

Virtual Electronic Combat Training System (VECTS)

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ABSTRACT

The US Air Force specifies C-130 aircrew training events for electronic combat (EC) as optical guided threats, infrared (IR) guided threats, and radar warning receiver (RWR) events. Training for these events is defined as proper application of tactics, techniques, and procedures to recognize and defeat the threat. The training media can be the weapon system trainer (WST) or aircraft. The on-aircraft training can be on a range, but this approach is costly, and has problems associated with availability, scheduling, and short notice access requirements due to aircrew availability. To eliminate these issues, in many cases the on-aircraft EC training is accomplished using 'flash cards' or 'hand-signals' to indicate a threat event completely devoid of the on-aircraft defensive systems. Training for the RWR may include flying in airspace with known radio signals in order to show a symbol on the RWR threat display. Based on these indirect threat alerts, the aircrew must then respond with the correct tactic or technique to defeat the threat. This method of on-aircraft training does not provide a realistic EC training experience nor does it integrate training into the aircraft defensive system suite.

The Virtual Electronic Combat Training System (VECTS) provides low-cost, rangeless threat recognition training using the existing on-aircraft defensive system displays and audio; and supports tactics training with real-time feedback using the existing on-aircraft electronic countermeasures, in-flight maneuvers and terrain to defeat the threat. The VECTS training simulations are hosted on a laptop computer that also serves as a planning station for the training missions. Additionally, VECTS records the training mission events and provides a capability to review the training mission post-flight. This paper will review the VECTS training methodology and test results which demonstrated that this training approach provides a realistic training solution using the on-board defensive systems to inject pseudo threats.

ABOUT THE AUTHORS

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Bob Baggerman is a Senior Research Engineer with the Electronic Systems Laboratory at the Georgia Tech Research Institute. Bob has extensive flight test experience which includes co-development of the GTRI Firefly Data Recorder. He has supported numerous C-130 flight test activities and his expertise includes various defensive systems. Bob was the GTRI Virtual Electronic Combat Training System flight test engineer for both the C-130 and MH-53 platforms. He received a Bachelor's degree in Electrical Engineering from the Georgia Institute of Technology.

Jeff Krug is a Research Scientist with the Electronic Systems Laboratory at the Georgia Tech Research Institute. He is the lead software engineer for the Virtual Electronic Combat Training System for the C-130 aircraft. His work has included developing and interfacing to many electronic warfare systems. Jeff received a Master's and Bachelor's degree in Computer Science from the Georgia Institute of Technology; and he is an active member of the Association of Computing Machinery.

Jonathan Martin is a Computer Support Specialist with the Electronic Systems Laboratory at the Georgia Tech Research Institute. He is a software engineer for the embedded training algorithms of the Virtual Electronic Combat Training System and he is currently involved in integrating the VECTS embedded training algorithms into the F-16 aircraft. His work has included development and integration of electronic warfare systems. Jonathan is pursuing a Bachelor's degree in Computer Engineering from the Georgia Institute of Technology; and he is an active member of the Association of Computing Machinery and the Institute of Electrical and Electronics Engineers.

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INTRODUCTION

This Virtual Electronic Combat Training System (VECTS) C-130 Carry-On Trainer provides in-flight rangeless tactical training for aircrews. This paper will provide an overview of the VECTS training methodology and how it is implemented on the C-130 aircraft. The paper will review details on the VECTS C-130 trainer flight test and present a post-flight test analysis.

VECTS OVERVIEW

The VECTS is hosted on a laptop portable computer (PC) and is connected to the aircraft defensive systems using a cable adaptor kit. The trainer obtains aircraft position data through a connection to the C-130 hand-held Global Positioning System (GPS) unit. No other equipment is required to be installed or carried onto the aircraft.

During in-flight training, the VECTS laptop sends pseudo training threats to the on-aircraft defensive systems. For the C-130, this includes the radar warning receiver (RWR) and missile warning system (MWS). VECTS also monitors the countermeasures dispensing system (CMDS) for chaff or flare events. Injecting pseudo threats into the RWR and MWS and monitoring the CMDS events is a fundamental element of the VECTS methodology.

The self-contained VECTS PC also hosts mission planning and playback tools. The mission planning tools are used to define the training threat behavior and to create the training mission. The playback application is used to perform post-mission debriefing.

Mission Planning

As shown in Figure 1, the VECTS PC provides a Threat Database and EC Mission Planner application that are hosted with the government provided Portable Flight Planning Software (PFPS)/FalconView mission planning tools. Together these tools are used by a training instructor to create a unique training mission which can be customized with training for specific threat-types of varying complexity. The Threat Database is used to define the attributes of the training threats. Multiple training threat

templates can be defined for each specific threat type. The attributes of each threat template define the in-flight training threat behavior.

After the training threats have been defined, FalconView is used to define the training mission. A training mission is defined as a geographical training area and the threats located within that training area. The training area is specified by the latitude and longitude of the boundaries of a closed region on the earth's surface. Training threats are planned by simply dragging and dropping threat templates onto the FalconView map at appropriate locations. The Mission Planner is then used to write the training scenario to a file, creating a Training Mission Data File for use by the threat simulation.

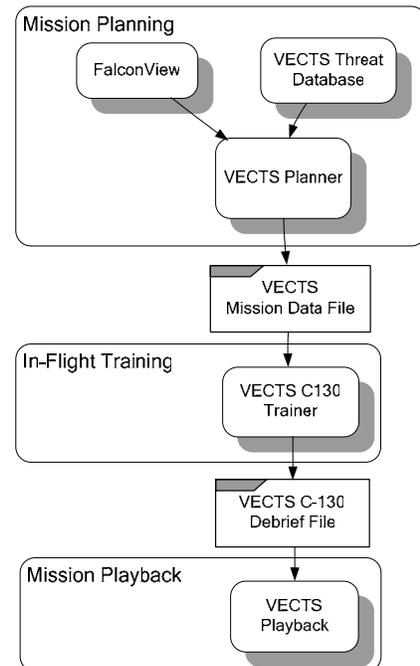


Figure 1: VECTS Functions

VECTS Threat Database

The VECTS Threat Database includes a set of radar and infrared (IR) training threat templates. Each template includes a set of parametric data and a specific behavioral threat model. The parametric data comes from military

intelligence and is not intended to be modified by the training instructor. A training instructor will customize the threat model data to simulate the tactical behavior of specific enemy threats or level of training complexity or both. Threat modes such as Search, Acquisition, Track, and Break-lock can be defined. For each threat mode, mode transitions are determined by defining the threat rules of engagement and planned countermeasures. For example, a SAM model can be defined with threat rules of engagement which specify that missile launches will only occur at a specific quadrant of the aircraft, or can be used to specify altitude and range constraints.

VECTS Planner

After customizing the threats for the mission, PFPS/FalconView is used to design the training mission. Using the same tool as is used for an operational mission, the planned aircraft training route is defined. Then using FalconView's native threat lay down tool, a threat overlay for the training mission is developed. Terrain masking may also be enabled within PFPS/FalconView to allow threat counter-tactics training with terrain. A training area boundary for the training mission is generated to demark the area within which training will occur. Outside this area, training threats will be disabled.

The final step of mission planning is simply to tie the work generated in the previous two steps together using the VECTS Planner. A simple application merges the data from the Threat Database and PFPS/FalconView to generate a VECTS training mission data file (TMDF). The TMDF will be used by the in-flight software to execute the planned training mission.

In-Flight Training

The in-flight training methodology is a key differentiator of VECTS. During in-flight training the VECTS on-board embedded training (OBET) algorithms execute the training mission. The VECTS PC continuously receives updated position information from the C-130 GPS unit and current expendable counts from the on-board CMDS. This information along with the VECTS TMDF (threat behavior models, terrain data, and training area) is used by OBET to update the state of all training threats being simulated.

GTRI has developed common OBET algorithms for three VECTS platforms: the C-130, the MH-53 helicopter, and F-16 fighter jets. The VECTS varying factors are host processor and source of aircraft position data. However, all use common threat models and algorithms. This is a key strength of the system.

OBET views the state of a threat as its current mode and position relative to the aircraft. Relative position is used to determine azimuth, range, power, and quadrant display

information. A threat mode transition may occur due to the predefined threat rules of engagement or in-flight countermeasures. The mode transitions can be either deterministic or probabilistic. With deterministic transitions a given event while in a particular mode is guaranteed to result in a transition to another specific mode. With probabilistic mode transitions an event can result in a mode change to any one of a number of modes or even no transition at all. The mode chosen depends on what probabilities are assigned for changing to a particular mode or staying in the current mode.

Deterministic mode transitions are useful for any training where clear feedback for correct performance is desired. Probabilistic mode transitions can be used to model more complex threat systems and to avoid over-confidence and potential negative training that can result from a sure result due to a given action.

Events that can trigger mode transitions include various rules of engagement related to the overall behavior of the threat system. Rules of engagement events can be due to passing a minimum or maximum range or altitude for a mode or staying in a mode past a maximum time. Chaff and flare events are defined as a certain number of bundles within a defined time window being expended as reported by the CMDS. These can be either real or simulated bundles depending on the fidelity desired.

Transitions can also occur due to the occlusion or masking of the threat by terrain. If pre-calculated terrain masking data has been included in the VECTS TMDF, this data along with the current aircraft position and altitude is used to determine line of sight visibility to a specific threat in real-time. An occluded threat is removed from the RWR display after an age-out period relative to the operation of the system, providing feedback for Nap-of-the Earth (NOE) threat avoidance training using real terrain. This is a key feature that allows training with real terrain without the burden of relocating or positioning real threat systems which can be costly and cumbersome.

An example of a complete state diagram of mode transitions for a single threat system is shown in Figure 2. Deterministic mode transitions have been used for simplicity. For every active threat mode different sets of associated parametric and sensor specific information are used to stimulate audio feedback and visual symbols on the RWR and MWS. This permits training against various threats with varying levels of complexity added to the training scenario.

The threat modes in the example state diagram are *Off*, *Acquisition*, *Track*, and *Missile Guidance*. Specific rules apply for the *Initial* mode. In transitioning from *Off* to the *Initial* mode, all rules must be satisfied. In this example the first transition to the *Initial* mode will occur when the

aircraft is within the maximum acquisition range and is not masked by terrain. Subsequent transitions from the *Off* mode to the *Initial* mode will first require that the threat remains off for a minimum time. This simulates the time that it would take the threat operator to reacquire the target after it was masked by terrain.

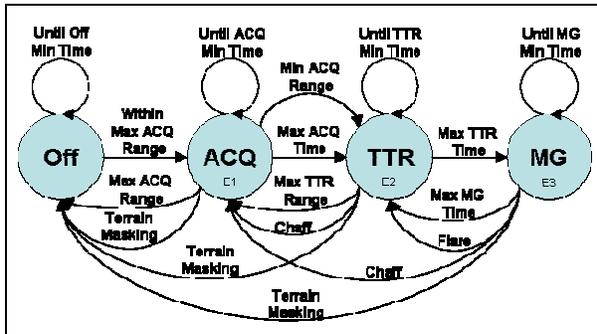


Figure 2: Example Threat Mode Transitions

After transition to the *Initial* mode, the rules which determine how the transitions will occur are based on the current mode of the threat. In this example a transition from *Acquisition* to *Track* will be attempted only after the minimum time in mode occurs. This simulates the time it may take for a threat operator to track a target.

Once in the *Track* mode, a transition back to *Acquisition* mode will occur if a specified quantity of chaff is dispensed within a time interval coincident with a maneuver. If this countermeasure technique does not occur before the maximum time, a transition to *Missile Guidance* will occur. Alternately, if the aircraft is masked by terrain, the threat will transition to *Off*.

In *Missile Guidance* mode the threat will transition back to *Track* if the maximum missile guidance time expires or if specified quantities of flares are dispensed within a specified amount of time after transitioning to the *Missile Guidance* mode. Alternately, if the aircraft is masked by terrain, the threat will transition to *Off*.

Mission Playback

During flight, the VECTS Console records the training data into a VECTS C-130 Debrief File. This data includes both real and training threat data and selected status information from the defensive systems. Post-mission, these files are loaded into VECTS Playback for analysis. VECTS Playback includes software versions of each of the on-aircraft defensive system displays as well as an Integrated Display which includes the primary data from each system's display. VECTS Playback is also fully integrated with PFPS/FalconView for monitoring the aircraft's location and navigation data throughout the training mission and during debriefing.

The VECTS Playback can be used to debrief the flight crews on specifics of the training mission, what techniques were performed correctly, and where improvement is needed. The tool provides the capability to move to a specific time segment of the flight which can be particularly useful for replaying long missions. The defensive system displays are modeled after the real displays and include simulated audio, allowing the debrief sessions to mirror the visual and aural stimulus of the real mission as closely as possible. These realistic system displays combined with the PFPS/FalconView moving map display allow for a realistic debrief of the training mission.

FLIGHT TEST

Flight Test Objectives

VECTS Operation Evaluation flights were conducted in December 2004 using a combined Air Force and GTRI test team. The test team members included instructors from the Advanced Airlift Tactics Training Center (AATTC) in St. Joseph, Missouri. Their current on-aircraft electronic combat training consists of using 'flash cards' or 'hand-signals' to indicate a threat event. This training is completely devoid of real use of the on-aircraft defensive systems. Training for real RWR usage may include flying in airspace with known radio signals in order to demonstrate a symbol on the threat display. Using these crude training tools, the trainees were expected to respond with the correct tactic or technique to defeat the threat. In view of the existing training methods, the main flight test objectives laid out by the test team were designed to evaluate VECTS tactics training effectiveness, and foremost to this metric was the ability to have the defensive systems maintain an 'operational-level' capability.

The flight test was planned to measure the VECTS' ability to effectively stimulate the embedded training interfaces of the on-board defensive systems to provide realistic threat representations. Key to stimulating the interface is real-time tracking of the aircraft position with respect to the training threat, assessing the countermeasures techniques applied against the threats, and applying the defined threat behavior. There was no doubt that these functions could be performed with software and they had been tested in the lab while connected to the defensive systems. But the goal was to test VECTS in the air and determine if it could perform such that an aircrew would react appropriately to the defensive system's threat cues. This was the opportunity to let the experts, the Tactics Training Instructors at AATTC, assess if VECTS was a viable in-flight tactics training tool.

VECTS On-Aircraft Configuration

The VECTS C-130 laptop is connected via MIL-STD-1553 cabling to the on-board defensive systems and obtains navigation data from the C-130 handheld GPS unit, as is depicted in Figure 3.

The complete set of VECTS on-aircraft hardware includes of a single notebook PC, a Personal Computer Memory Card International Association (PCMCIA) MIL-STD-1553 interface card, and a DC-DC power converter. The aircraft adapter cabling consisted of power, GPS, and EW system connections. On the C-130H2 used for the flight test, the connection to the defensive systems required a single MIL-STD-1553 cable from the laptop to the data port at the navigator's station, and a MIL-STD-1553 bus breakout cable to connect the MWS to the defensive system avionics rack. The MIL-STD-1553 cabling utilized an existing MIL-STD-1553 cable run from the flight deck to the defensive system avionics racks which connected both the CMDS and RWR to the data port at the navigator's station.

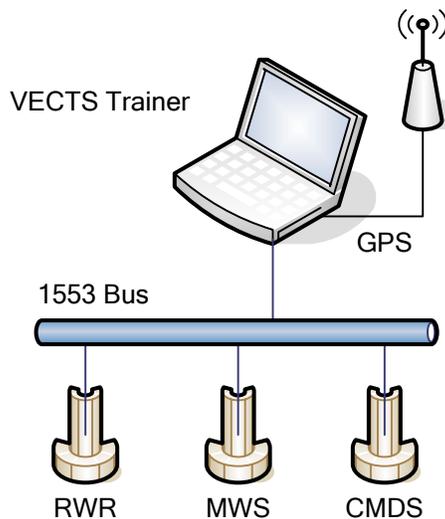


Figure 3: VECTS On-Aircraft Configuration

The interconnected MIL-STD-1553 cables are used to configure an electronic warfare (EW) Training Bus and the VECTS Console serves as the MIL-STD-1553 Bus Controller on this bus. This is a stand-alone bus, and is not connected to any other aircraft data buses. The aircraft wiring to the CMDS and RWR via the C-130 data port is used by maintenance personnel to load the subsystem operational flight programs and the breakout cable for the MWS is necessary for providing MIL-STD-1553 connection to this system. VECTS does not inject any signals into the existing aircraft wiring.

Flight Test Sorties

The flights were conducted in the St. Joseph Pony Low Altitude Tactical Navigation (LATN) area, and the in the Arkansas Hog Military Operations Area (MOA). The flight test threat scenarios were developed to first test the basic VECTS functionality and then to gradually increase the complexity of the threat engagements.

During the flight test, the VECTS laptop was installed, controlled and monitored by the test team's Tactics Instructor. The installation of the laptop including the aircraft adapter cabling and connections were completed by the instructor in less than 30 minutes. The installation time was a flight test metric which would be critical in determining the operational suitability of VECTS. Once in-flight, the VECTS laptop was used to inject new threats and threat updates into the RWR and MWS and to monitor the CMDS over the EW Training Bus. The VECTS Console application presented the Tactics Instructor with a view of the status of the defensive systems and of the GPS signal. Additionally, the PFPS/FalconView Map was used to track the position of the aircraft against the training threat scenario, and was used to perform dynamic insertion of threats during the mission.

St. Joseph Sorties

The first flights were in the St. Joseph Pony LATN area and included two sorties with separate TMDFs. The first sortie was designed to demonstrate radar and IR threat mode transitions based on range and altitude; no counter-tactics were employed. The second sortie added counter-tactics to the threat engagements. The planned training scenario for the first sortie is shown in Figure 4. A summary of selected threat engagements follows.

The first sortie started with a takeoff from St. Joseph and headed southeast to Turn Point 2 (TP2) where a training RF#2 had been placed (the threat model parameters are shown in Table 1). The aircraft immediately ascended to 3800' MSL to start the training mission. When the aircraft range-to-threat reached 20 nautical miles (NM), the RWR displayed an ambiguity by alternating between two threat symbols and then resolving to an RF#2. The aircraft continued at an altitude of 3800' MSL until it reached the range of the RF#2 track radar but was outside the altitude of the radar; the threat remained in Acquisition. The aircraft then flew over the threat and then descended below 3500' MSL; the threat entered the Track mode. The aircraft continued to descend below 3000' MSL and the threat was dropped by the RWR. This engagement demonstrated the basic capability of VECTS to execute threat mode transitions based on a combination of aircraft range-to-threat and threat altitude.

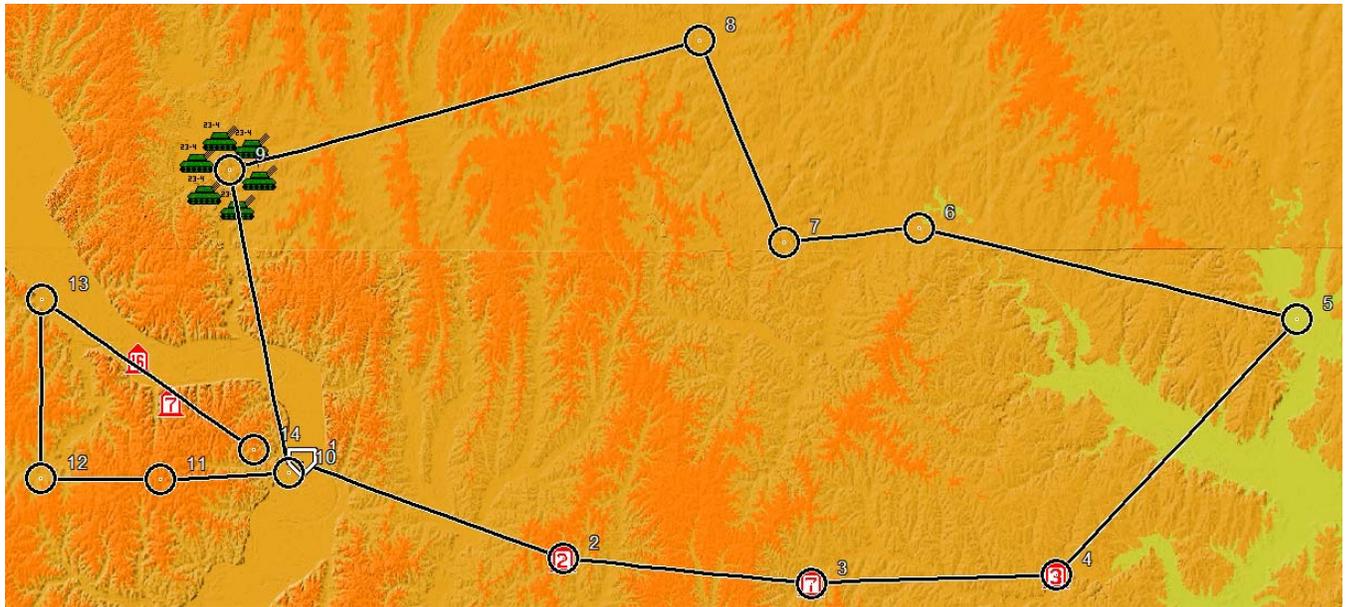


Figure 4: St. Joseph Sorties

RF#2 Mode	Acquisition	Track
Max Range	20 NM	15 NM
Min Range	15 NM	0 NM
Threat Altitude	> 3000'	> 3000' and < 3500'
RWR Threat Ambiguity setting		

Table 1: RF#2 with Range/Altitude Settings

After passing TP2, the aircraft descended and flew at 900' MSL. A training IR#7 was placed at TP3 to demonstrate basic VECTS IR missile warning operation with an engagement range of 3.2 NM and 360 degree missile launch aspect. As the aircraft flew into the threat's engagement range, the MWS detected the threat.

The flight path between TP5 to TP8 was designated to demonstrate VECTS dynamic threat insertion. During this portion of flight, the Tactics Instructor placed a training RF and a training IR threat along the flight path. This was facilitated using the FalconView Map to lay down the threats and transmit the threat data to the VECTS Console in real-time. The Console activated the threats using the preprogrammed threat model behavior in the same manner as the threats laid-down pre-mission. During subsequent flights, inserted threats were used to increase the level of training complexity.

The area around TP9 had six training Anti-Aircraft Artillery (AAA) sites arrayed in a circle. The AAA sites each had a radar range of 3 NM. The placement of these AAA sites was used to demonstrate VECTS simulation and

display of multiple threats simultaneously as determined by correct numbers and placement on the RWR display. As the aircraft moved through the turn, the RWR display accurately represented the movement of each threat symbol with respect to the aircraft position.

At the approach to St Joseph from the northwest, a training IR#7 was placed, configured with a rear launch aspect angle of 180 degrees (the threat model parameters are shown in Table 2). The threat behavior had been configured to transition to a breaklock if a flare dispense was detected within a 1 second interval immediately following the missile launch. On the approach the aircraft passed to the left of the threat location. At 1.6 NM an aft missile launch was detected by the MWS. In response to the launch, a flare dispense was initiated within one second of the launch and a breaklock occurred. At 2.3 NM the threat transitioned to off. The IR#7 engagement verified the ability of VECTS to monitor the CMDS for a dispense event, effect the mode of the threat, and provide immediate feedback to the aircrew.

IR#7	IR Missile	Breaklock
Max Range	3 NM	2.3 NM
Min Range	0 NM	0 NM
Min Time	0s	10s
Max Time	0s	10s
Flare/time	1/1 sec	NA

Table 2: Rear Launch IR#7

Hog MOA Sorties

The next set of sorties shown in Figure 6 was flown in the Arkansas Hog MOA. This area provided opportunity to demonstrate terrain masking and complex training scenarios. Two threat engagements which demonstrated terrain tactics and combined multiple threats are described below in detail including state diagrams of the programmed mode transitions.

RF#8 Engagement with Terrain

A training RF#8 was placed in the Hog MOA west of TP3 and TP4 on an elevated point as shown in Figure 6 (the threat model parameters are shown in Table 3 and threat model behavior in Figure 5). This placement offered an opportunity to aggressively demonstrate terrain masking. The green contour in Figure 6 shows the area of threat visibility at 832' MSL. The threat should become visible near TP3 and remain until just prior to reaching TP4. The flight altitude will start at 1400' MLS and will vary (drop) in order to evade the threat through the use of terrain. For reference, the blue contour shows the area of threat visibility at 560' MSL, and the cyan contour show threat visibility at 972' MSL.

At an aircraft altitude of 1364' MSL and 11.5 NM range-to-threat, the acquisition radar is detected by the RWR; ten seconds later at a range of 11.2 NM and altitude of 1636' MSL, the threat transitions to Track. At a range of 11.6 NM the aircraft altitude drops to 972' MLS, is terrain masked from the threats visibility, and the threat transitions to off. At 832' MSL the aircraft is reacquired by the acquisition radar, and 10 seconds later transitions a second time to the Track mode; the range-to-threat is 13.6 NM. As the aircraft approaches TP4, the altitude drops to 560' MLS, and the aircraft is terrain masked from the threats visibility; the threat transitions to off. At 580' MSL the threat is detected by the RWR in acquisition mode and transitions to track 10 seconds later. This demonstrates the ability to support tactics training in an area with varying terrain which allowed the pilot to fly below the radar.

RF#8	ACQ	Track	MG	Brklock
Max Range	30 NM	20 NM	10 NM	NA
Min Range	20 NM	10 NM	NA	NA
Min Time	10s	5s	5s	10s
Max Time	0s	0s	NA	10s
Chaff/Flare	NA	1/0	1/1	NA

Table 3: RF#8 with Terrain Masking

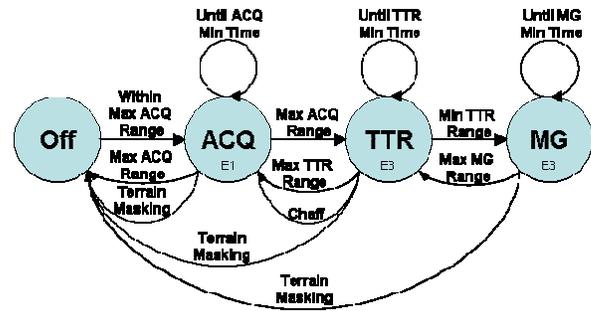


Figure 5: RF#8 with Terrain Masking

Multiple Threat Engagement with Terrain

As shown in Figure 6, an engagement was planned so that as the aircraft approached TP 7 it would encounter two AAA batteries protecting the Mena Municipal airport (M39) that were placed in open terrain where the aircraft would be vulnerable. A training IR#7 was placed adjacent to a set of training AAAs on the back side of a hill which was approximately 1000' in elevation. The AAAs would remain active while the aircraft decelerated to the Drop Zone at TP8. If the aircraft were to maneuver to the right of course to TP8 to avoid the AAAs, it would be visible to the IR#7 on the north side of the route in the valley. In any case, the IR#7 would engage the aircraft once it became visible near the drop zone. As the aircraft leaves the IR#7 launch zone, it is planned to proceed toward TP9 and cross a valley where a training RF#6 is waiting. If the aircraft can deviate to the right of course and race to the north side of the second ridge it may avoid a missile launch. Following is a summary of the actual threat engagement results. The AAA and IR#7 threat model parameters are shown in Table 4 and Table 5, and the threat model behavior are shown in Figure 7 and Figure 8.

When the aircraft's range to AAA #1 was 5 NM, the RWR presented the correct threat display and audio cue. As the aircraft maneuvered to the drop zone, the RWR detected AAA #2 and placed AAA #2 on the threat display in the correct position using the relative lethality of the two threats. The aircraft remained masked from the IR#7. As the range-to-threat closed on AAA #2, the RWR threat priority switched from AAA #1 to AAA #2. The aircrew did not dispense chaff during the AAA engagement and threat activity was based on range and time. At a range-to-threat of 5 NM both threats transitioned to off and were removed from the RWR display but not before the IR#7 on the backside of the hill acquired the aircraft.

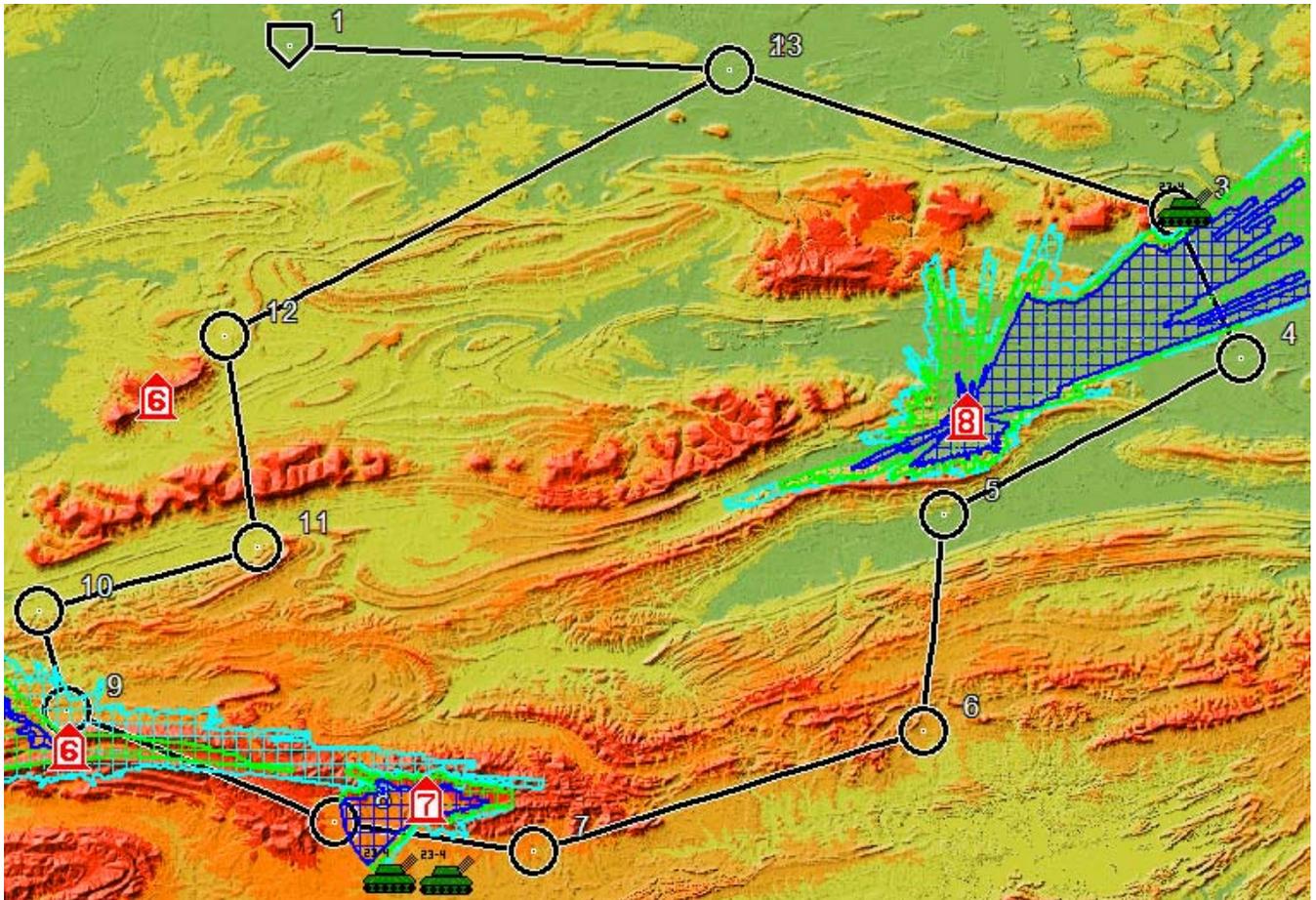


Figure 6: Hog MOA Sorties

AAA #1 & #2	Acquisition	Track	Breaklock
Max Range	5 NM	1 NM	NA
Min Range	1 NM	0 NM	NA
Min Time	10s	10s	5s
Max Time	10s	10s	5s
Chaff/Maneuver	NA	yes	NA
Terrain Mask Off			

Table 4: AAA Threat Model

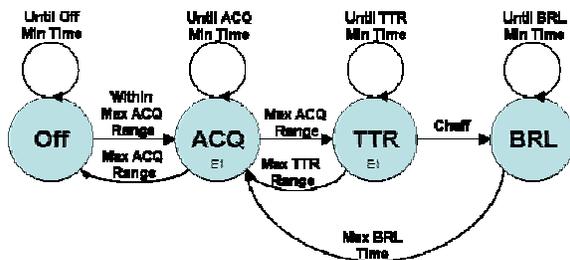


Figure 7: AAAs at Drop Zone

When the aircraft range-to-threat was 2.2 NM and 1300' MLS (IR#7 blue contour mask in Figure 7) the IR#7 immediately acquired the aircraft and a missile launch was detected by the MWS (the threat model parameters for the IR#7 are shown in Table 5 and the threat model behavior in Figure 8). The aircrew dispensed flares against the threat and a breaklock occurred. The aircraft left the line-of-sight of the IR#7 and proceeded toward TP9.

IR#7	IR Missile	Breaklock
Max Range	5 NM	2.3 NM
Min Range	0 NM	0 NM
Min Time	0s	10s
Max Time	0s	10s
Flare/Man	yes	NA
Terrain Mask On; 360 degree missile launch aspect angle		

Table 5: IR#7 Threat Model

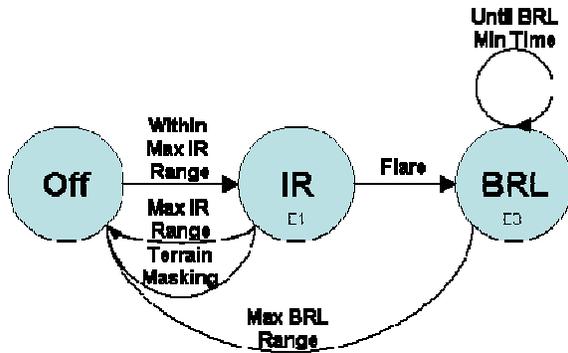


Figure 8: IR#7 on Northeast ridge of Drop Zone

As the aircraft crossed the ridge into the valley and approached TP9, it came into view of the RF#6 (the threat model parameters for the RF#6 are shown in Table 6 and the threat model behavior in Figure 9). At an altitude of 2944' MSL (RF#6 cyan contour mask in Figure 6) and range-to-threat of 4.7 NM, the RF#6 detected the aircraft. The RWR display indicated an RF#6 in acquisition mode; after 15 seconds at 4.5 NM, the RF#6 entered the track mode; and then 15 seconds later at 4.3 NM the RWR threat displays indicated the RF#6 had entered the missile guidance mode. The aircrew maneuvered to the north side of the second ridge and at 4.6 miles past the threat, the aircraft was no longer visible to the threat. The RWR display dropped the threat and no chaff was dispensed.

RF#6	Acquisition	Track	MG
Max Range	45NM	30NM	15NM
Min Range	30NM	15NM	0NM
Min Time	15s	15s	5s
Max Time	0s	0s	15s
Chaff/Man	NA	yes	yes
Terrain Mask On			

Table 6: RF#6 Threat Model

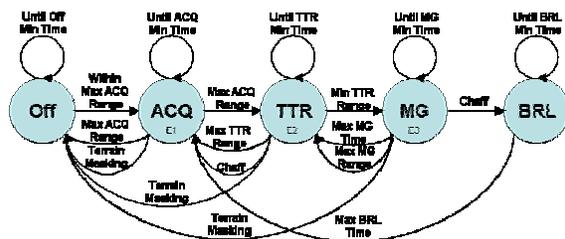


Figure 9: RF#6 in Valley

POST-FLIGHT TEST ANALYSIS

The Government flight test report is contained in the *Virtual Electronic Combat Training System (VECTS) Operational Assessment (OA) Final Report*. The specifics of this report will not be detailed in this paper, but general observations, feedback provided by the flight crew both during and post-mission, and the results of our own post-flight analysis will be discussed.

General Observations

During the flight test, GTRI VECTS team members were on-board the aircraft to assist for the first sortie and as observers for the remaining sorties. It was immediately apparent that VECTS was able to highlight aircrew deficiencies and was also able to correct them over the duration of the flight test. This was most likely due to limited experience with in-flight operation of the systems (having previously used flash cards almost exclusively).

Throughout the testing, the aircrew reacted to the training threats as if they were real even during low-altitude missions with no threat visible. The RWR and MWS audio alerted the co-pilot and navigator who made tactics calls to the pilot and flight engineer. The realism of the training was obvious.

On the last two sorties in the Pony LATN area, an AATTC Tactics Officer planned the threat scenarios and briefed the aircrew on the flight. On the second sortie he loaded a different training scenario than the one he briefed and surprised the flight crew with a different threat laydown. During this sortie, the crew reacted to the threats with maneuvers and countermeasures where necessary to counter the threat, reinforcing the realism of the VECTS training environment.

Flight Crew Feedback

Flight crew members were surveyed before and after the flight test with a series of questions that were designed to evaluate VECTS in-flight training potential for counter-tactics, threat identification, proficiency training on the on-aircraft electronic combat systems, effectiveness of the operator user interface, and operationally suitability. The independent assessment that GTRI received regarding the aircrew questions gave VECTS better than good rating. The high ratings centered on the VECTS ability to provide mission planning, in-flight training, and mission playback.

Use of Approved Government Hardware/Systems

Operators applauded the use of non-developmental, approved government hardware and software applications. The VECTS hardware was chosen to minimize operational impact. The laptop used is the Panasonic, CF-29, the same make and model as that currently used by the C-130

aircrew for other purposes. The use of PFPS/FalconView for Mission Planning and Mission Debrief significantly reduced the training that would be required with VECTS-unique new mission planning and debrief tools. The overall tool suite had an extremely low learning curve – AATTC instructors were planning and executing their own missions by the third day.

On-Aircraft GPS Issues

In order to obtain the aircraft position, latitude, longitude, and altitude during flight, VECTS used the on-aircraft GPS. Two alternative methods to obtain aircraft position were considered: 1) using a GPS feed and 2) monitoring the avionics bus. There was a concern that monitoring the avionics may be considered a risk and that it may be costly to prove that VECTS did not interfere with the existing aircraft capability when acting as a Monitor on this bus. Use of the on-aircraft GPS provided a minimum risk, low-cost alternative. Unfortunately for portions of the flight test, the GPS signal was intermittent. When GPS was lost, a negative altitude was processed and caused the threat to appear masked by terrain. When the GPS signal returned, VECTS would continue to process the threat as though it had been masked. To eliminate this issue, VECTS should be configured and certified to use the aircraft navigation bus as it becomes a production training tool.

CONCLUSION

The VECTS methodology represents a departure from previous on-aircraft threat simulation and training systems in that it focuses on realistic simulation of threats as displayed instead of as processed through the sensors. As a threat simulation, VECTS provides lower fidelity. However, the VECTS solution will have significantly lower cost for both system procurement and maintenance of threat models. Long-term, VECTS offers a seamless transition to training that is embedded in the aircraft mission computer.

The goal of the operational evaluation was to demonstrate realistic, rangeless training performance to the operator and evaluate performance of the models in real flight, both of which were accomplished. When AMC initiated the VECTS Operational Assessment it was to fill a training gap; to train aircrews on the use of their defensive systems before being placed in harms-way. For the C-130 aircrews, VECTS can provide an effective portable training system that can be used to train anywhere and anytime. Aircrew's preparedness will be greatly increased.

The proof that the VECTS is a realistic training system was validated by the AATTC as the flight crew. They are currently processing the approval necessary to put the VECTS on their C-130s to be used in their tactics training curriculum.

REFERENCES

Air Force Instruction 11-2C-130, Volume 1, dated 5 November 2004, Flying Operations, C-130 Aircrew Training

Virtual Electronic Combat Training System (VECTS) Operational Assessment (OA) Final Report, AMC Project 15-236-04

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