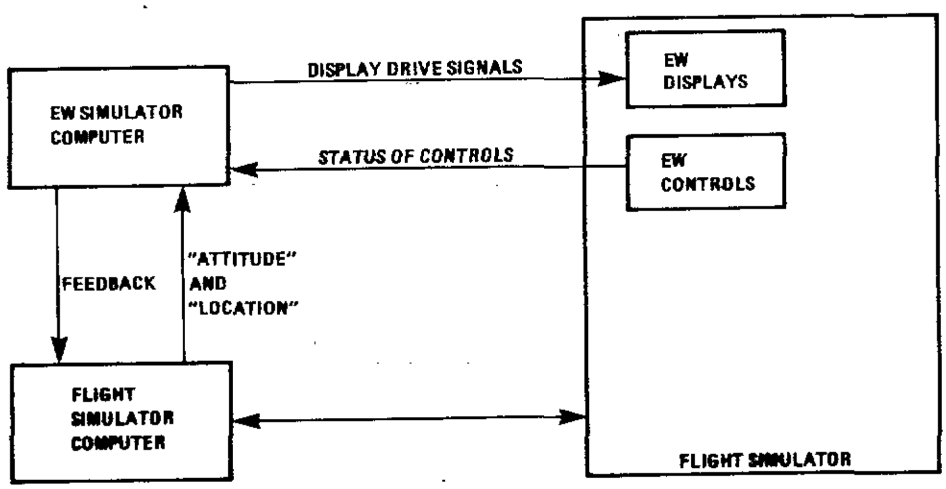

Figure 2. Emulation EW Simulation

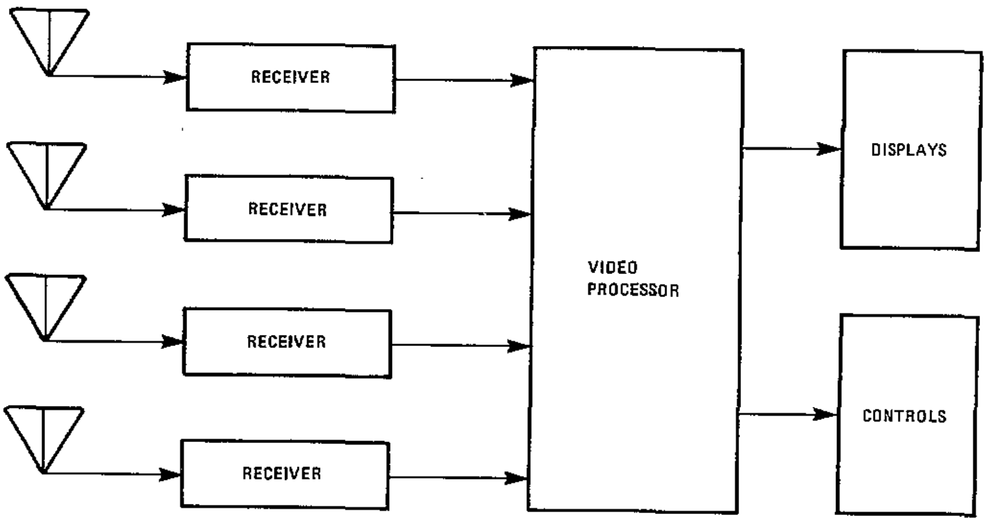

Figure 3. Functional Block Diagram of Radar Warning Receiver

DATA INPUT TO SIMULATOR

The EW data must be input to the simulator in ways that accurately reflect the way real data enters the EW equipment in the simulated aircraft. While the locations of the "aircraft" and the "threats" in the gaming area may be known within ±50 feet, it would be highly inaccurate to reflect this accuracy in the cockpit displays. As an example, consider a typical digital Radar Warning Receiver (RWR) with a block diagram as shown in figure 3.

This RWR must determine the type, mode, and location of threat signals relative to the aircraft from the information it receives through its four antennas.

Each antenna has a gain pattern as shown in figure 4. *(Note that this is a cosine pattern.)* The output amplitude of each antenna is thus approximately proportional to the cosine of the angle between the antenna boresight and the signal direction of arrival. Since the antennas are mounted on the "four corners" of the aircraft as shown in figure 5, the video processor can work the vector equations (figure 6) and determine the resultant signal strength and azimuth of arrival of each signal (hence the range and bearing to the threat). Of course, the processor must also determine the signal type from the characteristic parameters of the received signal.

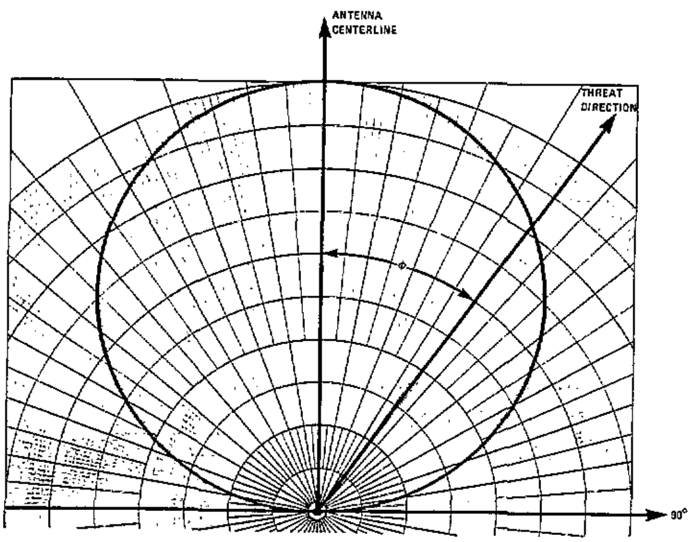

Figure 4. Typical Warning Receiver Antenna Pattern

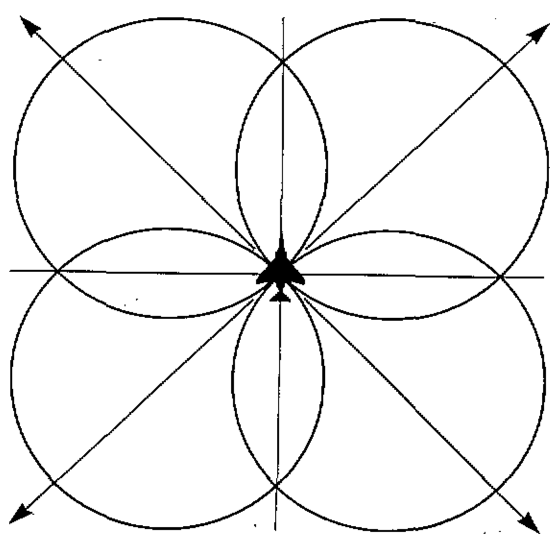

Figure 5. Aircraft Antenna Patterns

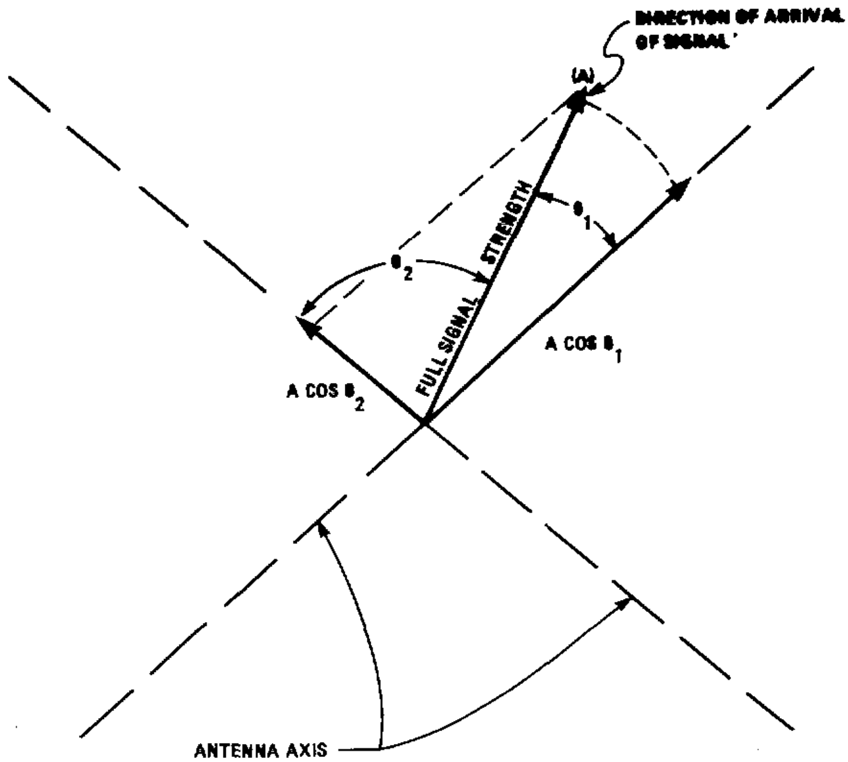

Figure 6. Components of Signal Vector in Each Antenna

That's easy so far, but there are some problems. The first is that the signal may not be within the plane of the four antennas and the aircraft may not be flying straight and level. So, the computer must work the coordinate transformation shown in figure 7 to determine the spherical angle between the signal and each antenna boresight.* Two interesting examples come immediately to mind:

- o If the aircraft is upside down, the RWR display will be reversed.
- o If the aircraft is in a 90 degree bank on a course perpendicular to the threat signal vector, all of the antennas will see the same signal level — so no valid display can be made to the student in the cockpit.

These are extreme examples, but they do serve to illustrate the display distortion effects that must be considered if a realistic data presentation is to be generated.

The other major effect is, of course, terrain occlusion of threat signals. Whenever the simulator approaches a threat emitter location, the computer must check that the vector between the aircraft location and the threat emitter location does not fall below the "surface of the terrain" in the gaming area (for simulators with that capability) before a signal is displayed. (See figure 8.)

* The actual antennas are also slightly depressed from horizontal plane.

PROGRAMMING THE EW SIMULATOR

While the detailed programming techniques applicable to individual simulators vary because of many technical and mission related factors, there are some requirements which they share. The most important of these is that the instructor be able to program the EW environment without having to learn any skills other than those required to fight in that environment and to teach others to fight in that environment. This specifically excludes direct knowledge of the parameters of signals associated with individual threats. The instructor must, therefore, be able to specify threats by threat type only (e.g., an SA-X) — and the simulator itself must then set up the proper pulse, scan, and RF frequency for each of the radars associated with the SA-X, or in some other way establish the information against which the threat displays will be generated.

The instructor must also be able to quickly and easily place those threats in the simulator's gaming area, either by specifying the gaming area coordinates at which the threats are to be placed or by placing threats in some graphic way. An example of a graphic technique is the movement of a threat symbol by use of a track ball — over a map of the simulator gaming area shown on a CRT.

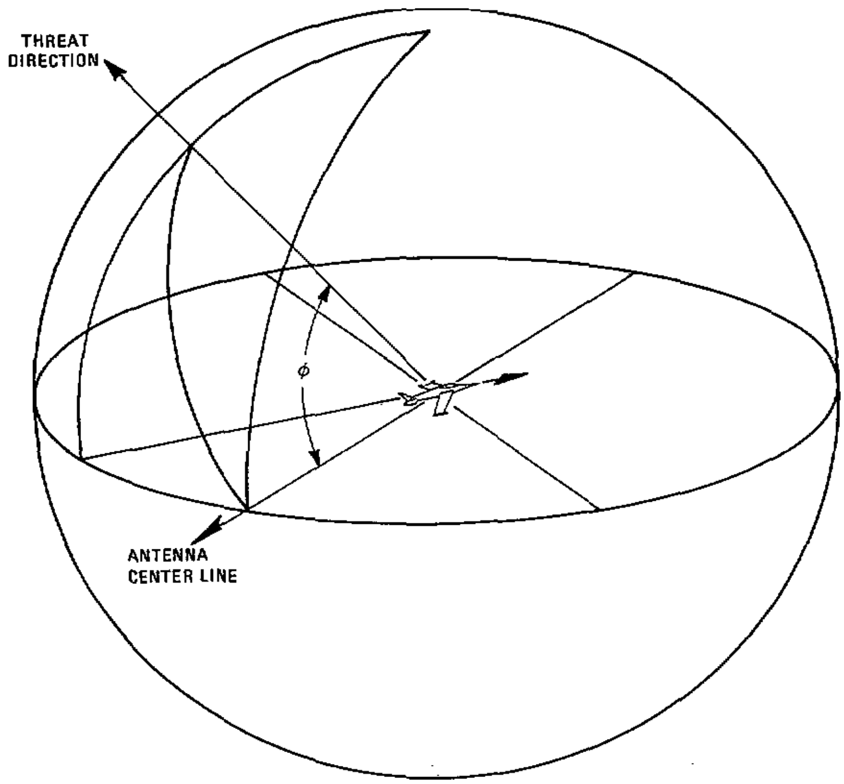

Figure 7. Determination Angle from Signal to Antenna Boresight

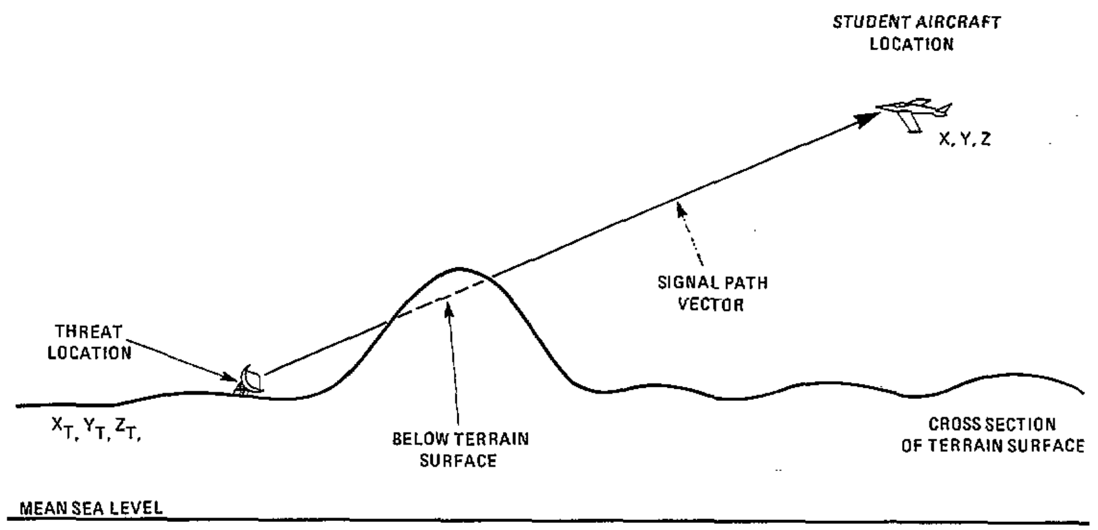

Figure 8. Terrain Masking Geometry

Another desirable feature is the ability to place groups of threats (for example, a complete defended airfield or city) with one set of coordinates or the placement of a single symbol with the track ball.

The above stated programming requirements assume that the instructor will be programming the EW simulator by the placement of individual threats or groups of threats – which is helpful for some types of training. However, another (perhaps more common) situation is the requirement to train the student to operate in a "typical" environment, or in the environment expected at some specific place on the earth. In both of these cases, the actual threat scenario would be prepared for the instructor by individuals with current and expert knowledge of the threat environment to be simulated. So the instructor need only use the provided environment.

But whether the instructor must create the environment, or merely use a preprogrammed environment, he can still concentrate on the instruction and evaluation of combat skills – not on EW skills as such.

EW TRAINING VS. FLIGHT SIMULATOR TRAINING

Despite the fact that the EW environment is now considered an integral part of the combat environment, it is often highly desirable to separate the flying part of the simulator from the EW part to conduct different types of training. Therefore, it often becomes yet another requirement of the EW simulator that it be usable with or without the flight simulator. The EW simulator shown in figure 9, which is in use with a flight simulator in Europe, has provision for the use of a parallel set of warning receiver displays (shown in place in the photograph). Since the EW simulator contains its own computer, which stores the whole EW environment gaming area, those front panel displays can be made to operate just as they would in the cockpit – by causing the computer to "fly" any desired course through the gaming area.

But the real payoff still comes when the system is used in its primary role, to provide students with as close as possible to a combat experience in the flight simulator by adding the EW environment to the other sensory feedback provided.

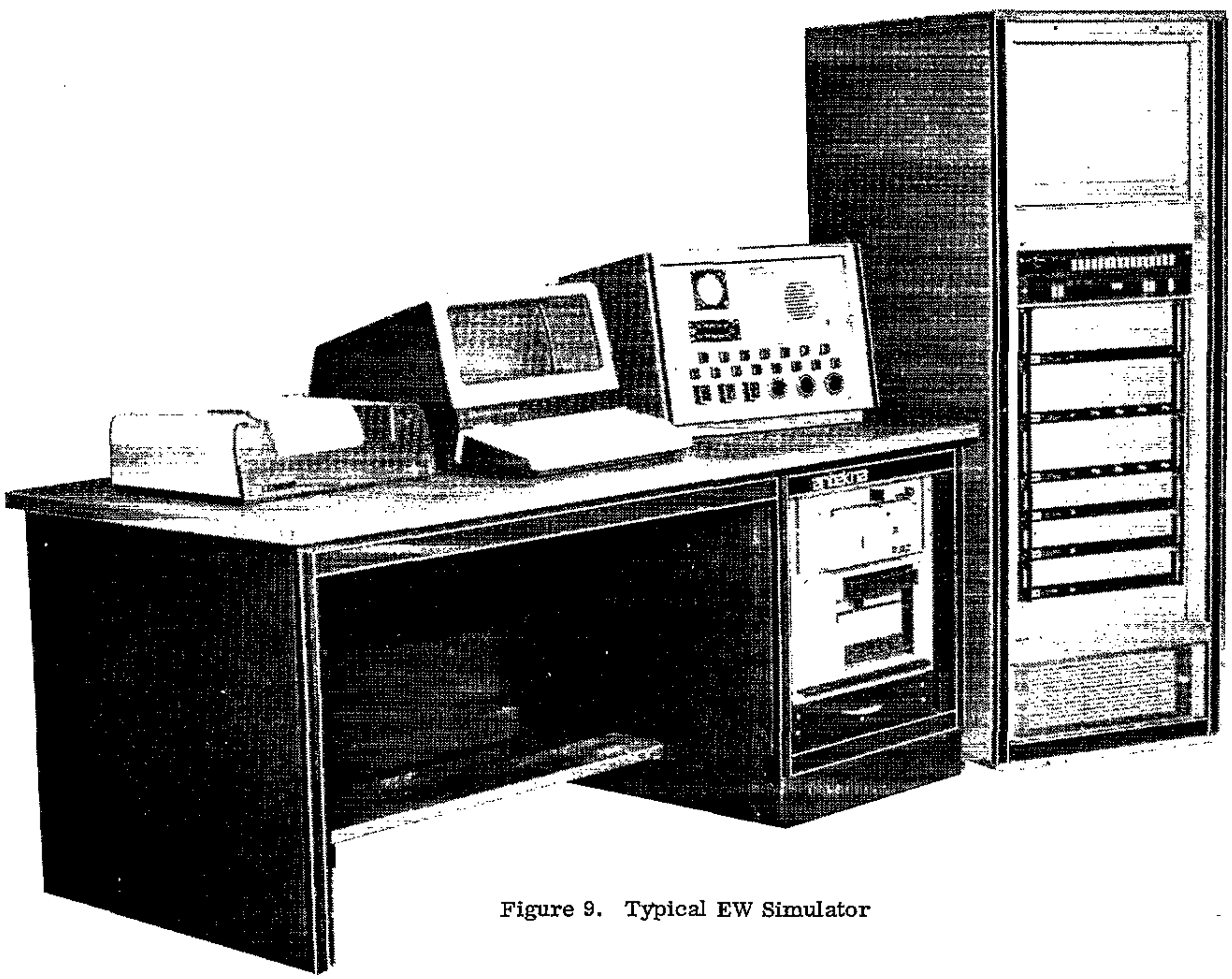

Figure 9. Typical EW Simulator

ABOUT THE AUTHOR

MR. DAVID L. ADAMY is an Engineering Manager at Antekna, Incorporated. He is responsible for the design of EW target simulator systems and the conduct of simulator system study activities. For the past 16 years, he has been a systems engineer and program manager in the EW field designing (and managing programs to develop) communication receivers, radar warning and automatic jammer interface systems, and remotely controlled direction finding receiver systems. While an Army officer, he was a technical instructor at the National Security Agency. Mr. Adamy holds a B.S.E.E. degree from Arizona State University and an M.S.E.E. degree from the University of Santa Clara.