PHANTOM RANGE - AN EW TRAINING SYSTEM

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ABSTRACT

Confronting NATO tactical air is a spectrum of Warsaw Pact defenses including SAMs, AAA, and airborne interceptors plus jamming of communications, fire control radars, and navigation equipment. Aircrews faced with this array, trying to perform their primary mission, must be trained to cope with the total anticipated task-loading and at the same time become neither casualties nor disoriented such that they fail to achieve their mission objective. Current training on large EW ranges is considered inadequate due to the limited accessibility and the infrequency with which aircrews can experience such training. The Phantom Range, an onboard, computer-generated threat simulator, can be programmed to provide threats at given geographic locations, independent of ground emitters, with appropriate envelopes modified by actual existing terrain. It allows the aircrew to defeat the threat by exercising proper procedures, or be "killed" if their actions are inappropriate. The whole scenario is recorded for ground debriefing.

INTRODUCTION

Phantom Range is an onboard, computer-generated threat simulation system that enables aircrews to interact with defensive scenarios during actual combat training missions and perfect their techniques in exercising appropriate defeat procedures independent of ground emitters (Figure 1). The system offers the capability to incorporate scenarios of varying complexity, in terms of varying locations, numbers, and kinds of threats. It provides real-time feedback of success or failure in accomplishing the proper procedures in a timely manner. Finally, it records encounters so that the aircrew can debrief, observing the actual displays that were seen during each engagement.

THREAT

Readiness of tactical air forces combines the availability of weapons systems, ordnance, and logistics support; the inherent capability of the weapons system itself; and most important, the ability of the aircrews to cope with all of the composite stresses of a combat situation and still function effectively to perform their primary offensive missions (Figure 2). This last, considering the anticipated threat, is a momentous task.

The threat consists of a very dense and effective array of surface-to-air weapons (SAMs and AAA), airborne interceptors, and electronic countermeasures (Figure 3). Communications jamming not only impairs command and control, it also serves as an annoyance and a distraction to aircrews. Jamming of forward-looking radars inhibits the ability to use this system for terrain avoidance or following. And of course jamming of navigation systems, or even worse, sending of false signals, makes radio navigation systems unreliable or erroneous. Together, these add significantly to the task-loading of crews -- many in single-seat fighters -- crews who are already heavily stressed just to navigate, maintain flight integrity, and accurately deliver their ordnance.

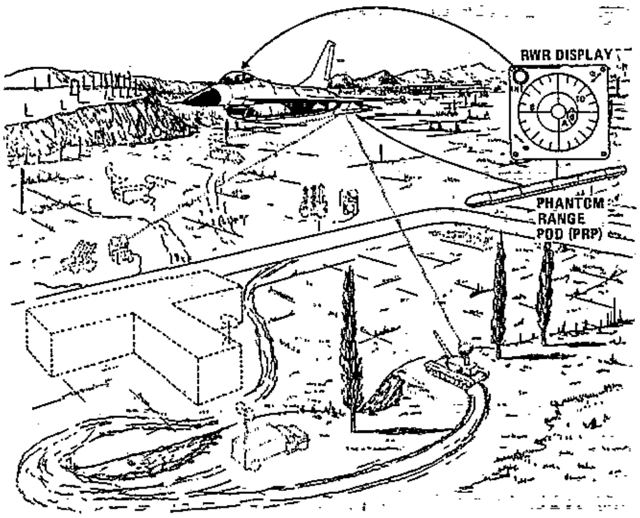

FIGURE 1. PHANTOM RANGE

FIGURE 2. THE COMPOSITE STRESSES OF A COMBAT SITUATION

SURFACE TO AIR MISSILES - DENSE, IN-DEPTH, NETTED

AAA - RADAR CONTROLLED, ACCURATE

AIR INTERCEPTORS - INTEGRATED DEFENSE (LESS THREAT TO LOW FLYERS)

COMMUNICATIONS JAMMING - INTERFERES WITH FLIGHT INTEGRITY AND CONTROL, DISTRACTING

AI/FLR/NAVIGATION JAMMING - INCREASED PILOT WORKLOAD AND VULNERABILITY

RESULT: DEGRADED NATO AIR EFFECTIVENESS
LOST AIRCRAFT/AIRCREWS
DISORIENTATION AND MISSION ABORT

FIGURE 3. THREAT

READINESS OBJECTIVE

To achieve the requisite readiness, aircrews must learn to accommodate all of the stresses and distractions and still perform effectively. They must be able to do the following:

- Navigate by dead reckoning only

- Reorient themselves and still reach their targets after performing defensive maneuvers that have driven them off their planned route

- Maintain flight integrity. Flight leaders must be able to direct the flight even though radio communications is unfeasible.

- Learn to respond to threats in a timely, correct manner so as to minimize loss potential

- Concentrate on employing their weapon systems while responding to defensive threats and ignoring distractions.

In summary, they must become completely acclimated to the conditions of the defensive scenario such that they can continue to function effectively in carrying out their primary mission.

TRAINING REQUIREMENTS

To achieve the above, the training program must provide realistic scenarios, crew interaction, and continuation training (Figure 4).

Realistic Scenarios

These scenarios should incorporate as near real conditions as feasible. Needless to say, as in any training situation, the environment should initially be somewhat simplistic: for example, one-on-one. Then, as proficiency grows, the scenarios should become increasingly complex until the aircrews are able to cope with a maze of defensive threats and distractions and still achieve their primary objective. Surprise (encounter with unanticipated threats) should be inherent in such a scenario. Implicit in providing realism should be the effect of terrain. Since terrain masking must be considered one of the most effective ways of evading or defeating a threat, aircrews should be trained to use terrain, taking it into account during mission preparation and instinctively including it in reactive options during flight.

- REALISTIC SCENARIO
  - INTEGRATED OFFENSIVE/DEFENSIVE
  - VARYING DENSITY
- CREW INTERACTION
  - RECOGNIZE, ASSESS, ACT
  - REAL-TIME FEEDBACK
  - NO NEGATIVE TRAINING
- CONTINUATION TRAINING
  - FREQUENT
  - COUPLED TO COMBAT TRAINING MISSIONS

FIGURE 4. TRAINING REQUIREMENTS

Crew Interaction

Crews must be able to exercise prescribed doctrine, be it maneuvers or employment of onboard countermeasures systems, so as to defeat threats. When actions are correct and timely, crews must receive feedback in terms of negation of the threat. When inappropriate, they should receive indications of failure, such as becoming simulated casualties. And most important, they should not receive negative training. They should not experience success if they ignore or react incorrectly. Conversely, they should not continue to be subjected to a threat if they follow the correct procedure.

While it is true that in real life exercise of proper procedures may not always guarantee success, it is most important that the training system not instill in aircrews such subjective scepticism that they not try. For example, if a simple emitter were put on a route and it were to activate the aircraft radar warning system, and if the aircrew were then unable to defeat it by employing their countermeasures in conjunction with prescribed maneuvers, they might eventually learn to simply ignore it. Since following prescribed procedures would add to the difficulty of concentrating on their navigation under such conditions but would do nothing to increase their perceived safety, they would be tempted to do the wrong thing.

To acclimate crews properly, they should have to interact with defensive scenarios every time they fly combat training missions so as to be psychologically prepared each time they start planning a combat sortie.

Continuation Training

Since learning procedures that must be implemented almost as an instinctive reaction requires constant iteration and practice, it is most important that the prescribed readiness criteria entail frequent, continual training of this sort. No one would suggest that a Navy pilot could shoot 10 carrier landings in a 2-week period, once a year, and still be proficient 9 months later — not unless he were practicing the equivalent on a continuing basis throughout that period.

Since most units do not have access to major hardware ranges on a continuing basis, routine local training today, particularly for tactical air forces stationed in Europe and the Far East, does not permit integrated offensive/defensive training as described above.

PHANTOM RANGE

The Phantom Range, which provides for the desired training on a continuing basis at local installations, consists primarily of a pod -- Phantom Range Pod (PRP) -- carried on a fighter aircraft standard wing pylon (Figure 5). Ground support hardware for the system consists of a Mission Planning and Debriefing Station (MPDS) and a Flightline Support Unit (FSU).

PRP

Inside the PRP (a 6-ft-long by 8-in-diameter pod) is a navigation system consisting of a Loran receiver and a strapdown inertial unit (Figure 6). This navigation system is capable of locating the aircraft position at all times, even during and after hard maneuvers.

The PRP also contains a minicomputer within whose memory is stored the geographic location of various simulated threats and the lethal envelopes modified by actual terrain surrounding those locations (Figure 7). Additionally, in memory are stored threat defeat procedures, be they maneuvers or switch positions of countermeasures equipment.

When the aircraft penetrates the lethal envelope as discerned by the Loran (Figure 8), the computer, having computed azimuth and range, commands the radar warning system to display the proper video signal on the radar warning indicator. It also lights the appropriate lights on the control panel and sends the proper audio signal through the intercom system. If communications jamming is desired, noise can be generated by the audio generator, which is used to construct synthetic radar warning audio signals and which can be injected concurrently into the intercom. (While the system as currently conceived does not provide jamming of the aircraft radar or navigation system, this capability could be added if desired.)

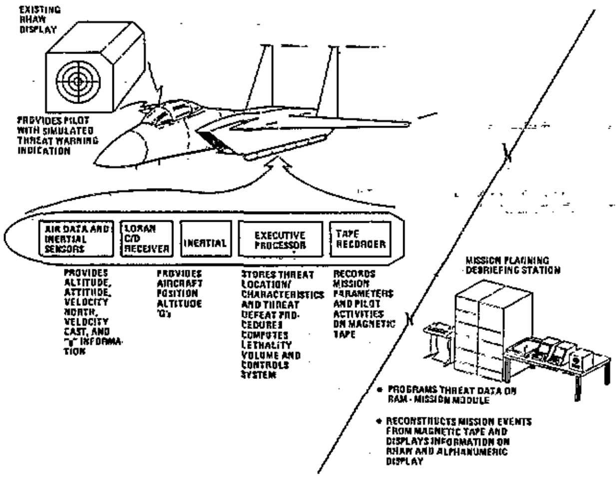

FIGURE 5. PHANTOM RANGE APPROACH

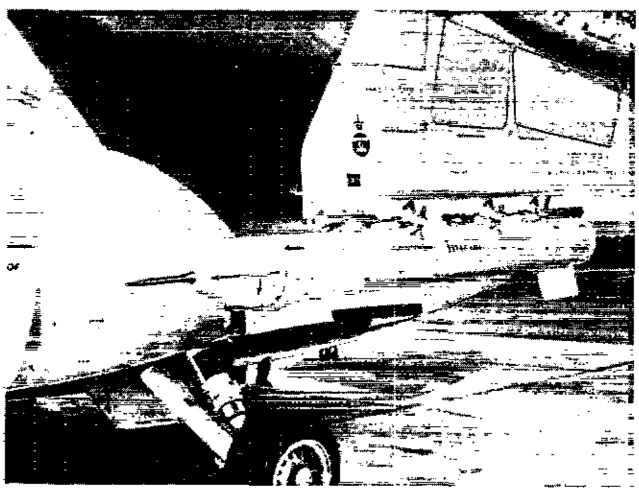

FIGURE 6. PRP - A DERIVATIVE OF TRIPOD

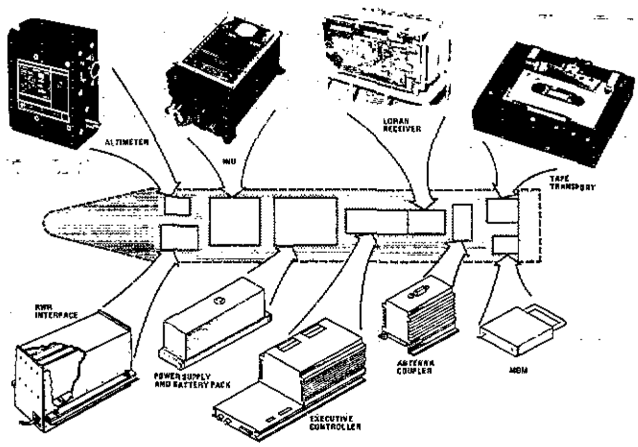

FIGURE 7. FUNCTIONAL SUBASSEMBLIES IN THE PRP

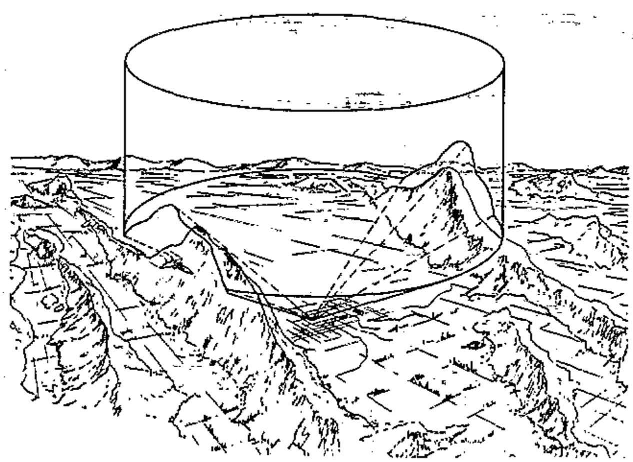

FIGURE 8. THREAT ENVELOPE

The computer also infers a launch after a nominal period subsequent to track radar lock-on. Depending on distance from launch site to aircraft, missile fly-out time is computed, and if the threat has not been defeated within that time, the video flashes and a buzzer sounds in the intercom to indicate the aircraft has been hit. After 1 sec, the system resumes normal operation so that the exercise can continue.

Finally, all visual and audio cues are recorded, as are significant aircraft and relevant aircrew threat defeat actions. These can then be inserted in the MPDS for crew debriefing.

MPDS

The Mission Planning Debriefing Station (Figure 9) has two functions: 1) preparing a RAM mission module for insertion into and control of the PRP during flight and 2) reconstructing the mission for debriefing.

For mission preparation, the MPDS, consisting of a minicomputer and input/output devices, receives generic threat data: i.e., lethal and audio characteristics, envelopes, geographic positions of each threat, significant terrain features surrounding each threat, and prescribed threat defeat procedures. These are inputted by EPROM in the case of generic threat data or threat defeat procedures, and either by EPROM or manually in the case of position location and terrain. Thus, if positions of several threats are to be changed, the operator need only delete the original locations and surrounding terrain and insert new locations of such threats and the terrain surrounding the new locations. An alphanumeric display is used to call up information from the computer and display to the operator results of his normal input. A strip printer provides hardcopy of relevant data, such as threat locations.

Once the computer has received inputs, it prepares the mission module so that it contains the appropriate threat and threat defeat data. Then the mission module is removed from the MPDS and inserted into the PRP on the flightline.

For the debriefing portion, a digital tape is removed from the PRP and inserted into the MPDS. Data on the tape are compressed for flight activities unrelated to the EW portion of the mission, while relevant data are sampled every 1 sec. The displays (the Radar Warning Scope and Control Panel plus a speaker for audio) are activated as they were in flight, while other significant parameters are shown on the alphanumeric display (Figure 10).

FSU

The Flightline Support Unit (Figure 11) serves to preflight the PRP, initialize the Loran, check the input of the mission module, and provide a go, no-go check. It also serves to diagnose and isolate faults or malfunctions to the Line-Replaceable-Unit level.

The FSU consists of a microprocessor, an alphanumeric display, and a keyboard for operator control.

PRP/Aircraft Interface

The PRP uses aircraft wiring currently existing at wing stations capable of carrying a jamming pod (Figure 12). It mounts on a standard stores pylon.

Electrical power (28 Vdc) existing at this station is used to power the PRP, with the PRP

TIME ____________

AIRCRAFT LATITUDE ______ LONGITUDE ______ ALTITUDE ______ HDG ______ A/S ______ G's ______

ECM SWITCH POSITION ______ CHAFF SWITCH POSITION ______

THREATS	NOM	POS L	POS L	POS EL	RELATIVE POSITION BEARING	RELATIVE POSITION RANGE	IN-RANGE TIME	DEFEAT TIME	RELOCK TIME	MISSILE* POSITION
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

*RANGE FROM AIRCRAFT
(*) MEANS KILL-TIME

FIGURE 10. PHANTOM RANGE DISPLAY INFORMATION

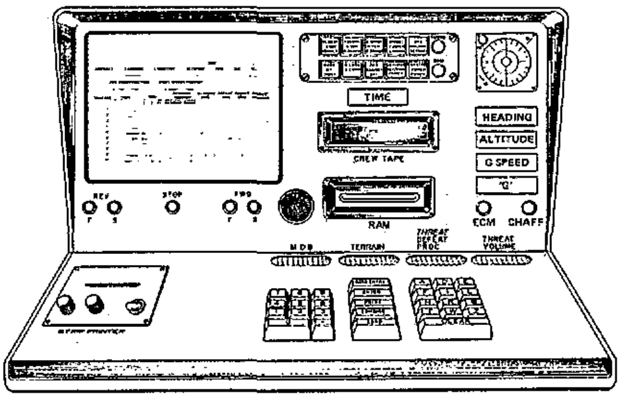

FIGURE 9. MISSION PLANNING DEBRIEFING STATION

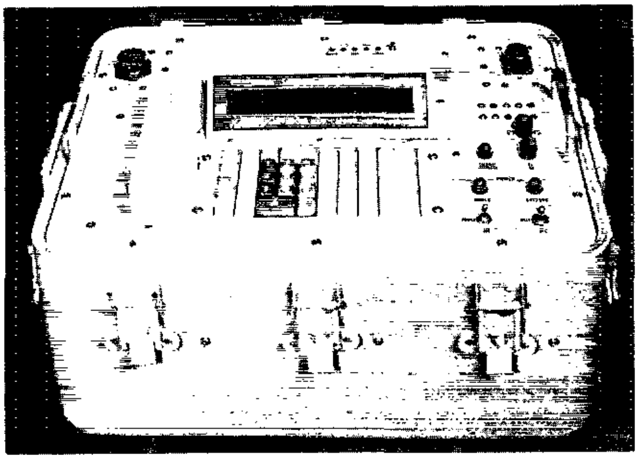

FIGURE 11. FLIGHTLINE SUPPORT UNIT

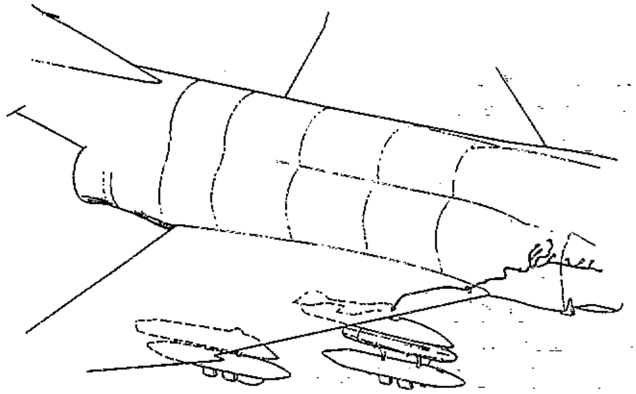

FIGURE 12. F-4E ECM CABLE HARNESS

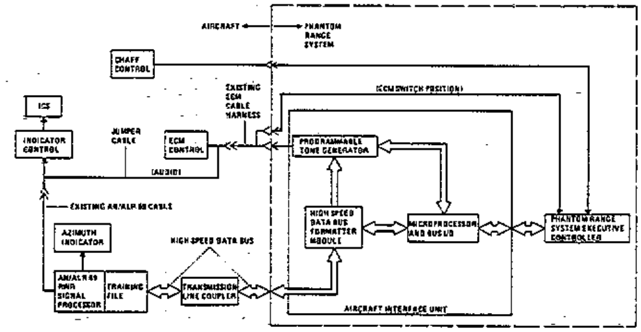

FIGURE 13. ACTUAL RWR EQUIPMENT DRIVEN BY THE PHANTOM RANGE EQUIPMENT

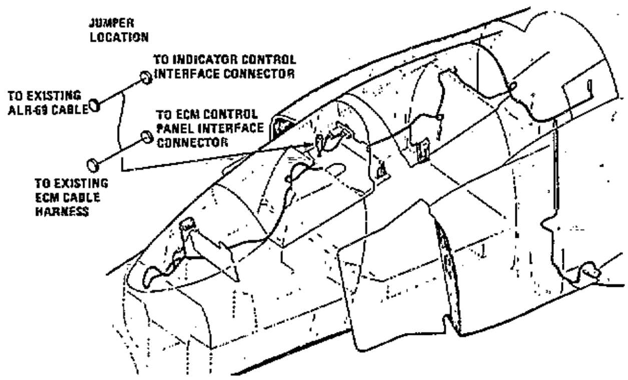

FIGURE 14. JUMPER CABLE PROVIDING AUDIO INTERFACE

operating any time power is available at the pylon. (A small rechargeable battery in the PRP maintains volatile memory when aircraft power is off or if there is a momentary interrupt.)

Commands for the video displays are sent through the radar warning system, which in turn generates the appropriate symbology and lights (Figure 13). Audio is generated synthetically since no actual PRF is available. The audio is then carried to the cockpit over existing wires and inserted into the intercom system (ICS) by means of a small jumper cable (Figure 14). The synthetic audio generator also creates noise representative of communications jamming and inserts this into the ICS in a similar manner.

By use of such an interface, the operational radar warning system can function normally, displaying real threats detected by the receiver simultaneously with Phantom Range threats. Thus the aircraft remains operationally ready at all times.

Finally, pilot action discrete signals, such as chaff deploy and jammer switch positions, are monitored at the pylon and introduced into the processor. These, together with aircraft maneuvers, provide the basis for determining whether the aircrew has performed the proper threat defeat procedures within an allowable time.

TRAINING UTILITY

The Phantom Range would be located at wing level with 10 to 12 PRPs, 2 MPDSs, and 2 FSUs per wing. Mission modules would be prepared locating threats along locally accessible, low-level routes used as ingress corridors to ordnance delivery ranges or for photo-reconnaissance missions. A number of such modules of varying complexity would be prepared ranging from one threat at a time and no communications jamming to a thicket of up to 10 threats displayed simultaneously and heavy communications jamming. As aircrews become more proficient, they would fly more and more complex scenarios until they are able to cope with each situation that would have been accurately prebriefed by intelligence and planned for by the mission leader.

At this point, threat locations could be altered such that the information received in the intelligence briefing would become more and more unreliable and threats would pop up where least expected. The ultimate condition would be for the aircrew to fly a mission in which all threats appear at locations other than those briefed or where no expected location information was provided prior to flight.

Aircrews would be forced to take hard evasive action, deviating from and reacquiring planned routes, while at the same time finding and turning switches on and off as appropriate. (Jammers would be turned off as soon as a lock was broken so as not to allow the simulated threat to reacquire through an implicit home-on-jam feature.)

Once aircrews had achieved and were able to maintain requisite proficiency, they would be prepared to engage in periodic Red Flag exercises where ground personnel operating realistic threat emulators would be able to interact with the aircraft, fire simulated smoke rockets, and provide the ultimate in realism.

CONCLUSIONS

The Phantom Range permits continuous training in all normal tactical air force flying areas, independent of ranges or ground emitters; it permits the aircraft to remain operationally ready at all times; it provides realistic, increasingly complex scenarios; it enables the aircrews to interact on a real-time basis in flight; and it furnishes the capability for reconstruction during debriefing.

By means of frequent local training using Phantom Range, aircrews can be exercised in all phases of mission planning, flight operations and tactics, and detailed debriefing so as to maintain the desired state of proficiency at all times. They can learn to react instinctively to near-real-world conditions of high stress loads and surprise. Should war occur, they would not have to endure the losses associated with on-the-job training during the first 10 combat missions, as experienced in Vietnam.

BIOGRAPHICAL SKETCH

Mr. Morton Eldridge, Director of Marketing, originator of Phantom Range, Teledyne Brown Engineering Company.

Served in USN and USAF, the latter as a fighter pilot. Eighteen years with McDonnell Douglas engineering and marketing, five years at Teledyne Brown Engineering. BSEE, BS Aero E, LLB (JD), University of Michigan; MBA, St. Louis University.