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for the Behavioral and Social Sciences

Research Report 2011

Enhancing Fire Control Decision-Making with the Patriot Cognitive Skills Trainer: Development and Validation

Thomas Rhett Graves
U.S. Army Research Institute

Paul N. Blankenbeckler
Gary M. Stallings
Northrop Grumman Corporation

November 2017

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14. ABSTRACT

This report presents research supporting the development and evaluation of the Patriot Cognitive Skills Trainer, a set of computer-based instructional modules designed to support Patriot crewmembers—specifically new Tactical Control Officers (TCO) and Tactical Control Assistants (TCA)—in developing an understanding of how Patriot subject matter experts address complex and ill-defined operational problems. The research was accomplished in three phases: (a) a needs analysis and training specification, (b) training development, and (c) training validation. Findings suggest that the Patriot Cognitive Skills Trainer would be an effective training tool to enhance new TCOs' and TCAs' decision-making and problem solving skills as a supplement to existing instruction. In addition, the methodology used to identify decision-triggers may be applied to other Army domains to develop instruction focused on cognitive skills. Finally, this research demonstrated that it is not necessary to simulate all aspects of classified systems in order to produce viable and engaging training to support the development of cognitive skills to be applied in utilization of those systems.

15. SUBJECT TERMS
Decision-Making, Patriot Missile Systems, Cognitive Skills, Training, Computer-Based Training

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Thomas Rhett Graves
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Paul N. Blankenbeckler
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ARI – Fort Benning Research Unit
Scott E. Graham, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
6000 6th Street, Bldg. 1464, Fort Belvoir, VA 22060

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ENHANCING FIRE CONTROL DECISION-MAKING WITH THE PATRIOT COGNITIVE SKILLS TRAINER: DEVELOPMENT AND VALIDATION

EXECUTIVE SUMMARY

Research Requirement:

In this research project, we developed and validated a desktop training module to enhance fire control decision-making and problem solving skills for the Phased-Array Tracking Radar to Intercept on Target (Patriot) surface-to-air missile system air defense launch control crewmembers. The intent was to provide training to familiarize less experienced air defenders with the types of complex problem solving and reasoning skills that expert air defenders bring to bear in making their engagement decisions.

Procedure:

The research was executed in three phases. In the first phase, we identified the training needs of Patriot air defense artillery (ADA) crewmembers specific to tasks relying on complex cognitive skills, i.e., decision-making and problem solving in the Patriot operational context. In the second phase, we developed training to address these identified needs. This was accomplished based on applying the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) training development process, with in-depth input from Patriot subject matter experts (SMEs). The final training design relied on identified decision-triggering events taking place within a hypothetical air defense mission. The materials developed were based on unclassified sources and focused on developing Patriot crewmembers fire control decision-making skills over training specific technical operations of the Patriot system. In the final phase of the research, the Patriot Cognitive Skills Trainer (PCST) was validated with Soldiers (Tactical Control Assistants (TCAs) and Warrant Officers) at the 108th ADA BDE at Fort Bragg, NC.

Findings:

When training with the PCST, Soldiers were engaged and found the training beneficial, although the training did not rely on simulating the sensitive capabilities and operations of the Patriot system. High fidelity simulation of classified systems may not be necessary to train the cognitive skills required in conducting operations with the systems. What is required is to provide scenarios that viably replicate the types of problems that would arise when those systems are put into operation. In this case, we developed Patriot mission scenarios and problem sets around a hypothetical air defense of friendly forces mission, using the geography of a location in the Southeastern United States. Enemy capabilities and threats were derived from open source materials and were intended to represent what air defenders could face in any number of real world situations. The PCST appeared to be effective in training Soldiers on decision-making and problem solving skills related to employment of the Patriot system in an air battle. Soldiers reported skill improvement in six out of 11 areas evaluated. The remaining five of 11 areas evaluated showed improvement, but were not statistically significant.

Utilization and Dissemination of Findings:

The results of the research were briefed to the U.S. Army Air Defense Artillery School leadership at Fort Sill, OK, in Oct 2016. Copies of the training product have been provided to Air Defense Artillery School (Fort Sill, OK), instructors at the ADA Warrant Officer Advanced Course (Fort Sill, OK), simulation operators with the Standardized Patriot Evaluation and Assessment Reporting (SPEAR) team (Fort Bliss, TX), the 32nd Army Air and Missile Defense Command (AAMDC; Fort Bliss, TX), and the 108th Air Defense Artillery Brigade (Fort Bragg, NC). This research and a training demo were presented at the Department of Defense Lab Day Conference at the Pentagon, Washington, DC, in May 2017.

ENHANCING FIRE CONTROL DECISION-MAKING WITH THE PATRIOT COGNITIVE SKILLS TRAINER: DEVELOPMENT AND VALIDATION

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Introduction

The Army Air Defense Artillery (ADA) leadership recognizes that new ADA Soldiers need to develop complex cognitive skills to execute air defense missions effectively.[1] Even so, most air defenders are trained in a way that emphasizes system-specific technical knowledge and skills over cognitive skills related to decision-making and problem solving (Stallings, Graves, & Blankenbeckler, in press). Often, expert air defenders have honed their decision-making and problem solving skills over the course of a career. The question that this research sought to answer, then, is how this learning process may be enhanced for ADA Soldiers who have not yet gained the experience of an expert. In this research project, we developed and validated a desktop training module to enhance fire control decision-making and problem solving skills for air defense launch control crewmembers on the Phased-Array Tracking Radar to Intercept on Target (Patriot) surface-to-air missile system. The intent was to provide training to familiarize less experienced Patriot air defenders with the types of complex problem solving and reasoning skills that expert Patriot air defenders bring to bear in making their engagement decisions.

The Context of the Research Problem

Patriot air defenders often face complex decision-making tasks under conditions of degraded and/or incomplete information. Moreover, various functions of the Patriot system can be automated, with the operator intervening only to break off an engagement. For more than a decade, researchers and air defense leaders have been raising concerns about the role, scope, and limitations of human operators within highly automated systems like Patriot (see Hawley, Mares, & Giammanco, 2006). Specific issues concern supervisory control, problem solving, and decision making when operating complex and lethal systems in ambiguous environments. Hawley and Mares (2007) pointed out that the evolution of Patriot crewmembers from traditional operators to supervisors of automated processes requires changes in system design, decision aids, training, and professional development.

Vigilance and situational awareness became critical issues in Patriot research following a fratricide incident that occurred during Operation Iraqi Freedom (OIF) I (Hawley, 2006; 2008; 2009). Out of the 11 engagements of the Patriot system during OIF I, nine (82%) were successful (Hawley, 2009). The two unsuccessful engagements ended in fratricides. One involved a U.S. Navy F/A-18 Hornet that was misclassified as an inbound missile. The other, a British Royal Air Force Tornado was misclassified as an inbound anti-radiation missile (ARM). Three air crewmembers were casualties in these engagements.

To reduce instances of fratricide, Hawley (2011) has emphasized that crews must have sufficient understanding of system operations and potential limitations of the data they are interpreting in order to decide effectively whether to launch a missile. Crews also require the expertise to understand the contextual meaning of the information they are interpreting to make a

[1] See Appendix A for a discussion of the contemporary ADA operational context.

fire decision. Hawley (2011) concluded that emphasizing reliance on automated technology over Soldier performance significantly contributed to the problems experienced during OIF. He further emphasized that current training practices and standards would not meet the challenge of developing expertise in technology-intensive systems. Fratricides are the most demonstrative and salient indicator of the training problem this research sought to address. This research was intended to begin to address these issues by focusing on developing and validating training to support enhanced situational awareness, information management, and decision making in complex air defense engagements.

The Design of the Research

The research project was executed in three phases. The end goal was to develop and validate a desktop training module to enhance fire control decision-making and problem solving skills in Patriot crewmembers. In the first phase, we sought to identify deficiencies in existing Patriot individual and crew training that may contribute to shortcomings in the development of complex decision-making and problem solving skills. In the second phase, we identified the skills that need to be trained and selected training techniques and methods to incorporate into a prototype training tool: the Patriot Cognitive Skills Trainer (PCST). Finally, we validated the PCST with ADA crewmembers.

To define deficiencies in existing Patriot training, we reviewed the research literature related to decision making and conducted interviews with ADA Patriot subject matter experts (SMEs). SMEs were accessed through the Air Defense School at Fort Sill, OK, and consisted of trainers, leaders, and training developers as well as Soldiers, leaders, and trainers in operational units. This phase of the research was focused on defining the problem and examining potential solutions. This included (a) identifying current institutional and unit training of Patriot engagement control station (ECS) crewmembers addressing cognitive skills development, and (b) documenting specific situations and examples of complex decision-making situations faced by Patriot ECS crewmembers. The ECS is the fire control unit for the Patriot system. It is usually manned by three Soldiers, including a Tactical Control Officer (TCO), a Tactical Control Assistant (TCA), and a Communications Operator. Fire control decisions typically are made by the TCO with support from the TCA and Communications Operator.

The research team examined various training designs and methods to specify the features of training that would provide the context and feedback essential to developing crewmembers' decision-making skills. The training scenarios were matched with instructional design concepts that applied principles of learning and the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model to create the PCST in an interactive multimedia instructional format (Morrison, Ross, Kemp, & Kalman, 2010).[2] Key to the design was an effective mechanism for providing feedback to the learner. Moreover, the training needed to be focused not on procedural solutions, but instead on solutions that engaged learners in information management, prioritization, interpretation, and reasoning. Finally, the prototype tool would need to provide trainers and learners with a clear path to developing progressively more complex decision-making skills.

[2] ADDIE is an instructional design framework used as a descriptive guideline for building effective training and performance support tools.

In the final phase of the research, the team validated the tool to provide recommendations for ongoing improvement of the product as well as ways to refine and sustain a training approach that would address perishable decision-making skills. The PCST was tested with air defenders at the 108th ADA Brigade and Fort Bragg, NC. Through the validation test, the participating Soldiers assisted us with a live environment assessment of the PCST and an examination of perceived skill improvements.

Phase I: Identifying Training Deficiencies

Literature Review

The research team conducted a two-pronged review to gain insight into the problems associated with Patriot fire control decision making. First was a review of the relevant scientific literature, including documents concerning Patriot and related air defense fire control decision making in combat and contingency operations. Significant background research was available due to the Patriot Vigilance Project (Hawley, 2009). Their efforts focused on crewmember vigilance and situational awareness in highly automated air defense battle command systems. The materials from the Patriot Vigilance Project addressed the fratricide incidents from OIF I that related to information and displays available to the crews and the crews' decision-making process.

Training Interviews and Observations

The second prong examined how Patriot ECS crewmembers are prepared and trained for the operational environment. This review included both institutional and in-unit training.

Air Defense School. The research team interviewed 25 trainers and leaders at the Air Defense School, Fires Center of Excellence, Fort Sill, OK, including:

- Senior warrant officer leaders at the ADA School.
- ADA School Course Managers and Course Developers.
- ADA School leaders and instructors representing:
  - Air Defense Artillery Basic Officer Leader Course – Branch (ADA BOLC-B)
  - Warrant Officer basic and advanced courses for 140E – Air and Missile Defense (AMD) Tactician/Technician
  - Noncommissioned Officer (NCO) leader and professional development courses – the Advanced Leaders Course and Senior Leaders Course for military occupational specialties (MOSs) 14E Patriot Fire Control Enhanced Operator/Maintainer and 14T Patriot Launching Station Enhanced Operator/Maintainer
  - Patriot Master Gunner Course[3]

[3] The Patriot Master Gunner Course is an intense 10-week course for 14T and 14E Staff Sergeants through Master Sergeants. It provides Patriot NCOs with the ability to develop, implement, and evaluate Patriot gunnery training strategies that will take units through Gunnery Tables I thru XII. They become experts on all aspects of the Patriot

- Patriot Top Gun Course[4]

Operational Units. Additionally, the research team interviewed 30 trainers and leaders from operational units, batteries, and battalions at two installations as well as their controlling and certifying headquarters. These groups included:

- Trainers assigned to a Patriot battalion who had recently returned from an operational deployment (representatives included the battalion Standardization NCO, and three battery trainers (one officer and two NCOs). Of note, all had experience from the previous deployment.
- The staff of the 32nd Army Air and Missile Defense Command (AAMDC) Standardized Patriot Evaluation and Assessment Reporting (SPEAR) Team.[5] This unique Team consisted of a core cadre from 32nd AAMDC, a group of highly skilled contractors (Wyle Laboratories, Inc.; all were retired Patriot senior warrant officers and NCOs) who operate the supporting simulation systems, and hand-picked Patriot SMEs (senior warrant officers and NCOs) drawn from the Patriot battalions of the 32nd AAMDC's ADA Brigades.
- Trainers and training staff assigned to an AMD Brigade with Patriot battalions preparing for two staggered overseas deployment missions. This group included:
  - The Standardization NCO from the brigade staff;
  - The Standardization Officer, fire direction officer in charge (OIC), and four battery trainers from one Patriot battalion; and
  - The Standardization NCO, fire direction OIC, and three battery trainers from the second Patriot battalion.

Finally, the research team also examined initial entry training and in-unit preparations and training.

Initial Entry Patriot Crewmember Training. Soldiers are first prepared for Patriot duties during initial entry training. The 14E (Patriot Fire Control Enhanced Operator/Maintainer) advanced individual training (AIT) is a 20 week course, introducing Soldiers to the Patriot system. The 14E AIT is focused on:

- Operating Patriot technology and missile systems,
- Placement and emplacement of the Patriot subsystems,
- Status reporting,
- Maintenance on coordinate, communications, and target-identification systems,

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weapons system technical and tactical employment capabilities and limitations, able to perform and analyze Air and Missile Defense Designs. The course has a 72% graduation rate and awards the additional skill identifier T4.

[4] The Patriot Top Gun Course is an intense 6-week open to selected promotable First Lieutenants, Chief Warrant Officers 2 (CW2s) and above, Captains, and some Majors. The Course trains the Patriot system as well as integrated missile and air defense systems and prepares the graduate to plan and design missile defenses and to advise commanders on all aspects of the weapon system, missile, radar, as well as threat system capabilities.

[5] The 32nd AAMDC SPEAR Team serves as a rigorous, third party mission certification element. They assure attainment of appropriate levels of task performance prior to the deployment of units to overseas peacetime contingencies and certifies units outside of these contingency rotation missions for their wartime missions.

- Evaluating intelligence and identifying targets,
- Establishing communications with tactical systems, and
- The basics of air defense tactics and battle strategy.

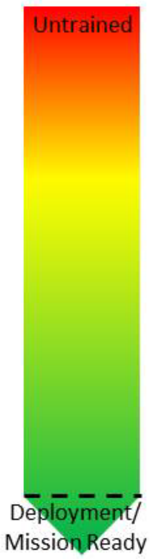
In later phases of AIT, Soldiers are introduced to the screens, control, and data in the ECS and Information Coordination Central (ICC). This introduction is with both actual hardware and simulations. On completing AIT, most 14E Soldiers are assigned to duties in a Patriot battery's fire control platoon, battery command post, or other units in a battalion. A smaller number are assigned to the ECS, ICC, or other battle management duties.

Warrant Officer Training. AMD Tactician and Technician Warrant Officers (140E) are vetted extensively prior to selection, meeting many rigorous prerequisites before they are appointed as WO1s. The 140E warrant officer candidates are selected from among mid-career NCOs (normally SSGs or higher) who have distinguished themselves with respect to their knowledge and skill with the Patriot system. A potential warrant officer also has at least two years leadership experience in a feeder MOS such as 14E, 14H, 14T, or 94S. Additional prerequisites include college credits in English and Mathematics. It is preferred that warrant officer appointees have completed the Patriot Master Gunner Course and have served at least two years as a TCA, Tactical Director Assistant (TDA), or System Maintenance NCOIC. Most applicants meet or exceed these prerequisites.

The Warrant Officer Basic Course consists of 35 weeks of classroom and practical training on tactics, maintenance, and logistics with the Patriot system and subsystems. The tactics phase of the course is six to seven weeks and centers on Patriot Gunnery Tables I-IV. The WO1s must score at least 80% on all exams, and achieve at least an 80% on the Reticle Aim Level (RAL) 5 practical exam to receive Patriot Basic Gunnery Certification before they graduate.

Figure 1 depicts mission readiness in relation to the Patriot Gunnery Table Certifications. The Reticle Aim Level (RAL) system is used to ensure that crewmembers master individual skills that support collective performance. This system of certifications keeps crewmembers from attempting procedures or air battle tasks that are beyond their skill level. Gunnery Tables guide training by providing checkpoints for required individual and crew skills. In certification drills, crews will often repeat specific drills until they have demonstrated proficiency. This approach tends to develop cognitive skills related to remembering, understanding, and applying information and procedures to complete successfully the gunnery/RAL task being assessed.

Patriot Gunnery Tables/ Reticle Aim Levels (RALs): Training Proficiency and Mission Readiness



Level	Table	Subject Matter	Corresponding RAL
Basic Gunnery Tables	I	Basic System Skills	
	II	Ready-for-Action Drills	
	III	Basic Air Battle Management	1, 2, 3, 4, 5
	IV	Basic Gunnery Certification	5 *
Intermediate Gunnery Tables	V	Air Battle Management/Missile Reload	6, 7, 8, 9
	VI	Daytime March Order and Emplacement	
	VII	Precertification Tables V and VI	1 through 10, 11
	VIII	Intermediate-Level Gunnery Certification	11
Advanced Gunnery Tables	IX	Advanced-Level Air Battle Management and Missile Reload	12, 13
	X	Nighttime MO&E Under Varying CBRN Conditions	
	XI	Precertification Tables IX and X	14, 16, 17
	XII	Advanced-Level Gunnery Certification	17

Table 2-1 from FM 3-01.86 Air Defense Artillery: Patriot Brigade Gunnery Program, dated 23 Dec 08 w/CH1.

*** RAL 5 Certification equates to a PATRIOT crew Learner's Permit.**

Figure 1. Mission Readiness in Relation to Patriot Gunnery Tables. Adapted from Patriot Gunnery Tables/Reticle Aim Levels (RALs): Training Proficiency and Mission Readiness.

Commissioned Officer Training. New Lieutenants come to ADA from various commissioning sources. These sources include the Reserve Officers Training Corps, the U.S. Military Academy, and Officers Candidate School. Commissioning requires that all have a bachelor's or higher degree. Few have AMD experience. The ADA Basic Officer Leader Course – Branch (BOLC-B) is two phased. Phase 1 (6 weeks and 3 days) focuses on common core program lessons, leadership and planning, and common warfighting skills. Phase 2 (12 weeks) provides branch and career management field technical content for warfighting skills and ADA, focusing on AMD weapon systems. This includes Short Range Air Defense Platoon Leader, Patriot Platoon Leader, Patriot TCO, and AMD Operational Exercises. The Patriot Platoon Leader module introduces new officers to the:

- Patriot gunnery program,
- Reconnaissance, selection, and occupation of position for the Patriot system, subsystems, and support elements,
- March order and emplacement for the Patriot system, subsystems, and support elements, and
- Responsibilities of the TCO.

The familiarization training for Patriot TCO includes:

- Identifying and defining the function of ECS switches, controls, indicators, and tabs,
- ECS initialization,
- Radar mapping,
- Patriot reports,
- Fix or fight fault assessments and maintenance,
- Ready for action drills,
- System reorientation, and
- Engagement decisions and weapon assignment processing.

BOLC-B Patriot training tends to be high level, since the majority of new Lieutenants (LTs) are assigned outside Patriot units. The training is intended to orient and familiarize LTs with Patriot associated duties. The officer's course is the shortest of the three basic courses, with only a fraction of training focused on Patriot.

In-Unit Patriot Crewmember Training. Duties at a Patriot unit of assignment vary. Duty assignments are based on unit needs and vacancies, command priorities, individual aptitude, career requirements, individual experience, and Soldiers' preferences. The structure and intensity of Patriot Fire Unit (FU) training goes beyond that of most Army units.[6] Training certifications are closely tied to evaluations of unit readiness. To maintain readiness, a Patriot FU must have at least two certified ECS crews. Both the primary and secondary crews should be collectively certified for Gunnery Table VIII (the gate for intermediate gunnery) and Table XII. Sustained operations, with 8-hour shifts, could require three crews. For peacetime operations, the third crew is considered a sustainment crew, which would also meet the minimum certification requirements.

Each ECS crew is made up of three personnel. The TCO is typically a Lieutenant or Warrant Officer. Several warrant officers we interviewed indicated that they had served as a TCO. In our observations, however, only Lieutenants were in the TCO position. Interviews also indicated that senior NCOs sometimes serve as TCOs. NCOs, Sergeants (E-5s) or Staff Sergeants (E-6s), are normally in TCA positions. During our observations, Specialists (E-4s) were serving as TCAs. In one situation, a Private (E-2) routinely manned a TCA position. We observed Specialists (E-4s) and Privates First Class (E-3s) in the Communications Operator position; no NCOs were observed in this position. Table 1 describes this typical crew composition.

[6] Army Field Manual 3-01.86, Air Defense Artillery: Patriot Brigade Gunnery Program is the guide of training standards and requirements for Patriot units at all echelons (Department of the Army, 2008b).

Table 1
Patriot Engagement Control Station (ECS) Crew Composition

Duty Position	**Crewmember**
Tactical Control Officer (TCO)	ADA Lieutenant (14A) **or** AMD Patriot Systems Technician, Warrant Officer (140E)
Tactical Control Assistant (TCA)	Patriot Fire Control Enhanced Operator NCO (14E20 - 14E30)
Communications Operator	Multichannel Transmission System Operator (25Q10 -25Q20) **or** Network Switching System Operator (25F10 – 25F20)

Note: Units develop and maintain three crews to assure effective 24-hour operations.

The TCO is responsible for crew and ECS operations. The TCO's duties are to protect friendly aircraft in their sector, monitor the network, maintain voice communication with ICC and other batteries, as well as with higher echelon networks. The TCO updates the system, assuring accurate input, activation, and deactivation of AMD messages, orders, and plans. These include:

- Area air defense plans and changes,
- Special instructions for theater specific air defense operations,
- Air tasking orders as specified within the air defense plan,
- Airspace control orders coordinated by higher headquarters, and
- Tactical operations data.

The TCA assists the TCO by assuming, as needed, TCO duties. We observed TCAs engage tracks as instructed or, after confirming tracks as hostile, handing them off to the TCO. The TCA brings the launchers from "standby" to "operate" and presses the "engage" switch to initiate a missile launch. The TCA also monitors launcher and missile status, and missile expenditures and impacts.

The third member of the crew, the Communications Operator, is technically not an air defender. The Communications Operator is responsible for receiving, processing, and submitting reports, and maintaining a log of critical actions. The TCO, TCA, and Communications Operator train to function as team. In proficient crews, the TCO and TCA are cross-trained on each other's duties. The research team frequently observed TCOs and TCAs working over each other's shoulders when required. Communications Operators were observed to assist in the synergy between TCO and TCA. On occasion, the Communications Operator relieved some workload from TCO or TCA, assisting with or assuming, a lower priority task. These tasks included alerting the crew to status changes, critical situations, or reminding them of required actions.

The Patriot unit is primarily responsible for training Basic Gunnery and RAL 1 through 4 (refer to Figure 1), although there is no official duty position for Battery Trainers. Our interviews indicated that all batteries had appointed battery trainers, who served in this position as an additional duty. Battery trainers would manage, coordinate, administer, and conduct training for new arrivals and crewmembers requiring certification. We observed that the appointment of a battery trainer was based on the needs of and vacancies within the battery, demonstrated aptitude of the appointee, command priorities, individual experience, and sometimes the preferences of the appointee. In some cases, commanders had taken particular care to ensure a high quality, very knowledgeable lieutenant or NCO assumed this additional duty. We did not observe any warrant officers in these positions. Most often, battery trainers were senior First Lieutenants or NCOs, who were Sergeants (E-5) through Sergeants First Class (E-7). In one case, our research uncovered a Specialist (E-4) who had been appointed a battery trainer due to unit turbulence and his "knack for teaching."[7] Many battery trainers received little if any additional training to prepare for the position. However, we did interview some NCOs serving as battery trainers who were graduates of the Patriot Master Gunner course. If they received additional training, a battalion Standardization Officer or NCO often provided it. To conduct training, battery trainers often relied on their own experiences, materials existing in the battery or battalion, or materials they developed on their own.

SPEAR Certification Training. The research team observed two SPEAR training and certification events for Patriot battalions preparing for overseas missions. The two missions varied in areas of operation, geography and air space, potential threat, and controlling integrated air and missile defense (IAMD) command structures and procedures. As a result, each unit observed had divergent rules of engagement (ROE) and tactics, techniques, and procedures (TTP), adjustments to existing tactical standard operating procedures, and routine operations procedure. The unique characteristics of each unit's mission were incorporated into the framework and standards of the SPEAR assessment and training.

Each SPEAR event included three to four time-collapsed simulated air battles per day, with each battle lasting between 20 and 45 minutes. Air battles were followed by an after-action review (AAR). Communications links were realistically simulated, involving role players acting as higher headquarters and IAMD controlling agencies. Impartial observers tracked and assessed how each crew performed. Performance observations were made in the ECS and ICC vans as well as on simulation terminals, listening to radio communications, and reviewing recorded communications in text and on voice circuits. AARs were conducted both on-site, sometimes with an observer facilitating the crew discussions, and as a group, with all training participants attending. The AARs covered performance standards, challenges, areas for improvement as well as individual and crew strengths. Identified challenges were addressed in subsequent air battles. Scenarios were modified to provide remediation, practice, and reinforcement. SPEAR certification events may last up to two weeks and include multiple visits. For example, some certifications begin with an intense training session, followed by a break for in-unit training, remediation, and practice, and then are concluded with the SPEAR certification session.

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[7] The "Specialist's knowledge sought as battery trainer" article (2013) describes a Specialist (E-4) with the 10th AAMDC serving as a battery trainer, who had been handpicked for the position because of his highly developed Patriot knowledge and skills. Accessed: https://www.dvidshub.net/news/printable/113278

SPEAR air battle scenarios were based on the Patriot Gunnery Tables. However, SME evaluators and simulation operators incorporated novel but plausible situations into the simulated air battles. The intent was to challenge the crews. The simulation operators were very adept in orchestrating the novel scenario details. They were able to introduce on short notice novel situations as teaching points when requested to by on-site observers/evaluators. Simulation operators also introduced variations to scenarios on the fly, responding to comments made by participants over voice communications nets.

The SPEAR training we observed consisted of battalion ICC, the ECS crews of three or more FUs (depending on crews to train), and in one case a battery command post. Air battle scenarios included:

- Real world (potential) enemy and coalition/friendly air and missile order of battle,
- Mission area of operations (both terrain and airspace),
- Mission area unique ROE, restrictions, and limitations,
- TTP modified for the mission area, and
- Operations under the unique IAMD command and control (Joint or Combined) procedures for the mission area.

Many variations were introduced into the simulations, specific to the units' upcoming mission areas. These included theater ballistic missiles (TBMs) and Air Breathing Threats (ABTs) portraying probable threat platforms, and tactics and techniques that the enemy could be expected to employ. Some scenarios incorporated degraded system capabilities and communications. Other scenarios were conducted under chemical, biological, radiological, nuclear, and explosives (CBRNE) conditions while wearing protective ensembles. SPEAR trains for a worst-case eventuality; should adversaries initiate hostilities, the units trained in SPEAR are prepared. The air battles we observed allowed crews to practice high-intensity AMD operations, preparing them to handle enemy threats while deployed.

Developing an Unclassified Set of Training Scenarios

The research team considered existing training scenarios to help us plan how we would develop the PCST to elicit and develop decision-making skills. We examined scenarios used in SPEAR events and on the Patriot Reconfigurable Table Top Trainer (RT3), a computer-based air battle simulator. Due to classification restrictions, the existing training scenarios were used only as a model. We intended the PCST to be unclassified. Therefore, real world missions and locations as well as actual air and missile order of battle and system capability information could not be included in the product we were planning to develop. Yet, the training product still needed to be realistic and engaging for our intended audience. To assist in our effort, the SPEAR Team staff provided copies of two archived unclassified sources:

- An unclassified exercise model used in previous joint and combined training, and
- A status monitor handbook developed by 32nd AAMDC for the Patriot software build, Post-Deployment Build–7, providing information on fix or fight system maintenance displays and faults.

The SPEAR Team also provided recommendations and guidance in developing realistic training scenarios while avoiding classification issues and information restrictions. These included:

- Develop a general situation with fictitious combatants, one being supported by the contingency deployment of a United States mythical Joint Task Force.
- Frame the general situation in a developing theater with limited resources and tailored constraints. Patriot should be the primary missile and high altitude antiaircraft protection for U.S. forces as well as the host nation and cooperating coalition forces.
- Select a location and area of operations within the continental United States away from external borders. The situation should have no implications of or connections to a real world contingency or possible homeland defense mission. The Washington, D.C. area for example should be avoided. Keep the air battle over land.
- Design a plausible and moderately capable enemy air and missile threat. Build a simple threat order of battle composed of Cold War era systems and weapons that have seen a wide proliferation through foreign military sales. This order of battle should include aircraft, TBMs, cruise missiles, and unmanned aerial vehicles.
- Draw threat system capabilities from open source, unclassified websites and technical sources that are credible.
- Avoid restrictive ROE; keep the air battle and the AMD operations of the force in a doctrinal context.

Results of the Phase I Analysis of Training

In Phase I of this research, the research team analyzed Patriot ECS crewmember training in the context of scientific literature concerning decision-making and critical thinking skills development. This process was intended to identify shortcomings in current training for developing complex cognitive skills. We sought to specify what scientific findings and concepts held promise for a training solution based on the current training and working environment.

Identifying Thinking Skills Required for Decision-Making in Patriot Crews

A well-known approach to classifying cognitive skills is Bloom's taxonomy (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). Bloom's taxonomy differentiates and hierarchically arranges thinking skills in terms of higher-order and lower-order skills. Lower-order thinking skills relate to knowing, comprehending, and applying information; higher-order thinking skills relate to analyzing, synthesizing, and evaluating information. Each higher-order skill incorporates those of a lower-order. For example, one cannot apply knowledge without first knowing it and comprehending it.

This taxonomy has continued to develop in contemporary psychological research (Anderson & Krathwohl, 2001). This contemporary take on Bloom's taxonomy retains the lower-order to higher-order hierarchy of cognitive skills, but transforms Bloom's static nouns into verbs. It also puts 'creating' at the top of the hierarchy, rather than 'evaluation.' Figure 2 illustrates some of the distinctions between the early and contemporary theories.

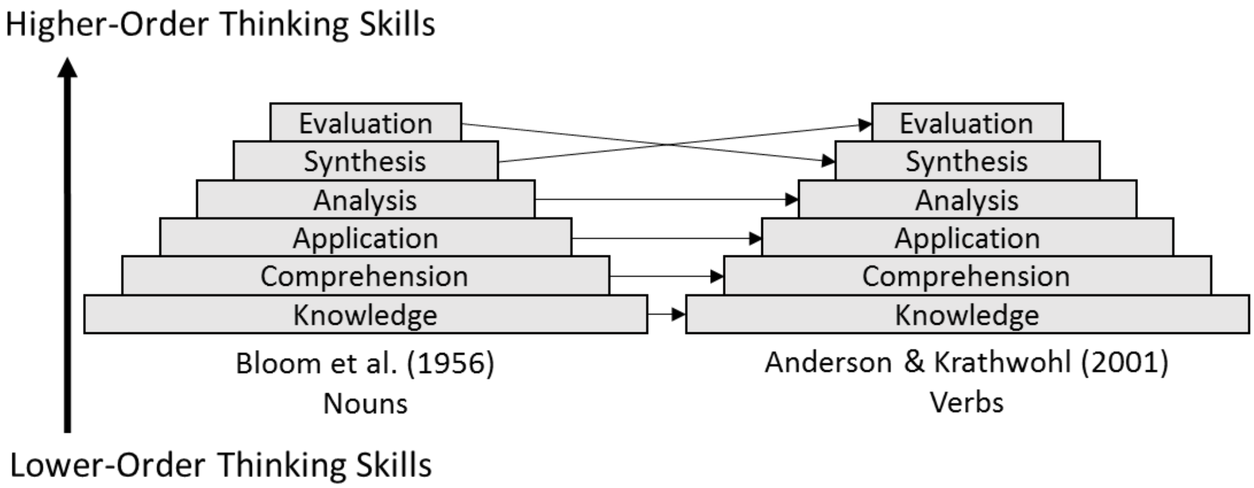

Figure 2. Thinking skills hierarchy. Adapted from Stallings, Graves, & Blankenbeckler (in press).

Anderson and Krathwohl (2001) have further specified cognitive processes into six levels and 19 categories. Table 2 provides a synopsis of their terminology. The updated terminology can be more easily related to processes in military operations, including those related to crew operations in the ECS and AMD actions and engagements.

Table 2
Contemporary Terminology Describing Thinking Skills

Level	**Descriptive Terms**	**Additional Examples**
Create	**Generating –** hypothesizing **Planning** – designing **Producing** – constructing	create, invent, compose, predict, plan, imagine, propose, devise, formulate, combine, originate, forecast, invent, produce, assemble
Evaluate	**Checking** – coordinating, detecting, testing **Critiquing** – judging	select, choose, decide, justify, debate, verify, argue, recommend, assess, discuss, rate, prioritize, determine, critique, criticize, weigh, value, estimate, defend, convince, support, score
Analyze	**Differentiating –** discriminating, distinguishing, focusing, selecting **Organizing** – finding coherence, integrating, outlining, parsing, structuring **Attributing** – deconstructing	examine, investigate, separate, take apart, differentiate, subdivide, deduce, compare, contrast, infer, calculate, monitor
Apply	**Executing** – carrying out **Implementing** – using	solve, construct, compute, complete, make, put together, change, produce, calculate, manipulate, modify, demonstrate
Understand	**Interpreting** – clarifying, paraphrasing, representing, translating **Exemplifying** – illustrating, instantiating **Classifying –** categorizing, subsuming **Summarizing** – abstracting, generalizing **Inferring –** concluding, extrapolating, interpolating, predicting **Comparing** – contrasting, mapping, matching **Explaining –** constructing models	outline, discuss, distinguish, predict, restate, describe, relate, summarize, convert, visualize, describe, sketch
Remember	**Recognizing** – identifying **Recalling** – retrieving	tell, list, locate, write, find, state, name, identify, label, define, reproduce, memorize, select, recite

SME comments indicated that they believed new ECS crews' decision-making skills improve with time and experience. Likely due to the complexity of the Patriot system, most training targets improved procedural techniques rather than decision-making skills. Procedures rely on lower-order thinking skills: remembering, understanding, and applying. True decisions—requiring crews to analyze and evaluate information, and create a solution—were infrequent. Our research team observed that situations requiring decisions, other than prioritizing and reprioritizing actions, occurred once or twice a day. That is, at a rate of approximately every other air battle scenario. On this basis, we determined that a training solution that compressed time and provided multiple decision points could provide increased decision-making opportunities and practice of higher-order cognitive skills. This compressed period could build decision-making experience, if combined with feedback and a means of showing and tracking skill improvement.

A long-standing question in training research is how to develop learners' conceptual frameworks to enable them to use what they have learned in contexts that differ from training (Blume, Ford, Baldwin, & Huang, 2009). When learners are able to develop a more abstract representation of knowledge, they are more likely to be able to apply it in real world contexts beyond the training environment (Bransford & Schwartz, 2001). Mental models research concerns both how an individual comes to represent information internally as well as how a group comes to share an understanding. Research on teams has shown that when they share a conceptual framework, they tend to be more effective as they are more able to anticipate each other's needs (Van den Bossche, Gijselaers, & Segers, 2011). Our observations indicated that the more effective ECS crews could anticipate each other's actions and emerging information needs during the simulated air battles, responding to the present context of the air battle.

A number of techniques have been developed to enable individuals and teams to represent and communicate about their conceptual understandings (e.g., mental models). Individuals and teams can use these techniques to reflect more ably on their own and their team members' thinking processes. These techniques include (de Bono, 1985; Teach for America, 2011):

- Visualizing a problem by diagramming it,
- Separating relevant from irrelevant information,
- Seeking reasons and causes,
- Justifying solutions to problems,
- Seeing more than one side of a problem,
- Weighing sources of information based on their credibility,
- Revealing assumptions in reasoning, and
- Identifying bias or logical inconsistencies.

During our observations of training, we noted that many times, crewmembers would externalize mental processes by drawing diagrams, making notes, etc., using a wax pencil on the scope. A problem arises because crew stations in the ECS van have little extra space (see Figure 3). These externalization techniques were based on individual preference and were not standard. The workstation design afford little room for supplemental checklists or information displays. Visualization of the problem, diagraming of information, or comparing information would ultimately need to rely on a conceptual framework. In the design of our decision-making skills training, we determined that we would need to use a design that permitted learners to compare information and to determine whether pertinent data was present for their decision-making process. In this way, we would be able to sequence training to provide scaffolding for mental processes early in the training, then shift users toward greater reliance on their conceptual frameworks later in the training, as they advanced.

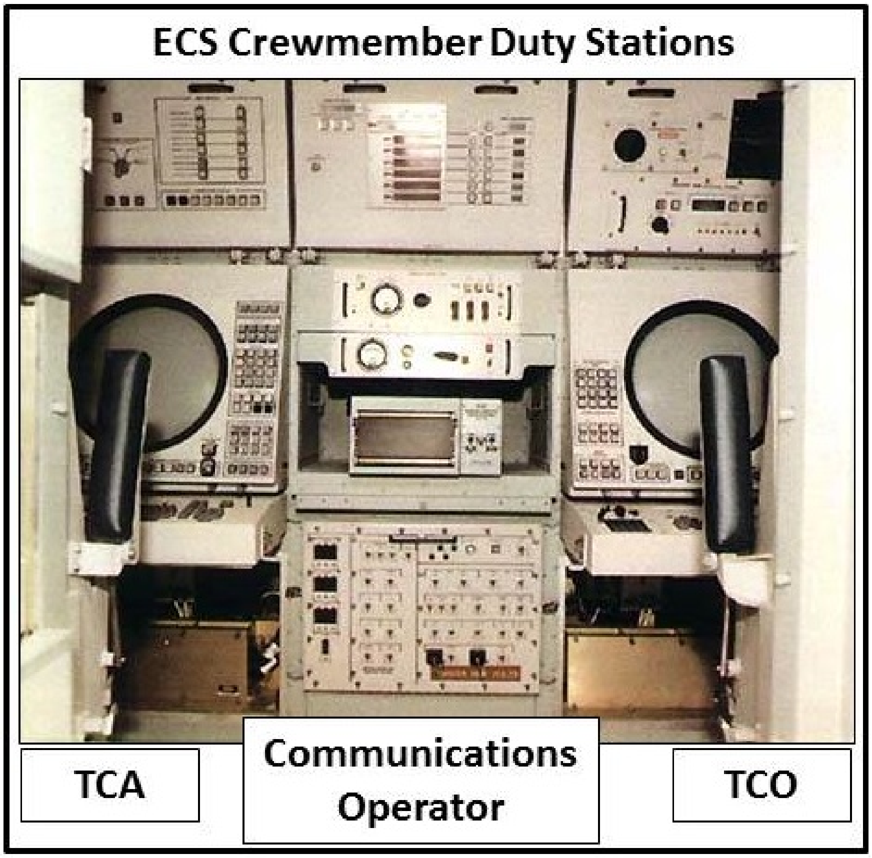

Figure 3. ECS Crewmember Duty Stations (adapted from Balmefrezol, 2009)

Types of Decision-Making for Patriot Crews

In a Patriot context, decisions often are tied to actions, such as engagement, attack, resupply, or fault identification and repair. The action in question may require immediate execution, or it may address an anticipated need to be incorporated into a plan for future action. In the research literature, decision-making is often described from two perspectives: normative and descriptive. Normative decision-making concerns how people ought to make decisions. It assumes that our decision-making process is optimally rational and mathematical, but that various psychological mistakes bias the process. The idea is to figure out the mistakes and inoculate decision-makers against them. Descriptive decision-making concerns how people actually make decisions in the real world. It seeks to document the decision-making process from an ecological perspective—how do people actually decide in normal, everyday settings. Here, we sought a middle-ground approach to understand how decision-makers in the ECS van actually make decisions as well as how their process could potentially be improved.

Under ideal circumstances, TCOs and TCAs will develop skills with both intuitive, everyday decision-making and more systematic, rational approaches. Different situations call for different types of decision-making processes. For many engagement decisions, the speed at which an aircraft or missile is approaching calls for a rapid decision-making process. Only so much information can be gathered and weighed before a decision must be made. There is frequently an element of uncertainty to an engagement decision; accuracy and completeness cannot be sacrificed without also incurring risk. Failing to consider all the available pertinent factors can result in a flawed decision. The dichotomy between taking the time to be methodical and risking protected assets, or making a hasty decision and risking friendly causalities, fratricide, or mission failures highlights the need for some structure in all ECS decisions. In developing the PCST, we sought to design around a process that allowed for identification of essential information to mitigate the risk of overlooked, ignored, or omitted information so that the result of one decision does not adversely affect the conditions or outcome of another.

Fratricide is a frequently cited example of the result of a poor engagement decision. Losing a friendly aircrew is a terrible tragedy. A fratricide, however, pales in comparison the impact a hostile TBM, aircraft bomb, or cruise missile delivering a weapon of mass destruction can have on a friendly unit, troop concentration, or urban complex. Recent U.S. combat experience holds no example of this type of decision; one that let a hostile system get through.

Conclusions from the Phase I Analysis

Current Patriot training, while often intense, is focused on procedural skills. It exercises cognitive skills related to remembering, understanding, and applying information. In the cognitive skills hierarchy, these tend to be lower-order thinking skills. While these skills support decision-making, they are still removed from what ECS crews need to learn in order to be most effective at the decision-making process.

It is important that junior enlisted Soldiers, new warrant officers, and newly commissioned officers establish a baseline of knowledge and familiarity with the Patriot system and mission. In courses such as AIT or BOLC-B, only the most basic Patriot procedures and skills are introduced. While talent and achievement are recognized and encouraged in all training programs, mastery of the Patriot system is not a training goal. This early-career training assures that course graduates attain the minimum standard required to begin more intensive training and performance in a Patriot unit.

The institutional training for officers, warrant officers, or enlisted Soldiers appears not to focus specifically on broadening critical thinking and decision-making skills or to refine their skills as trainers. Generally, these Soldiers and junior officers are trained to execute procedures. While lieutenants receive some training in troop leading procedures (TLP), mission analysis, and developing an operations order, this training focuses on identifying mission tasks, planning to execute them, then executing them in the context of a specific mission and the stated commander’s intent. Seldom do missions require extensive analysis. Innovation is often discouraged in mission accomplishment as “innovation” by an inexperienced junior officer can precipitate disaster. NCOs train Soldiers, uphold standards, and carry out or execute orders. Their duties seldom require more than basic comparative analysis or planning.

Critical thinking was only occasionally observed in SPEAR, gunnery certification training, and in-unit training. Most training we observed was procedural. In training, crewmembers' actions tended to focus on:

- Proper preparation of and initialization of the Patriot system,
- Operation of the Patriot system,
- Use and proper interpretation of switches, controls, indicators, settings, and tabs of the ECS,
- Updating the file holdings and databases as new orders and special instructions changed the air battle details and geometry, and
- The execution standard (or mission modified) TTP.

Some missions and deployments introduced additional ROE. These restrictive rules frequently required modifications of existing standing operating procedures (SOPs) and TTP, dictating very exacting permissions and procedures for specified situations and engagements. These became rigid, structured procedures. In short, restrictive procedures further reduced the latitude and decision-making role of crewmembers, reducing some potential decisions to procedural tasks or gaining approval for a task with actions dictated by direction of higher headquarters.

Aside from threat or work prioritization, crew activities seldom used higher-order thinking skills—such as analyzing, evaluating, or creating—during the mock air battles. In discussions of air battle scenarios, Patriot SMEs rarely agreed on all aspects of critical thinking. There appeared to be no standard set of best practices for decision-making or problem solving. While some checklists were used for procedures such as troubleshooting or fault isolation, no other job aids were observed to assist less experienced crewmembers. No models were observed for organizing information for decision-making or problem solving tasks. Frequently, SMEs commented that improved decision-making would come as crewmembers experienced many different situations over time. However, the specifics of these experiences were not defined nor were any of the specific decision-making skills they hoped would emerge over time.

Gunnery certification training, including SPEAR assessments, are often based on complex scenarios and conditions. However, these are procedural evaluations. Scenarios providing true decision situations seldom occurred. When crewmembers performed poorly, the same scenario or close variations of it were rerun. Crewmembers tended to reapply the procedural steps they used previously to address issues instead of applying problem solving skills to arrive at novel solutions. The end goal was doing it right, not necessarily understanding why it was right or transferring what was learned to other situations.
In summary, Phase I analysis indicated that:

- Crewmember (TCO and TCA) training and preparations are focused on lower-order thinking skills, primarily those that supported the correct performance of routine and critical procedures.
- The development and improvement of decision-making skills in crewmembers could benefit from the compressed practice of decision-making skills related to crew duties.

- Beneficial practice must include feedback to the practicing crewmember and should provide some form of feedback to unit trainers and leaders.
- Decision making in the ECS could benefit from some structure or organization to help the crewmember visualize the problem and its context, and examine relevant information. However, the confined space of the work area and the rapidly changing situation are not conducive to a chart-type job aid and there is no time to record data.
- Any training developed must complement and not supplement engagement skills and procedural training.
- To avoid classification restrictions while providing authenticity, training would need to reflect a fictional but plausible situation. A realistic but unclassified enemy air and missile order of battle would need to be developed and some unclassified technical information on systems made available for use in training.
- The user/training audience should be cast in a familiar role.

Our analysis also yielded some additional questions:

- What realistic situations could crewmembers encounter that would elicit decision-making skills?
- What feedback scheme could be used to support learning? SMEs sometimes disagree on the correct solutions.
- What potential models can be applied to support decision-making across a broad set of problems in the military context?
- What instructional designs and principles would be most applicable to Patriot ECS crewmembers? The crewmember/user would need to be cast in a role, but success in that role needed to be based on exercising thinking skills, not procedural skills.

Phase II: Defining the Training Solution

In Phase II, the research team defined what was required to develop a training prototype to address the identified shortcomings in decision-making training. The ADDIE process model was used to frame its development, with the Analysis step applying our findings from Phase I of this research.

Phase II Method

The first question we sought to address concerned what situations would most effectively elicit decision-making and problem solving skills for ECS crewmembers. In addition, we sought out common elements of those situations to identify a job aid to support less experienced crewmembers in their decision-making process.

Decision-Triggering Events

The research team spoke with 26 SMEs at the ADA School to identify situations in Patriot ECS operations that elicit complex decision-making skills. The following describes the background experience of the SMEs:

- An SSG (14T30) with ten years in Patriot operational system repairs. This SME had extensive experience leading or working as a member of a *hot crew*. A hot-crew is composed of an NCOIC and one or more additional launcher crewmembers on-call and on-hand as a contact team to rapidly repair or refuel Patriot launching stations.
- A Top Gun Course Manager who was a senior warrant officer with enlisted time as a TCA, Battery Trainer, battery and battalion Master Gunner, TDA in the ICC. As a Warrant Officer, he had extensive experience as a TCO and as a battalion and brigade Electronic Missile Maintenance Officer/Standardization Officer.
- Four new Warrant Officers (140E), who were about to graduate from the MOS basic course. Each had six to 11 years enlisted experience. Most were Patriot Master Gunner graduates and all had extensive time as TCAs.
- Two DA Civilians employed by the ADA School as Reconfigurable Table Top Trainer (RT3) trainers and training developers. One was a former Avenger gunner. However, he had extensive knowledge of the RT3, RT3 software, and Patriot ECS operations. The second had extensive enlisted/NCO experience as a TCA and had been an enlisted TCO prior to leaving active duty and assuming a GS position. These technicians maintained RT3 software and were retained by the School to develop customized training packages for in-unit training.
- Two CW4s assigned to the Warrant Officer Basic Course (WOBC) as the Course Manager and as an Instructor/Writer. Both had extensive enlisted experience on Patriot and they had both served as TCOs in the ECS, Tactical Directors in the ICC, and as battalion and brigade Electronic Missile Maintenance Officers/Standardization Officers.
- Five CW2s in the final days of their WO Advanced Course. The group was mixed with experience concerning both Patriot maintenance and operations. They represented extensive enlisted experience (five-and-a-half to 10 years). All had tactical/operations experience.
- Eleven SMEs composed of nine Master Gunner students and two Master Gunner Course Trainers. While their actual time in operations and engagement crew duties varied, all students were approaching graduation from the Patriot Master Gunner course. Seven expected to return immediately to ECS or trainer duties in a Patriot battery. One was slated to become a Platoon Sergeant and one was a battery First Sergeant designee.

From these discussions, we identified nine situations or elements of situations that elicit decision-making skills. These situations incorporated plausible tactical problems, maintenance issues, and unexpected circumstances—the raw materials for realistic scenarios and problem situations. While some events were only discussed or put forward by a single source, their plausibility and validity was verified across multiple sources. The uniqueness of some situations, the frequency with which others were mentioned, and the circumstances of the accounts indicated that these situations could be developed into training scenarios requiring higher-order thinking and/or problem solving skills on the part of ECS crewmembers. Table 3 describes the decision-triggering situations we derived based on our discussions with SMEs.

Table 3
Decision-Triggering Situations Described by Patriot Subject Matter Experts

Decision-Triggering Situations	Conditions/Examples
Determining the mission impact of a fault	The system capabilities are degraded but the Patriot can still engage – degraded operations; launcher problems; recommend repair priorities/ modify operations as required.
Recommending reload and maintenance priorities	Time and task management - during air battle; fault ID; launcher and system maintenance; reloading.
Reacting to an ARM launch	Saturate the environment (friendly and enemy); screening ARM carriers; alert line/screen warnings; misclassified missile track or type.
Executing the directed engagement of a track	Merge tracks for enemy and friendly aircraft (hazard); depict threat systems in a friendly air corridor at a protected altitude.
Acting to clarify an erroneous or misclassification	TBMs/ARMs/ASMs; slow ABTs or TBMs; bad track or tab data.
Executing cruise missile (air or land launched) engagement	Portray a high, fast track or a high launch and descent out of radar coverage.
Executing engagements of threatening massed ABTs	Varied aircraft in coordinated effort. Determine the highest threat; multiple ABTs emerge from single track.
Acting against swarm attacks or massed suppression of enemy defenses (SEAD)	Swarm; multiple ARM launches.
Executing engagement of varied types of TBMs and mixed multiple threats	Mix TBMs; saturate with coordinated ABT and ARM attacks

Organizing Data Elements

Research has shown that graphic organizers can be a successful tool for teaching thinking skills (Burns et al., 2006). Graphic organizers provide structure and organization as students develop their thinking and problem solving skills. Seven discrete thinking skills have been taught effectively using graphic organizers, including:

- Determining cause and effect,
- Making decisions,
- Comparing and contrasting information,
- Classifying information,
- Making observations,
- Planning for future events, and
- Predicting outcomes.

These thinking skills are applicable to the duties and actions of Patriot ECS crews during air battle operations. This suggests a graphic organizer could benefit the ECS crewmembers in developing their critical thinking and decision-making skills. The limitations of using a traditional graphic organizer in the context of Patriot are:

- Confined space in the van and at the ECS workstation,

- Rapid pace of operations in an air battle,
- Frequent changes and updates to data and information available,
- High probability that inputs for multiple decisions are constantly being assimilated,
- Available information relates to more than a single decision or action, and
- Actions related to some decisions may be interrelated with another decision.

We developed a simple graphic organizer to serve as a conceptual framework to assist Soldiers in identifying factors that may constrain their decision-making. This model is utilized throughout the training scenarios the research team developed. When engaged in Patriot operations, ECS crewmembers focus on their radar scopes, supplemented by information derived from tabs, tables, alert lines, and brief liner displays. Crewmembers may attend to many different pieces of information at a given time. The graphic organizer needed to facilitate a crewmember in quickly attending to pertinent information in the context of the total situation. Likewise, the organizer needed to alert crewmembers to missing information, things they may have overlooked. We intended that the graphic organizer allow crewmembers to distinguish relevant attributes of available information, and evaluate, assess, and compare information in determining what actions are required. The graphic organizer would need to be both reactive and proactive—respectively providing support leading to a decision and anticipating future decisions in response to enemy intentions and actions.

Building a Database for Decision Related Information

The requirements for an instructional design model were determined and draft scenarios were developed. The scenarios needed to be set in the context of an unclassified general situation, not associated with an existing mission or contingency area. The research team developed an unclassified air and missile order of battle to present a capable threat. We used dated materials (e.g., Department of the Army, 1991) to derive examples of threat air force and missile elements. Unclassified, but credible, websites such as MISSILE THREAT provided detailed information on threat ballistic missile systems.[8] IHS, Inc.—the holder of Jane's Information Group—provided an unclassified, open-source intelligence database of defense and security information, frequently used by U.S. and NATO intelligence communities. Using threat systems derived from the Cold War era provided abundant technical information and capabilities on long-exploited systems still in service in some nations.

A fictional area of operation and general situation were developed using the southeastern United States. A complete Air and Missile Defense annex was created for the fictional Joint Task Force (JTF), deploying with an AMD Task Force (TF). The JTF deployment was an action in support of a developing friendly nation being attacked by a more technologically advanced, well-armed, and hostile neighboring nation. A special situation was developed, providing defensive operations by a Patriot battery positioned to protect the forward assembly area of a major ground component of the JTF. The research team was careful to draw all information from open sources, and to keep all materials unrelated to possible contingencies or real-world events.

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[8] http://missilethreat.com/missile-class/tactical-ballistic-missile-tbm/. MISSILE THREAT is a project of the George C. Marshall and Claremont Institutes.

When designing the PCST, the research team determined that it should focus on developing critical thinking and decision-making skills over procedural and technical skills specific to the Patriot system. As such, it would only require the most basic knowledge of the actual Patriot system. Users would need to be able to read the symbols and track icons generated on scope in the ECS. Users would not need to know specific switches, controls, indicators, and tabs of the Patriot system. The PCST would not reference or use any classified information and would not require detailed understanding or divulging of sensitive embedded resources or processing capabilities of the Patriot system.

Scope views were presented as a series of progressive still images, rather than a full motion displays. Users were not required to manipulate the switches, controls, indicators, and tabs of the Patriot to compile information from multiple embedded sources. Data would be presented already compiled. These simplified data presentations were created for each step in a scenario. This would allow the PCST to focus on developing data interpretation and decision-making skills rather than the procedural skills related to compiling data during normal Patriot operations.

Users would be provided feedback on how they performed on each scenario. A number of assessment schemes were considered. The research team determined that the performance of the user should be compared against that of an experienced Patriot expert. In this scheme, the user selects a decision set and then identifies the factors that most influenced the ranking, priority, or selection of the decision set. We scored users against the consensus responses of a group of senior Patriot SMEs. Scoring user selections in this way moved the assessment away from absolutes and toward a visual and auditory feedback system that rated how close users' individual selections came to those of the SME consensus.

Materials for the PCST were reviewed by experts from 32nd Air and Missile Defense Command's Directorate of Plans, Training, Mobilization, and Security (i.e., G3) staff and SPEAR Team. Based these reviews, the research team further refined the PCST design. Working sessions were conducted with these experts to mature further the draft scenarios, data, presentations, and assessment schema. Both active duty military and contractors contributed to these sessions, making corrections and adjustments to the problem sets and associated scenarios, how data were presented, and the assessment and user feedback scheme.

The tool was organized in terms of an introduction followed by five training modules. Each module presented a realistic scenario and contained decision-triggering situations recommended by the ADA School SMEs. The scenarios and decision-triggers were intended to elicit and exercise aspects of critical thinking. The design incorporated one basic, one intermediate, and three advanced or mission modules. The degree of scaffolding support provided to users was tapered and the number of potential decision-triggers was increased as the training moved to more advanced levels. Early in training, users received feedback on each decision; later in training, multiple decisions were made before feedback. Each module included an AAR that scored the users' responses against Patriot SME responses. At the end of the modules for a section, users were provided with overall feedback on how their performance compared to that of experts. Users were able to print this page to provide to unit trainers or supervisors.

The storyboards for the five training modules were prepared and presented to Patriot SMEs at the Air Defense School. The SMEs reviewed the storyboards for accuracy and authenticity, and to provide their input to the consensus decisions used as the foundation for the performance feedback system. This panel consisted of:

- Patriot Top Gun Course Manager – CW3 with almost five years of experience as a TCA, two years of experience as a TCO, and over four years of experience as a Standardization Officer.
- Patriot Warrant Officer Basic Course (140E) Course Instructor/Writer – CW4 with two years of experience as a TCO, two years of experience as the ICC TD spanning two battalions, and two-and-a-half years of experience as a Standardization Officer spanning two battalions.
- A recent graduate of the Warrant Officer Basic Course (140E) – WO1 with six months experience as a TCA and two years of experience as a TDA in a battalion ICC.
- Patriot Master Gunner Course Instructor/Writer – SSG with almost two years as a TCA, over one year as a platoon sergeant, and one year as a battery Master Gunner and trainer.

In order to derive consensus decisions based on the scenarios presented, the research team conducted extended dialog with participants. These discussions concerned the rationales involved in the tactical and other supporting factors that contributed to the SMEs' decision-making processes. The SMEs viewed all storyboards, including images and data files. They reviewed and discussed all decision and supporting data. Their consensus was documented to provide a basis for assessing users of the PCST. After all final input and critical reviews were incorporated into the storyboards and accompanying materials, they were turned over to media developers to produce the training product.

Results of the Phase II Analysis

With a focus on the process of developing the PCST for Patriot ECS, the following results address three key issues:

- Defining the deficiencies in existing Patriot individual and ECS crews training that perpetuate shortcomings in critical thinking skills,
- Identifying and selecting training techniques and methods that could be employed in a multi-media tool to address these deficiencies and build them into a practical prototype PCST, and
- Validating the prototype PCST.

The PCST was developed using the ADDIE process, augmented by principles derived from research addressing multimedia instructional design (Blankenbeckler, Graves, & Wampler, 2014; Blankenbeckler, Graves, Dlubac, & Wampler, 2016; Ingurgio, Blankenbeckler, & Wampler, in press) and more general instructional principles (Merrill, 2002).

Common Elements of Decision-Triggering Situations

When the research team analyzed the decision-triggering situations in greater depth, data elements that were common to all the situations were identified. While the salience of elements varied across different situations, a general process for considering the elements arose from this analysis, which pointed the research team to a common process for identifying and evaluating the elements in specific decision-triggering situations. This model provided a basis for a graphic organizer to support crewmember analysis, problem-solving, and decision-making.

The core element of every decision is how it will affect the units' ability to sustain its mission. To determine this, a decision-maker must consider some aspect of the enemy situation and the enemy's ability to react to the decision. The battlespace is key in this determination, including the air and terrain situation in the units' area of operation. In addition, the decision-maker needs to consider the origin of hostile aircraft and missiles, their current locations, transit times and airspeeds, launcher locations, weapon types and warhead capabilities. Decision-makers also need to consider the situation from the standpoint of their own systems. For instance, what the equipment and missile/ammunition status of the Patriot system is, as well as what maintenance and repair is needed. Time to repair, time to reload, time of flight, last time to launch, time to impact—all were potential factors adding an element of urgency to the decision-making process.

Members of the research team with prior Army service recognized that the METT-TC process could serve to organize the information required to come to a decision in response to a decision-triggering situation. METT-TC is acronym for the factors fundamental to assessing, estimating, and visualizing a tactical situation: **M**ission, **E**nemy, **T**errain and weather, **T**roops, equipment, and support available, **T**ime available, and **C**ivil considerations (Department of the Army, 2008a). Rather than repackage the process as something new, we applied the familiar Army process to the Patriot ECS decision-making context. Civil considerations were not a distinct factor in our discussions with Patriot SMEs. As a result, we organized the evaluation process around METT-T.

The research team developed draft scenarios and an interface providing data emulating the Patriot ECS. While data were presented in a manner similar to the ECS, the arrangement presented situations for a decision, permitting the user to select an action and to prioritize the information that influenced their decision. The scenarios presented were unclassified, based on a general mission in an area of operation that was in the southeastern United States. A fictional belligerent nation had forcibly annexed a border province of a U.S. ally. Threat and situational information drawn from open sources was consolidated into an Air and Missile Defense Appendix to the Fires Annex of a fictional Joint Task Force Operations Order. This converted the information to a form expected by the tool user. Again, the research team was careful to draw all information from open sources and to keep all scenarios unrelated to possible real-world contingencies, events, or the classified capabilities and characteristics of air and missile platforms.

The design of the tool was such that use would require only the most basic knowledge of the actual Patriot system. Snapshot images of the scope were developed to support the scenarios, replacing the constantly changing radar images. These sequentially changing images provide users with selected views, similar to those routinely available through the scope displays of the ECS van. Sequential images and brief text or narrative updates take the place of the constantly changing real-time radar images on the TCO and TCA scopes.

Previous research identified and documented instructional design principles to enhance the learning effectiveness of interactive multi-media instruction products (Blankenbeckler, Graves, & Wampler, 2013, 2014; Graves, Blankenbeckler, Wampler, & Roberts, 2016; Blankenbeckler et al., 2016; Ingurgio et al., in press). We reviewed the principles and drafted an instructional design concept. The design concept focused on the principles and generalizable strategies supported by relevant research literature, expert knowledge, and practical experience. The principles are summarized below:

Define the learning task - what the learner should know or be able to do after instruction. The learning task for this effort is skill focused. The learning goal is to have the new learners make and select decisions similar to those expressed in the consensus of Patriot SMEs. A secondary goal of training is to model the users' decision processes. Not only do we assess the decision, but by ranking the data elements that most prompted the decision selections, the Tool leads the user toward a more refined practice of decision-making.

Link new knowledge and skills to real world tasks and missions in context (problem based). Real world problems in a contingency mission context are the focus of the training. While the situations and enemy order of battle are fictitious, equipment capabilities and threat tactics are real. Users are given actual problems to solve that impact their ability to protect elements of the ground component of a U.S. JTF. The displays and data provided are the same as would be expected from the Patriot system. The content is chunked into small sequential problems and the user is provided with related data sets arranged in a graphic organizer, an appropriate cognitive representation for ease of understanding, assimilation, and to support the management of essential processing.

Encourage practice of new knowledge and skills in context. The tool design provides for user decisions in varied air battle situations. It provides training in progressively difficult and complex situations, divided into introductory or *crawl* training (one module); intermediate or *walk* training (one module); and advanced or *run* training in three mission modules. There are five modules in total. In the later modules instructional scaffolding is diminished as learners' facility with AMD engagement decision-making processes increases. It provides for both general performance feedback at the end of the module as well as specific feedback at selected decision points (see Appendix B for example scenarios).

The first instructional module is the crawl phase. It provides three decision points in an evolving situation. While working through the module, users make three decisions and rate the factors that most contributed to their decisions. Then, their responses are compared to those of senior Patriot SMEs. An SME verbal rationale is provided for each decision point. At the end of the module, an AAR compares the users' decisions to those of the SMEs.

The second module is the walk phase, providing four decision points. Users are provided scaffolding in terms of favorable or unfavorable comparisons to SMEs. If they have a low score, they are provided an opportunity to reconsider their decisions. Again, at the end of the module, users are provided an AAR comparing their decisions and selections to those of the SMEs.

The final three modules comprise the run phase. In the run phase, users are exposed to scenarios with more decision-triggers than the first and second modules. In addition, the third module extends the number of decisions users must make before receiving direct feedback. Instead, feedback comes by way of navigation routing. They are able to see the consequences of their decisions and how their decisions are influencing their later options. When the user selects decisions that deviate significantly from SME selections, they are routed toward catastrophic consequences. They are then allowed to reconsider their decisions. At the end of the run phase module, users are provided with feedback that compares their decisions to those of SMEs.

Within scenarios, problems were introduced visually using graphics similar to those of the scopes in an ECS. Minor displacements of track markers and objects from frame to frame substituted for real-time movements. Movements were depicted in a manner to show the relative speeds of track icons. For example, high-performance aircraft advanced across or down the scope faster than UAVs. TBMs and ARMs were depicted as moving at very rapid speeds. Standard symbology was used to portray each track. However, no time references were provided on these frames. For identification, all tracks are labeled with a discrete reference number that remained consistent for the track throughout the scenario. Figures 4 and 5 below provide samples of how scenarios progressed from frame to frame.

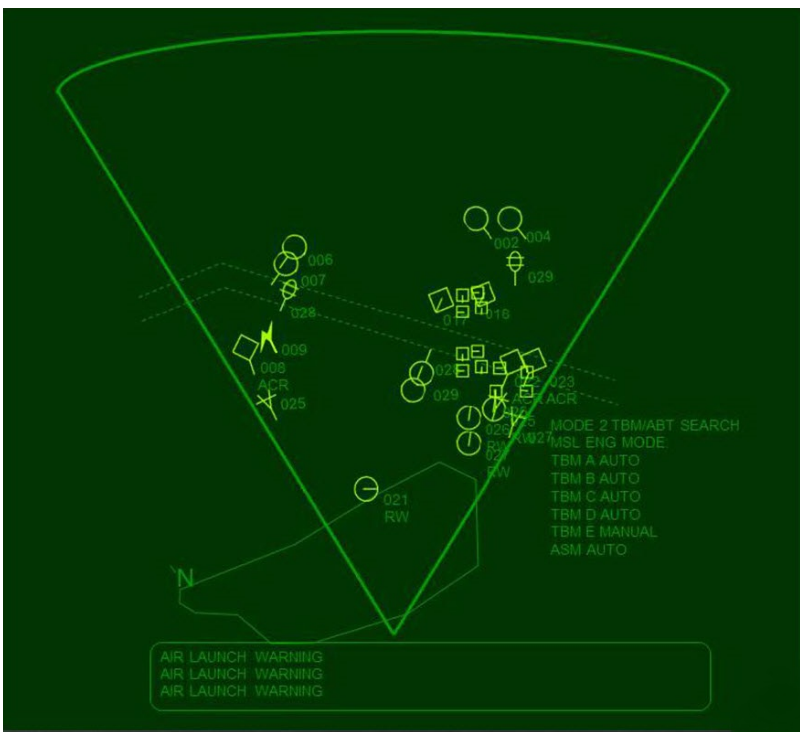

Figure 4. Scope View 1: Radar Image

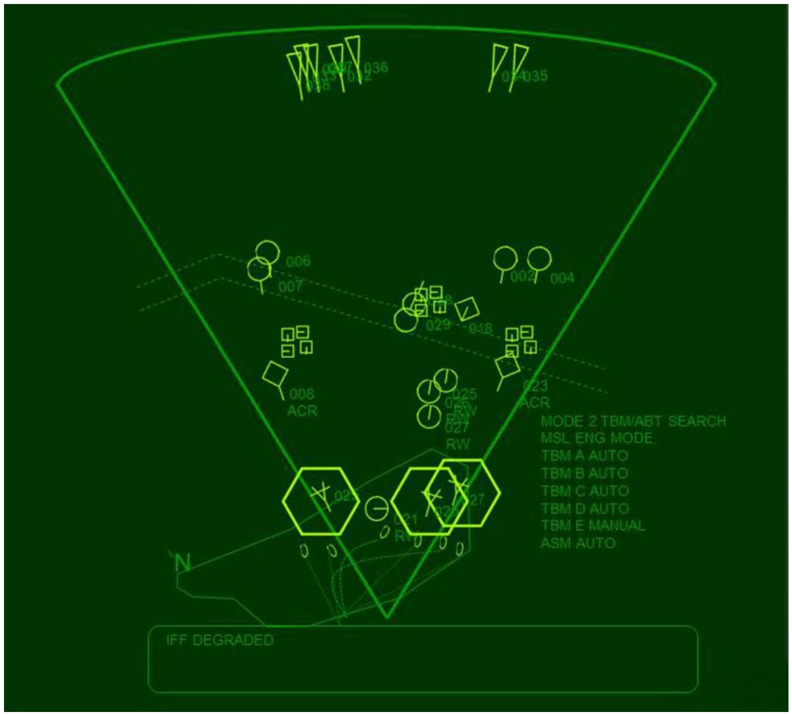

Figure 5. Scope View 2: Progressive Sequenced Radar Image

In the Patriot system, data on tracks or events is accessed through multiple switches, controls, indicators, and tabs. In the PCST, data was presented on a single page (see Figure 6). Users were not required to obtain data by manipulating the system and then compile it from multiple sources. Simplified data sets were created for each element in a scenario. The data was displayed to according to the scheme of the graphic organizer, METT-T, described previously.

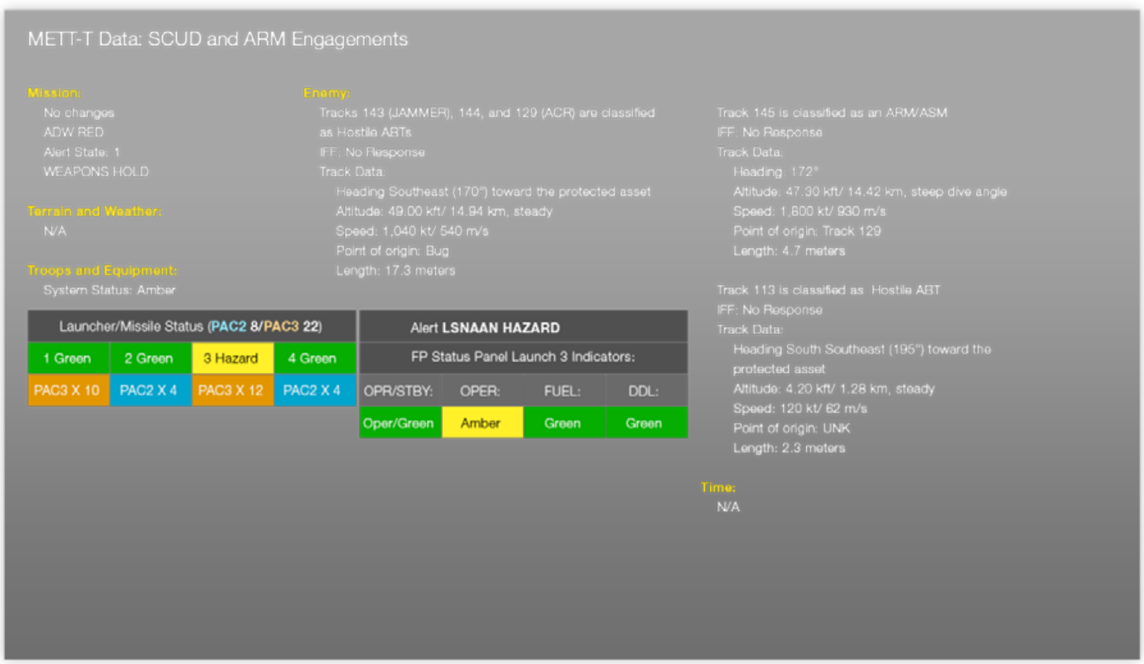

Figure 6. METT-T factors relating to a decision.

The example in Figure 6 includes a maintenance fault. On the METT-T screens, users were given an option to return to the previous screens to review scope images. Launcher status and missile counts were also provided. Given that users come from units with mission areas that span the globe, metric and imperial measures were reported. Radar-measured lengths were provided in meters.

Assessment and Scoring

The research team developed a scheme to assess the performance of users. This scheme used the consensus solution of Patriot experts as the criterion. The assessment asked users to make decisions then identify factors that influenced their decisions. User selections were scored in terms of how close they were to Patriot SME selections. While time is a factor in making decisions, the tool was focused on proficiency over speed. Given a data set and a scenario, can the user make decisions that approximate those of Patriot experts? Users' responses were scored as being dissimilar, related to, or similar to the SMEs' consensus response.

In establishing the criterion for scoring, we worked with a panel of Patriot SMEs. The comments, decisions, and inputs of the Patriot SME panel varied for each scenario. Individual experiences weighed heavily in these discussions. Rather than establishing an absolute best answer, the research team decided that users should be scored in terms of how closely they approximated the SMEs' consensus solution.

Scoring considered two aspects of users' performance. First, it focused on the decision(s) they selected. Second, it focused on the factors that influenced their decision(s). Most often, users were asked either to make a decision or to prioritize, from a list, three choices of how they would respond to a situation. Prioritized responses were scored in terms of how closely they reflected the sequence selected by the SMEs. The closer a response reflected the sequence selected by SMEs, the better the score. Options that were not prioritized by the SMEs (i.e., distractor items) were all treated equally in the scoring system.

When user responses are scored, the tool calculates the variation of user responses from SME responses using the explained sum of squares (ESS) model of linear regression. Users' scores are calculated by adding up the squared differences between the users' responses and the SMEs' responses. The differences were squared only for mathematical purposes: so a negative number resulting from subtracting users' responses from SMEs' responses would be made positive before adding the differences together for a deviation score. If differences were not squared, extreme user responding on either side of the SMEs' response line would cancel out. The research team treated all SME responses as correct, so the ESS generated from the SMEs' responses to correct user responses is linear, with a deviation of zero. The more users' responses deviated from SMEs' responses, the larger the number representing the difference. Therefore, a higher sum of squared deviations for a given user represents less similar responding when they are compared to the SMEs. Likewise, the closer to zero the sum of squared deviations was for a given user, the more similar their responding was to the SMEs.

Consider the example data presented in Table 4. The example shows SME responses as baseline, with a deviation score of zero, and three sample user responses as well as the calculations of the ESS deviation score for each. In addition, recall the distractor response was defined in terms of no SME endorsing the response. If a hypothetical user were to respond with all distractor options, then they would earn the worst possible score, a score indicating the highest degree of deviation from the SMEs. In this example, that score would be 26. Note that SME responses are a linear function. In the example, User #1's decisions (score = 24) are less similar to SME decisions than User #3 (score = 8). User #2 decisions (score = 2) are the most similar to SME decisions among the three users, as this users' score is the closest to zero.

Table 4
Example of Prioritized User Decisions

			User Decisions (Prioritized)			
Options		**SME Baseline**	**User #1**	**User #2**	**User #3**	**Distractor Response**
A		1	4	1	3	4
B		4	3	4	4	2
C		2	4	2	2	4
D		4	1	3	4	1
E		3	2	4	1	3
			ESS Scoring			
A		$(1-1)^2 = 0$	$(4-1)^2 = 9$	$(1-1)^2 = 0$	$(3-1)^2 = 4$	$(4-1)^2 = 9$
B		$(4-4)^2 = 0$	$(3-4)^2 = 1$	$(4-4)^2 = 0$	$(4-4)^2 = 0$	$(2-4)^2 = 4$
C		$(2-2)^2 = 0$	$(4-2)^2 = 4$	$(2-2)^2 = 0$	$(2-2)^2 = 0$	$(4-2)^2 = 4$
D		$(4-4)^2 = 0$	$(1-4)^2 = 9$	$(3-4)^2 = 1$	$(4-4)^2 = 0$	$(1-4)^2 = 9$
E		$(3-3)^2 = 0$	$(2-3)^2 = 1$	$(4-3)^2 = 1$	$(1-3)^2 = 4$	$(3-3)^2 = 0$
	Sum (ESS)	0	24	2	8	26

The research team decided that to provide effective feedback the deviation scores for users would need to be translated into readily interpretable categories. Users were given feedback based on whether their scores were "similar," "related," or "dissimilar" to those of SMEs. These categories were determined by calculating the best and worst possible scores for each decision point. The best score is always zero, however, the worst score varied depending on the number of response options available for each scenario. The worst possible score for each scenario was summed from the worst possible scores for each decision point within a scenario—a summed score which would indicate that the user's responses were 100% dissimilar from the SMEs. Categorical scores were interpolated to percentages from the raw scores calculated for each scenario. If a user deviated from the SMEs by more than 50% they were rated as *dissimilar*; between 20% and 49% they were rated as *related*; and 19% or less, they were rated as *similar* (see Table 5). Consider a hypothetical scenario that has a worst possible score of 82. Using the percentages for each category, ESS scores from 0 to 16 would be rated as *similar*, those from 17 to 41 would be rated as *related*, and those from 42 to 82 would be rated as *dissimilar*.

Table 5

Ranges of Percentages used for User Feedback

	Total ESS %
Similar	0 to 19%
Related	20% to 49%
Dissimilar	50% to 100%

While the above discussion of scoring focused on prioritized responses, in a few instances decision points within a scenario ask users to make dichotomous decisions. For those cases, either user responses match the SMEs' or they do not. Others decision points ask users to rate the likelihood of an event based on their present information. In both cases, similar ESS calculations were made for scoring purposes.

In addition to selecting/prioritizing decisions, users were also asked to indicate the factors contributing to their decisions. These factors were not prioritized. As above, these scores were calculated in terms of deviation from the SME consensus. The math was simplified, however, as it did not need to account for the order in which responses were prioritized.

The last page of each section of the PCST presents an AAR, providing scoring and auditory feedback to the user concerning the SME consensus decision(s) and rationale for those decisions. This feedback is reduced in the run phase of training, as users were expected to diagnose where they had made decisions that produced negative outcomes. The users' performance is compared to SMEs in terms of both their decisions and their selection of factors contributing to their decisions. The AAR page is printable and could be provided to unit trainers or unit chain-of-command to track performance and progress. Figure 7 provides an example of an end of module AAR. The closed caption (CC) narration is displayed for this instructional frame.

Figure 7. Example Training Module AAR Page

Phase III: Validation of the Patriot Cognitive Skills Trainer

In the third phase of the research, we validated the PCST with Patriot operators at the 108th ADA BDE, Fort Bragg, NC. Twenty (N = 20) Soldiers gathered in a classroom at a BDE facility. On arrival, we briefed the Soldiers on the research purpose, their rights as participants, and administered informed consent. All Soldiers chose to participate. Soldiers were seated at desks, allowing sufficient space to operate laptop computers with a mouse and to fill-out the data collection forms. Soldiers were provided headphones so that computer audio would not become a distraction.

Procedure

Following informed consent, Soldiers completed a pre-training questionnaire. The pre-training questionnaire asked questions about demographics (e.g., rank, MOS), background experience and training related to their Patriot assignments. They then completed the five training modules. After completing each module, they recorded their progress on a data collection form. Once training was complete, they filled out a post-training questionnaire and a questionnaire to evaluate the training design, content, and their learning experience. The full data collection session required two-and-a-half to three hours. The average time spent training was two hours, 13 minutes.[9]

Participants

Table 6 presents the sample demographics. The sample composition matched the intended audience for the trainer, except that no commissioned officers—who would have been serving in the TCO position—participated.

Table 6
Demographic Characteristics of the Sample

Demographic Variable	
Sample Size	*N* = 20
Rank	Private First Class (PFC E-3) = 2 (10%) Specialist (SPC E-4) = 13 (65%) Sergeant (SGT E-5) = 1 (5%) Chief Warrant Officer 2 (CW2) = 1 (5%) Chief Warrant Officer 3 (CW3) = 3 (15%)
MOS	14E = 16 (80%) 140E = 4 (20%)
Assignment	Battery Command Post = 1 (5%) Battalion Readiness Center = 1 (5%) Communications Operator = 1 (5%) Standardization Officer = 2 (10%) Tactical Control Assistant = 13 (65%) Tactical Director = 1 (5%)
Time in Current Assignment	*M* = 14.6 mo. *SD* = 16.5 mo. *Range* = 1 to 61 mo. *Distribution*: 1 to 6 mo. = 11 (55%) 15 to 24 mo. = 4 (20%) 30 to 61 mo. = 4 (20%) *Unknown* = 1 (5%)
Highest Gunnery Table/RAL Certification	II (Ready-for-Action Drills) = 1 (5%) IV (Basic Gunnery Certification) = 1 (5%) VII (Precertification Tables V and VI) = 2 (10%) VIII (Intermediate-Level Gunnery Certification) = 9 (45%) XII (Advanced-Level Gunnery Certification) = 2 (10%) RAL11 = 3 (15%) RAL17 = 3 (15%)

[9] Crawl phase training required an average of 34 minutes. Walk phase required 36 minutes. The average for the Run phase training was 63 minutes.

Of N = 20 participants, n = 16 were 14E (Patriot Fire Control Enhanced Operator/Maintainer) and n = 4 were 140E (Warrant Officer MOS Air and Missile Defense Systems Tactician/Technician). Most participants were Specialists (E-4; n = 13) who were serving in TCA positions (n = 13). The participants had been in their current assignment for M = 14.6 months (SD = 16.5 months), with most (55%) in their current assignment for six or fewer months. Most participants (n = 11) were certified at least Level VIII, Intermediate-Level Gunnery Certification, which is the requisite certification for executing a real-world mission on the Patriot system.

Results of the Phase III Validation

Background Training of Participants

Prior to the experimental training, participants completed a questionnaire asking about their training background in Patriot (see Appendix C). Participants were asked to rate each statement on the questionnaire in terms of frequency: 1 = Never; 2 = Occasionally; 3 = Often; and 4 = Always. Table 7 presents the results.

Table 7
Participant Responses to Pre-Training Training Background Questionnaire

	Item	Never	Occasionally	Often	Always
1.	The Patriot engagement training received in my unit has been focused on remembering and understanding procedures.	1 (5%)	4 (20%)	6 (30%)	9 (45%)
2.	My Patriot engagement training has focused on applying the procedures that I can recall and understand.	1 (5%)	2 (10%)	8 (40%)	9 (45%)
My Patriot training has provided information that my crew and I were required to analyze and evaluate information and data in order to: (See 3 – 14 below)					
3.	Set work and task priorities	2 (10%)	4 (20%)	5 (25%)	9 (45%)
4.	Review and modify priorities	5 (25%)	--	6 (30%)	9 (45%)
5.	Set engagement priorities for tracks or targets on my scope	2 (10%)	3 (15%)	5 (25%)	10 (50%)
ANTICIPATE:					
6.	Track separations	2 (10%)	4 (20%)	5 (25%)	9 (45%)
7.	Launch of ASMs or ARAMs (1 missing)	3 (15.8%)	1 (5.3%)	5 (26.3%)	10 (52.6%)
8.	Jamming	4 (20%)	2 (10%)	7 (35%)	7 (35%)
9.	The intent of a track or a hostile formation	3 (15%)	1 (5%)	9 (45%)	7 (35%)
10.	Launcher reload requirements	3 (15%)	2 (10%)	7 (35%)	8 (40%)

Table 7
Participant Responses to Pre-Training Training Background Questionnaire (Continued)

	Item	**Never**	**Occasionally**	**Often**	**Always**
11.	Need to alter system settings on the Patriot	2 (10%)	3 (15%)	5 (25%)	10 (50%)
12.	The probable sequence of events during a hostile attack	3 (15%)	3 (15%)	4 (20%)	10 (50%)
ACT TO COUNTER:					
13.	Erroneous classification of tracks	3 (15%)	3 (15%)	8 (40%)	6 (30%)
14.	Coordinated SEAD directed against my battery	5 (25%)	3 (15%)	5 (25%)	6 (30%)

Note: *N* = 20. ASM is an Air-to-Surface Missile. ARAM is an Anti-Radiation Missile. SEAD is Suppression of Enemy Defenses.

More than half of the participants reported that they always received training that prepared them to analyze and evaluate information to set engagement priorities for tracks or targets on scope, anticipate the launch of ASMs or ARAMs, anticipate the need to alter system settings on the Patriot, and anticipate the probable sequence of events during a hostile attack. The fewest participants indicated that they always received training on analyzing and evaluating information to act to counter erroneous classification of tracks, and coordinated suppression of enemy defenses (SEAD) directed against their battery.

We asked additional questions concerning cognitive skills training the participants might have received. Sixteen (80%) participants reported they had been provided training on models and methods for problem-solving and engagement problems. Thirteen (65%) reported that they had been provided scenarios and situations to assess their critical thinking and problem solving, and had been given feedback. Fifteen (75%) reported that they had been trained on situations to practice critical thinking and problem solving skills.

User Performance within Modules

Following the pre-training data collection, the participants then completed the five training modules. On completing each section, participants documented their progress on an in-route assessment form. The details of the in-route assessment are presented in Appendix D. Table 8 summarizes the participants' performance in terms of raw mean and percentage scores for each of the five modules.

Table 8
Participant Performance for Each Training Module

Module/Problem Set	*N*	*M*	*SD*	Low Score	High Score	Number of Items
Crawl (Beginner)						
Problem 1—Decision for TBM track	18	3.44	0.86	2	5	5
Problem 2—Decision for Unknown track	18	3.94	1.06	2	5	5
Problem 3—Decision for 3 Unindentified aircraft	18	4.83	1.20	2	6	6
Total Raw Score	18	12.22	2.37	6	16	16
Percent Correct	18	76%	15%	38%	100%	--
Walk (Intermediate)						
Problem 1—Multiple aircraft attacking	18	3.05	1.47	1	6	6
Problem 2—Determine probable enemy actions	18	6.50	2.66	3	12	12
Problem 3—SCUDs and an air launch	18	5.72	1.67	3	8	8
Total Raw Score	18	15.28	4.44	7	24	24
Percent Correct	18	64%	19%	29%	100%	--
Run Scenario I (Advanced)						
Problem 1—Multiple aircraft attacking	18	2.94	1.16	1	5	7
Problem 2—Multiple aircraft attacking	18	4.33	1.85	1	6	6
Problem 3—Maintenance and reload	18	2.28	1.02	0	4	5
Total Raw Score	18	9.95	2.75	4	14	18
Percent Correct	18	53%	15%	22%	78%	--
Run Scenario II (Advanced)						
Problem 1—Current threats and probable actions	18	3.67	2.25	0	8	10
Problem 2—Multiple TBMs on scope	18	2.00	1.14	0	4	4
Problem 3—Quickly recover mission capabilities	18	2.33	1.41	0	4	5
Total Raw Score	18	8.00	3.82	0	15	19
Percent Correct	18	42%	20%	0%	79%	--
Run Scenario III (Advanced)						
Problem 1—Multiple aircraft attacking	19	2.47	1.50	0	5	7
Problem 2—Multiple aircraft attacking	19	2.68	1.34	0	5	6
Problem 3—Multiple inbound TBMs	19	2.16	1.80	0	5	6
Total Raw Score	19	7.32	3.45	0	14	15
Percent Correct	19	48%	23%	0	93%	--

Note that as the difficulty of scenarios increased—from crawl, to walk, to run—the participants' percentage scores decreased from 76% in the crawl phase to 48% in the run phase. In the crawl phase, participants made simple decisions, identified targets, and provided a rationale for their decisions. In the walk phase, participants prioritized threats in multipronged attacks, predicted enemy actions, identified targets, and provided a rationale for their responses. In the run phase, participants prioritized threats in multipronged attacks, predicted enemy actions, identified targets, made fix or fight decisions, and provided a rationale for their responses. We manipulated training complexity by changing the number of elements participants had to consider in their decision-making process, as well as the types of decisions they were being asked to make (e.g., simple identification of a threat vs. prioritization of multiple threats).

User Evaluation of the Training Supports

As each phase of training concluded, participants rated how well scaffolding features of the training had supported them in addressing the presented problems. Table 9 summarizes their responses.

Table 9
User Evaluation of Training Supports

Training Module	Content Area	Not Useful	Somewhat Useful	Useful	Very Useful	Essential
Crawl*						
	AAR/Feedback	0 (0%)	5 (29%)	4 (24%)	6 (35%)	2 (12%)
Walk						
	AAR/Feedback	1 (6%)	3 (18%)	6 (35%)	5 (29%)	2 (12%)
	Graphic Organizer/Mental Model	1 (6%)	3 (18%)	4 (24%)	5 (29%)	4 (24%)
	Additional Resources	1 (6%)	3 (18%)	6 (35%)	3 (29%)	4 (24%)
Run						
	AAR/Feedback	0 (0%)	4 (24%)	6 (35%)	4 (24%)	3 (18%)
	Graphic Organizer/Mental Model	0 (0%)	1 (6%)	4 (24%)	9 (53%)	3 (18%)
	Additional Resources	0 (0%)	3 (18%)	4 (24%)	8 (47%)	2 (12%)
Introductory Training						
	Task and Purpose	1 (6%)	0 (0%)	6 (35%)	7 (41%)	3 (18%)
	Graphic Organizer/Mental Model	1 (6%)	1 (6%)	6 (35%)	6 (35%)	3 (18%)
	Scenario/Problem Presentation	0 (0%)	1 (6%)	6 (35%)	5 (29%)	5 (29%)
	General Situation/Additional Resources	0 (0%)	1 (6%)	6 (35%)	8 (47%)	2 (12%)

***Note:** $N = 17$; at the conclusion of the Crawl phase of training, Soldiers were asked to rate the Graphic Organizer/Mental Model and Additional Resources in terms of whether or not they assisted with their decision-making process. Fifteen out of 17 Soldiers (88%) reported that the graphic organizer assisted their decision-making process; fourteen out of 17 Soldiers (82%) reported that the additional resources assisted their decision-making process.

Most participants found the scaffolding features useful in assisting their decision-making process. Note the large number of participants who found the graphic organizer and additional resources ‘very useful’—53% and 47%, respectively—in the run phase of training. In the run phase, scaffolding feedback was reduced and participants had to make multiple decisions before receiving an AAR/feedback. With reduced AAR/feedback, participants had to infer that they had made the wrong decision based on the consequences of their decision in the evolving scenario. They may have relied more on the graphic organizer to support the evaluation process in the absence of direct AAR/feedback.

User Ratings of Learning Outcomes

After training, we asked participants to complete a questionnaire concerning various aspects of the training scenarios and their learning outcomes (see Appendix E). Most participants (95%; n = 19 out of 20) reported that (a) the cognitive skills training provided models or methods for problem solving and engagement problems, (b) that the training provided scenarios and situations to assess their critical thinking and problem solving, and (c) that the training provided a means to practice their critical thinking and problem solving skills. The participants rated the scenarios as (a) realistic (90%; n = 18 out of 20), (b) challenging (75%; n = 15 out of 20), (c) frustrating (40%; n = 8 out of 20), (d) too difficult (10%; n = 2 out of 20), and (e) too easy (5%; n = 1 out of 20).

Participants were asked to rate their understanding and skills before and after training for a set of relevant topic areas. These ratings were made on the scale: 0 = 'No Experience'; 1 – 3 = 'Can Get By'; 4 – 6 = 'Pretty Good'; and 7 = 'Can Train Others'. The differences between participants' before and after ratings were examined using a within-subjects repeated measures analysis of variance (ANOVA). The partial eta-squared effect size measure was used. Table 10 presents the results of the participants' ratings.

Table 10

Results of Soldier Ratings of their Understanding and Skills Before and After Training

Item	Rating Before M (SD)	Rating After M (SD)	N	$F(df)$	p	η_p^2
To What Degree Did the Patriot Cognitive Skills Trainer improve on your understanding of the following:						
Setting work and task priorities	3.94 (2.21)	4.89 (1.64)	18	8.82 (1, 17)	0.009	0.34
Reviewing and modifying priorities	3.94 (2.23)	4.67 (1.81)	18	4.69 (1, 17)	0.019	0.29
Setting engagement priorities for tracks or targets on my scope	4.28 (2.52)	5.06 (1.92)	18	5.95 (1, 17)	0.026	0.26
Self-assess your understanding and skills when reviewing Patriot system data and anticipating:						
Track separations	4.72 (2.56)	5.22 (1.90)	18	5.28 (1, 17)	0.035	0.24
Launch of ASMs or ARAMs	4.78 (2.51)	5.33 (1.78)	18	5.12 (1, 17)	0.037	0.23
Jamming	4.56 (2.41)	5.06 (1.98)	18	2.89 (1, 17)	0.11	0.15
The intent of a track or a formation of hostile aircraft	4.44 (2.33)	5.22 (1.77)	18	7.37 (1, 17)	0.02	0.30
The need to alter system settings on the Patriot	4.00 (2.42)	4.56 (2.28)	18	3.86 (1, 17)	0.07	0.19
The probable sequence of events during a hostile attack	4.28 (2.44)	4.83 (2.01)	18	4.21 (1, 17)	0.06	0.20
Self-assess your understanding and skills when reviewing Patriot system data and acting to counter:						
Erroneous classification of tracks	3.72 (2.54)	4.33 (2.43)	18	4.35 (1, 17)	0.05	0.20
Coordinated SEAD directed against my Patriot system and my battery	3.00 (2.67)	3.50 (2.60)	18	3.40 (1, 17)	0.08	0.17

Soldiers indicated that they perceived improvement in their understanding and skills in six (6) of the 11 areas evaluated. Figure 8 presents results for these areas of perceived improvement.

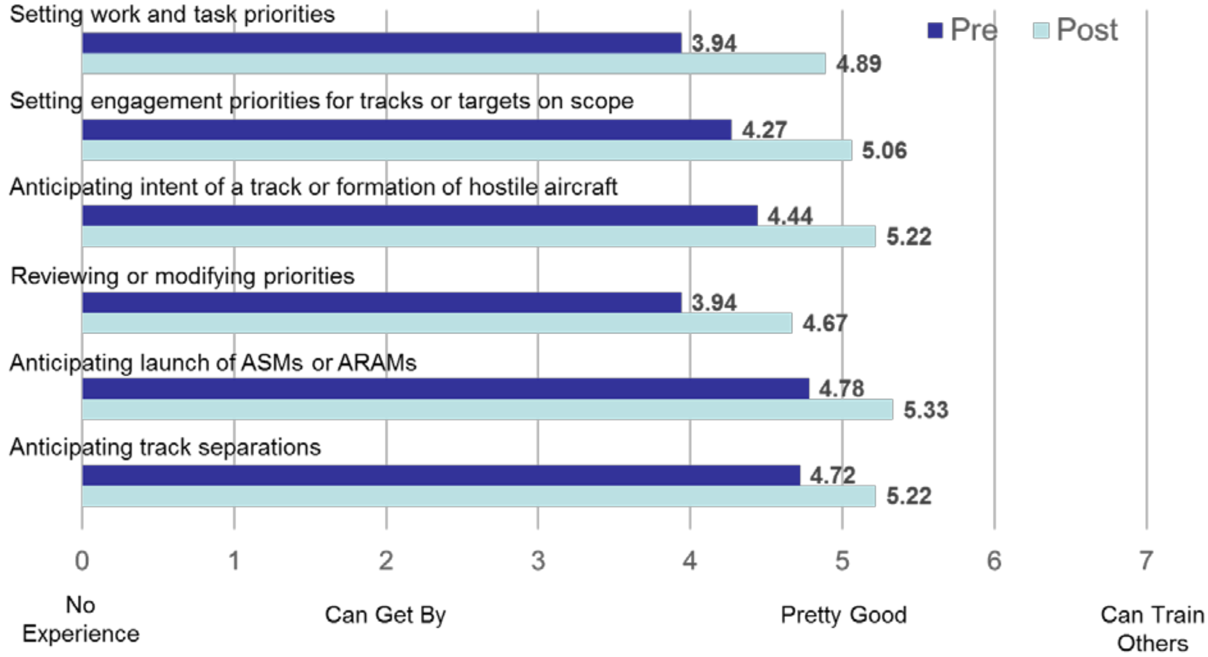

Figure 8. Six Areas of Perceived Improvement Attributed to the Patriot Cognitive Skills Trainer.

Based on the results of the within-subjects repeated measures ANOVA, participants perceived significant improvement in their understanding and skills regarding (a) setting work and task priorities, (b) setting engagement priorities for tracks or targets on scope, (c) anticipating the intent of a track or formation of hostile aircraft, (d) reviewing or modifying priorities, (e) anticipating launch of ASMs or ARAMs, and (f) anticipating track separations. These results appear to relate to two key cognitive skills: anticipating events and prioritizing actions.

User Evaluation of the Patriot Cognitive Skills Trainer

Concluding the data collection, participants were asked to rate the training content and quality of their learning experience. The Training Module Rating Questionnaire was adapted from a six-factor computer-based training evaluation developed by Graves, Blankenbeckler, Wampler, and Roberts (2016). The ratings covered six topic areas: (a) Quality of Learning Experience, (b) Quality of Design and Content, (c) Continuity of Topics, (d) Credible Examples, (e) Focus and Relevance, and (f) User Ability to Track Progress. Participants' detailed responses are presented in Appendix F. Participants were asked to rate statements concerning each of the six topic areas on a standard 5-point Likert scale from 'Strongly Disagree' = 1 to 'Strongly Agree' = 5. Soldiers' responses on the Training Module Rating Questionnaire are summarized in Table 11.

Table 11
Soldiers' Responses on the Training Module Rating Questionnaire

Factor	***N***	***M***	***SD***	**Low**	**High**
Quality of Learning Experience	20	3.66	0.86	1.86	5.00
Quality of Design and Content	20	4.02	0.59	2.86	5.00
Continuity of Topics	20	4.13	0.57	2.80	5.00
Credibility of Examples	20	3.86	0.86	2.00	5.00
Focus and Relevance of Training	20	4.07	0.66	2.75	5.00
Ability to Track Progress in Training	20	4.45	0.51	4.00	5.00

Participants' ratings of the training tended to be positive. The highest rated areas concerned (a) the participants' ability to track their own progress when executing the training, (b) the continuity of topics presented in the training, (c) the focus and relevance of the training, and (d) the quality of training design and content. Although also in the positive direction, the lowest rated areas were factors related to (a) the quality of the Soldiers' learning experience and (b) the credibility of examples. Based on Soldiers' comments, some found the training difficult in that there was no solution that was absolutely "correct" for the types of problems the training presented. Some Soldiers found themselves arguing with the decision and the rationale of the SMEs against which their own decisions and rationale were being scored. For two participants, this created observable frustration—particularly when Soldiers had deprioritized a novel threat in the Run phase of the training that the SMEs had perceived to be far more salient (i.e., swarming HARPYs). In different training situations, this discrepancy could be turned into an informative discussion about decision-making and problem solving in the Patriot operational context.

User Comments

Soldiers were asked to provide feedback on how the PCST could be improved. The following comments were of particular interest:

- "Some answers were dissimilar to SMEs due to battery SOPs." Trainers/instructors could address this issue in AARs and discussions following the training. When the SMEs were presented with the problem sets covered in the training, they were told to answer from the perspective of doctrine and the ROE presented in the training. While unit SOP and ROE will differ between units and particular engagements, we sought to set the context of the scenarios as generally as possible to broaden the applicability of the training to as many units as possible.
- "Maybe have a more experienced TCA paired with a less experienced TCA to clarify unclear things." This is an excellent suggestion for how to utilize the PCST in a battery training context. In one case, two Warrant Officers were working through the training together. This led to a number of informative discussions not only about the problem at hand, but the rationale presented for the decisions and rationale of the SMEs.
- "Make sure all the info is up-to-date and the narrative is up-to-date"; "Familiarity with some threats and aircraft"; "Up-to-date kinematics." Because the training needed to be unclassified, we used somewhat dated kinematics and hardware for the opposing force—

using information available in open sources. The specified technological capabilities of the opposing force were intended to mirror what Soldiers may encounter in a real world, operational context.

Discussion

This research targeted the need to provide ADA Soldiers with cognitive skills training related to fire control decision making in the Patriot system. The training was focused on new TCAs and TCOs, serving as Patriot crewmembers. Our research resulted in the PCST, a computer-based training package that was intended to familiarize less experienced air defenders with the types of complex problem solving and reasoning skills that expert air defenders bring to bear in making their engagement decisions.

Following the fratricide incidents in OIF I, it was noted that crews required training to develop their situational awareness and vigilance with respect to launch control decision making. The Patriot system is highly automated and complex; crews require the expertise to understand the significance of the information the system is presenting to them in order to make effective decisions (Hawley, 2011). This requires cognitive skills related to analyzing and evaluating information, creating solutions, and anticipating outcomes.

The research and training development problem was addressed in three phases. In the first phase, we gathered information on the types of problems that Patriot crews encounter and find difficult to resolve, and sought to develop a training solution to address their identified needs. In the second phase of the research, we developed the training based on our findings from the first phase of the research. In the third, and final, phase of the research, we validated the PCST with Soldiers at the 108th ADA Brigade at Fort Bragg, NC.

Considerations for Training with the Patriot Cognitive Skills Trainer

The PCST is a computer-based training program intended to assist new Patriot TCOs and TCAs in learning the complex decision-making and problem solving skills of more experienced Patriot operators. We envisioned that the trainer would be used in Schoolhouse and unit training settings, incorporating it into existing training to help structure a broader approach to developing decision-making and problem solving skills. One advantage to the unclassified nature of the training is that a unit trainer or instructor can provide the training on a disk for a learner to execute on his or her own. The feedback from each section can be printed and used to facilitate later discussions between the unit trainer/instructor and the learner.

The types of problems the learner encounters within the PCST are rare. To encounter similar decision-making situations and problems in normal operational experience could take many years. The PCST was designed to familiarize Patriot operators earlier in their careers with the types of unfamiliar decision-making situations and problems they may encounter in order to give them insight into how more experienced operators think about and work through similar issues. There are no absolutely correct or incorrect answers to these types of ill-defined problems; what the learner is being trained to do is how to think about these types of problems. A similar training outcome is targeted in SPEAR. While the PCST does not have the on-the-fly adaptability of SPEAR training, it could be used as part of the preparation for the novel problem solving situations Soldiers may experience when engaged in a SPEAR training/certification.

The purpose of the PCST is to provide a supplement to traditional Patriot training, which tends to focus on procedural skills to achieve tactical and technical mastery of the Patriot system. The users of the PCST need to have some understanding of the context of Patriot operations and know how to read and interpret an air battle on scope. They do not require specific knowledge of how to execute technical procedures with the Patriot system. In this way, the trainer targets the cognitive skills needed to make sense of an air battle, interpret changes in information, and make decisions based on that information. The additional cognitive load of operating the technology is reduced in the trainer, allowing learners to focus on critical cognitive skills development.

In developing the PCST we did not seek to simulate sensitive capabilities, processing capabilities, or embedded resources of the operational Patriot system. This choice was made for two reasons. First, many of the technical capabilities and procedures for operating the system are classified. Second, we wanted Soldiers to focus on the air battle and events shaping the context of the air battle. The information used in developing the scenarios and specifying the capabilities of enemy threats was drawn from open source literature. It was determined that having the most up-to-date, and classified, information to enhance the realism of the training would ultimately yield little additional benefit to developing Soldiers' cognitive skills development. The requirement for developing decision-making and problem solving skills would necessitate a plausible set of scenarios and problems and a believable context, but not faithful emulation of the Patriot system and the particulars of current ROE in real-world deployment locations.

Further supporting this focus on cognitive skills development is the application of the METT-T framework to assist crewmembers in identifying relevant information during their decision-making process. This framework was intended to facilitate the learner in visualizing their immediate problem and its context. Through repetition of the METT-T framework across the various problem sets, and reduction in scaffolding feedback, the learner is encouraged to rely more and more on the model to organize information and think through the relevant aspects of their present problem.

Finally, the training was designed to escalate in complexity and difficulty as the learner progresses. This was accomplished by introducing additional decision-triggering events along with reduced information, scaffolding, and feedback. Although our validation of the training took place in a single session, a trainer/instructor would likely be able to yield better results by spreading the training across multiple sessions. This would provide trainers/instructors and learners with time to engage in more in-depth discussions. These discussions would support learners in learning to evaluate scenarios of increasing complexity as well as to evaluate and discuss their own decisions and rationales as well as those of the SMEs presented in the training. This would allow a trainer/instructor to address specific topics concerning how unit SOP and ROE may differ from what is presented in the training, and how those differences may impact decision-making and problem solving in a concrete operational context.

In the second phase of the project, the researchers identified context specific decision-triggering events around which to design the problem sets presented in the trainer. Identifying context specific decision-triggering events seemed to be an effective technique for identifying the types of problems that would have both face validity to learners and elicit the complex cognition necessary for training decision-making and problem solving skills for the Patriot context. A similar technique would be applicable across Army training domains to elicit decision-triggering events around which cognitive skills training could be developed. What is key in the process is identifying problems that elicit a cognitive rather than procedural response. Establishing a viable setting and context for a problem is critical in this respect. For instance, in Patriot operations a fix or fight decision will only arise when there are both enemy targets on scope and a degraded technological capability in the Patriot system. Under those circumstances, operators are forced to decide between addressing the degraded capability, or whether they can still effectively engage the immediate threat on scope first and then address the degraded capability at another time. Working with a set of domain specific decision-triggering events, a training designer can derive a number of different types of problem scenarios that will be novel and plausible to knowledgeable learners and will present a sufficient challenge to their decision-making and problem solving skills.

Validation of the Patriot Cognitive Skills Trainer

Overall, the group of Soldiers we tested the trainer with at the 108th ADA BDE responded positively to the training. While the sample was small (N = 20), it was an ideal mix of TCAs with varying levels of experience and certification, as well as some warrant officers with TCA/TCO experience. The full data collection session required approximately two-and-a-half to three hours. This would not be an ideal period for conducting the training in a regular unit. As noted above, it would be better to spread the training across multiple sessions to allow for discussion between trainers/instructors and learners to evolve.

Given our findings in the first phase of the research that most Patriot training is focused on tactical and technical procedures specific to the system, it was notable that many Soldiers in the validation reported ‘often’ or ‘always’ receiving training related to analyzing and evaluating information to perform various Patriot tasks. Consistently, more than 50% Soldiers from the 108th ADA BDE reported receiving training related to analyzing and evaluating information as well as anticipating and acting to counter events such as track separations, erroneous classification of tracks, launch of ASMs or ARAMs, or the intent of a hostile formation. Eighty percent (80%) of participating Soldiers indicated that they had been provided training on models and methods for problem solving and engagement problems; 65% reported being provided scenarios and situations to assess their critical thinking and problem solving and had been given feedback; and 75% reported being trained on situations to practice critical thinking and problem solving skills. Given these findings, one may conclude that the sample of Soldiers who participated in the evaluation of the PCST were not naïve to training focused on decision-making and problem solving. Without directly observing the in-unit training, however, our conclusions about the degree to which higher-order thinking skills were actually addressed are limited. This set of results may reflect a command emphasis on training these skills at the unit level, but how the reported in-unit training was executed is unknown.

Even given the participants' potential familiarity with training for decision-making and problem solving in the Patriot context, the participating Soldiers appeared to be sufficiently challenged by the scenarios and problem sets presented by the PCST. Most were very successful in the crawl phase of the training, averaging scores of 76%, including some perfect scores of 100%. In the walk phase of training, when they were presented with more complex problems, the participants' average scores dropped to 64%, although some still achieved perfect scores of 100%. Participants appeared to have the greatest difficulty with the run phase of training, which presented them with even more complex problems, reduced information, and reduced scaffolding/feedback. In the first run scenario, participants averaged 53%; dropping to 42% in the second run scenario; and rebounding slightly to 48% in the third run scenario. This pattern of results led us to conclude that the training may be effective in challenging Soldiers who report receiving some background training on decision-making and problem solving skills specific to the Patriot operational context. The PCST may be useful to challenge Soldiers in units even where there already exists some emphasis on training these skills. Soldiers may benefit from in-depth discussions with peers and instructors following the very challenging run phase scenarios.

To derive additional information about participants reaction to the training, we asked them to rate how they perceived their skills to have changed from before the training to after the training. While this is not an ideal approach to looking at the longer-term skill development attributable to the training, it was a more feasible approach compared to alternatives such as a study of far transfer, requiring tracking of participants and later additional data collections. In six of the 11 areas evaluated, participants reported that they perceived improvement in their understanding and skills after training. These six areas mainly focused on anticipating enemy actions and establishing and revising priorities. It is notable that they did not indicate perceived improvement in two areas that were directly related to problem sets within the training—a problem that focused on overcoming enemy jamming of the Patriot radar, and another problem related to a direct SEAD against their battery. Both of these problems were introduced in the run phase of training and may indicate useful topics for additional face-to-face discussion with trainers/instructors.

Overall, Soldiers rated the training positively, particularly in terms of (a) their ability to track their own progress when executing the training, (b) the continuity of topics presented in the training, (c) the focus and relevance of the training, and (d) the quality of training design and content. While still positive, the lowest rated areas concerned (a) the quality of the Soldiers' learning experience and (b) the credibility of examples. Participants' comments may explain these lower ratings, particularly those related to how the PCST differed from unit SOP and that the technology employed in the scenarios was "out-of-date." These ratings reflect the trade-off we made in order to keep the Trainer in the unclassified domain. We focused the training on general Army doctrine—reducing the impact of SOP and theater-specific ROE—and used open source materials to gather information about the technical capabilities of the systems being employed in the scenarios.

Conclusions

This research demonstrates it is possible to train complex cognitive skills for Patriot fire control decision-making and problem solving using hypothetical scenarios and problem sets, and unclassified technical information. The critical aspect of developing this type of training concerns developing a list of viable decision-triggering events, that are both challenging and context specific. Training scenarios can be designed to introduce decision-triggering events in various sequences and rates to increase the complexity of the training that Soldiers are working through. In addition, feedback and scaffolding support can be augmented or diminished to manipulate the challenge presented to learners in the training. Finally, even when training designers are faced with ambiguous or ill-defined problems, they can design feedback for learners around the reactions of more experienced SMEs to the same set of problems. This provides a point of comparison for less experienced learners to gain insight into the decision-making and problem solving processes of those who are more experienced in a domain.

Based on these results, we expect that the PCST may be used to supplement existing training in the ADA Schoolhouse and at the unit level to support the development of skills related to decision-making and problem solving for Patriot operations. While the PCST may be used for stand-alone training, the most benefit will likely be derived when it is incorporated into a training situation that will allow for additional discussion between trainers/instructors and learners.

Key Limitations

A primary limitation of this research was the small sample size used in the validation. A preferable approach would have included a larger number of Soldiers from a variety of units. With a broader sample, variations in organization-specific training emphases and practices would have been mitigated. Moreover, a longer term of evaluation would have enabled us to evaluate training transfer. We can infer from the results of our field test with the PCST that Soldiers felt they learned from the training, but we cannot definitively say that their decision-making and problem solving performance in operational contexts has been improved. In order to determine this, future research could look toward executing longitudinal research emphasizing the transfer of PCST training to the operational context.

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List of Acronyms

AAMDC	Army Air and Missile Defense Command
AAR	After Action Review
ABT	Air Breathing Threats
ADA	Air Defense Artillery
ADDIE	Analysis, Design, Development, Implementation, Evaluation process
AIT	Advanced Individual Training
AMD	Air and Missile Defense
ANOVA	Analysis of Variance
ARAM	Anti-Radiation Missile
ASM	Air to Surface Missile
BDE	Brigade
BOLC-B	Basic Officer Leader Course—Branch
CBRNE	Chemical, Biological, Radiological, Nuclear, and Explosive
CC	Closed Caption
COL	Colonel
CW	Chief Warrant Officer
DUST	Drive-Up Simulation Trainer
ECS	Engagement Control Station
ESS	Explained Sum of Squares
FU	Fire Unit
IAMD	Integrated Air and Missile Defense
ICC	Information Coordination Central
ID	Identification
IFF	Identification of Friends and Foes
IMI	Interactive Multimedia Instruction
JTF	Joint Task Force
LACM	Land Attack Cruise Missile
LOP	Level of Protection
LT	Lieutenant
M	Mean (Average)
MEP	Minimal Engagement Package
METT-TC	Mission, Enemy, Terrain and Weather, Troops, Time, Civil considerations
MG	Major General
MOS	Military Occupational Specialty

NATO	North Atlantic Treaty Organization
OIC	Officer in Charge
OIF	Operation Iraqi Freedom
PAC-2/3	Patriot Advanced Capability Missiles
Patriot	Phased-Array Tracking Radar to Intercept on Target
PCST	Patriot Cognitive Skills Trainer
RAL	Reticle Aim Level
ROE	Rules of Engagement
RS	Radar Set
RT3	Reconfigurable Table Top Trainer
SCUDS	Russian Made Missile
SD	Standard Deviation
SEAD	Suppression of enemy defenses
SME	Subject Matter Expert
SO	Standardization Officer
SOPs	Standing Operating Procedures
SPEAR	Standardized Patriot Evaluation and Assessment Reporting
TBM	Theater Ballistic Missile
TCA	Tactical Control Assistant
TCO	Tactical Control Officer
TDA	Tactical Director Assistant
TF	Task Force
THAAD	Terminal High-Altitude Area Defense
TTP	Tactics, Techniques, and Procedures
USAADASCH	U.S. Army Air Defense Artillery School

APPENDIX A

A Brief Discussion of the Air Defense Mission

A Brief Discussion of the Air Defense Mission

The ADA mission is "to protect the force and selected geopolitical assets from aerial attack, missile attack, and surveillance" (Department of the Army, 2007). The ADA mission makes use of a complex set of lethal missile systems and sensors, among which the Patriot surface-to-air missile system is key to their mission (Department of the Army, 2010a). Patriot batteries and battalions are normally task organized as part of an IAMD TF reinforcing a supported unit's AMD capability and enhancing force protection. These TFs may also include a combination of Army or Joint air defense systems. A TF may consist of a combination of command and control, detection and tracking, and units with their weapon systems. These may include:

- Patriot,
- Terminal High-Altitude Area Defense (THAAD),
- Short range air defense systems,
- Counter rockets, artillery, and mortar system,
- Long range alert and tracking radar systems,
- Area air defense command and control systems, and
- Other Joint and multinational capabilities or units.

The composition of an IAMD task force is based on specific mission requirements, units, and systems available.

While conventional thinking may view IAMD as primarily a wartime or contingency operation, today U.S. Army Patriot units play a vital role in deterrence through "Patriot Diplomacy." The forward deployed presence and the familiar silhouettes of Patriot launchers on foreign soil provide tangible evidence of U.S. commitment to allies, a resource to preserve peace and deter hostilities in potentially unstable regions. Army Patriot units are currently deployed in operational missions across the globe, providing protection to allied cities, transport and logistic facilities, waterways, and air corridors as well as forward deployed U.S. forces and facilities. The proximity of these forward deployed units to potentially hostile nations and the relative short flight times of available strike aircraft and missile systems of these nations, keep Patriot crewmembers only seconds away from the front page of tomorrow's newspaper or a flash bulletin on one of the 24-hour news channels should their mission of deterrence fail.

For contingency operations or war, Patriot may be present in the AMD force package of a mature or maturing theater of operations (Department of the Army, 2008a). For example, initial entry of U.S. forces into an opposed or unopposed theater is generally characterized by a buildup through the introduction of tailored force packages and elements. For the Patriot, this initial air or sea deployable element may be as small as a minimal engagement package (MEP) (O'Neil, 2011). A basic MEP consists of an engagement control station (ECS), a radar set (RS), two or more launchers, electric power plant, repair parts, limited utility and cargo vehicles, a fuel tanker, guided missile transporters, and a mission tailored load of missiles. A MEP deploys with sufficient supporting equipment, munitions, supplies, rations, and personnel to sustain 24-hour operations for only a limited period. The exact composition is mission and situation dependent. However, for the Soldiers manning a MEP the responsibilities for protection of the supported force against air and missile attacks are enormous.

In contrast, a full Patriot battalion may consist of a headquarters battery, a maintenance company, and between four and six firing batteries along with all of their primary weapons systems and supporting equipment (Department of the Army, 2010a). Current configurations include "pure" battalions and mixed battalions providing a combination of Patriot, the short range Avenger, and THAAD missile systems. A Patriot firing battery generally consists of six launching stations, RS, ECS, electric power plant, and one antenna mast group (AMG). The Patriot units' ability to simultaneously engage large numbers of attacking aircraft, theater ballistic missile (TBM) systems, standoff jammers, and specific aircraft at relatively long ranges, allows the supported commander increased freedom to execute the close as well as the deep battle with reliable protection against enemy aircraft and missile attacks (Department of the Army, 2008a).

While there are currently several system and missile variants, two primary missile types provide defensive lethality to the Patriot system: 1) the Patriot Advanced Capability (PAC)-2 and 2) PAC-3 missiles (Department of the Army, 2010a).[10] Varied engagement techniques are available to the ECS crew.

Patriot may be employed to execute a variety of AMD roles. These roles include, but are not limited to:

- Executing long and medium range engagements against manned and unmanned enemy aircraft, airborne jammers, and reconnaissance systems;
- Bounding forward with attacking or maneuvering forces to provide protection for elements within an axis of advance or priority sector;
- Protecting defending or stationary forces and/or facilities with overlapping fires, defense in depth, and weighted coverage;
- Protecting AMD radars and installations against attack by air-to-surface (ASM), anti-radiation missiles, and land attack cruise missile (LACM) systems; and
- Providing single system TBM defense or the lower-tier of integrated TBM defenses.

Patriot fire units (FUs) acquire and track the incoming threats using strategic and theater detection and interceptor systems and organic sensors (Department of the Army, 2010a). AMD operations are characterized by centralized control and planning and decentralized execution and

[10] The PAC-2 configuration is the larger of the two and provides a single missile in a canister with a load of four canisters per launcher. PAC-2 is a single-stage, solid-fuel, ground-launched interceptor designed to destroy aircraft, cruise missiles, or tactical ballistic missiles with a conventional high-explosive warhead and proximity fusing. With a maximum speed of over 3,500 mph (1.56 kilometers per second), it operates between 1.5 and 20 miles (105,600 feet/32 kilometers) altitude and has a range in excess of 60 miles (96.5 kilometers). While optimized for missile engagements, the PAC-2 has a primary role against high performance aircraft and other threat air breathing threats. The PAC-3 was designed from inception as an agile, high velocity missile interceptor. It defeats incoming targets by direct body-to-body impact. However, it employs a lethality-enhanced explosive warhead with a radial pattern of fragments to increase missile cross-section and enhance kill probability. The PAC-3 configuration provides four missiles in a canister with four canisters (16 missiles) per Patriot launch station.

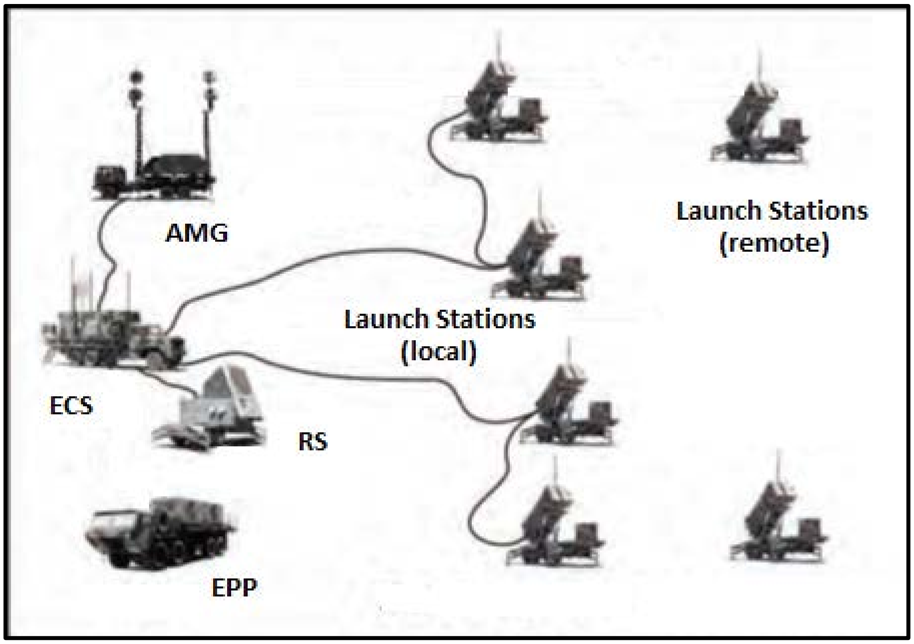
engagements. Depending on the directed alert state[11] and weapons control status[12], the crew takes the handoff of hostile tracks as they come within range, threaten a protected asset, or when engagements are directed against specified tracks or track types. Aircraft engagements are generally performed under centralized control to optimize fires as well as to minimize fratricide risks. Missile engagements may be executed by Patriot units alone or in coordination with THAAD units, with Patriots operating as the lower tier of a two-tier system. In these integrated TBM defenses, coordination is required to optimize the use of interceptor resources as well as to ensure the required level of protection (LOP)[13] for resources and units being defended.

Engagements by the Patriot FU are controlled and executed by the battery ECS. Figure 1 provides an example of the FU's deployment and the battery data network. Supported by varied radio and cable communications systems, the data network provides connectivity between the ECS, the RS, and its launchers, as well as the ECS and the broader AMD system. This data network is used to monitor tracks, launch missiles, establish missile availability, and monitor launch station status.

[11] Alert states represent the degree of readiness of ADA units, from the time of alert notification, to the time of engagement capability or battle stations. The decision as to which to degree of readiness to implement is situation dependent and determined by the commander in coordination with higher headquarters or the controlling authority, as appropriate. Alert states may be used to specify personnel and manning requirements. Utilizing alert states allows for maximum flexibility to conduct training, sustainment operations, or perform other duties while meeting mission requirements.

[12] Weapon control statuses (**Weapons Free**, **Weapons Tight**, **Weapons Hold**) describe the relative degree of control of air defense fires. Weapon control statuses may apply to weapon systems, volumes of airspace, or types of hostile air platforms or missiles. The degree or extent of control varies depending on the tactical situation. Establishment of separate weapon control statuses for fixed and rotary wing aircraft, UAV, and missiles is normal. Air and missile defense forces have the ability to receive and disseminate weapon control statuses for all classes of air platforms. **Weapons Free** is the least restrictive. Weapons can fire at any air target not positively identified as friendly. **Weapons Tight** limits engagements to targets that are identified as hostile according to the prevailing hostile criteria. Identification can be effected by a number of means to include visual identification (aided or unaided), electronic, or procedural means. Capabilities dictate that ADA units engage TBMs and ASMs based on classification, not identification. **Weapons Hold** is the most restrictive weapon control status and units are not to engage except in self-defense or in response to a formal order.

[13] For a detailed explanation of the integrated TBM defense, levels of TBM operational engagement effectiveness, and LOP see Chapter 3 of ATTP 3-01.87 (Department of the Army, 2010b)



Appendix A, Figure 1. Patriot Battery Data Net (adapted from page C-12 of FM 3-01.85)

During FU operations, the ECS is the only manned piece of equipment. It is operated by a crew of three, consisting of one tactical control officer (TCO), one tactical control assistant (TCA), and one network switch operator. Three crewmembers are generally available to assure continuous, 24-hour operations. ECS operators, under the direction of the TCO, initiate manual target engagements or enable the Patriot to engage selected types of targets automatically. The TCO is usually an air defense lieutenant or warrant officer and the TCA, a junior or mid-grade air defense noncommissioned officer (NCO). While AMD headquarters establishes priorities for protection, alert state, weapons system status, and Rules of Engagement (ROE)[14] control the air defense battle, the ultimate FU engagement decision is made by the TCO and crew of the ECS using information available to them at the time. While the higher headquarters may provide guidance and directives, nothing precludes the battery from taking actions in self-defense against air or missile attacks.

The potential threats that could require defense by Patriot capabilities are numerous. For example, a brief and unclassified review of order of battle and organizational factors indicates that over 30 other nations in the world hold operational tactical (shorter than 300 kilometers [km] in range) and theater ballistic missile (TBM) systems (George C. Marshall & Claremont Institutes, 2012a & 2012b). TBMs vary from the larger intercontinental ballistic missiles to smaller tactical systems. Larger TBMs may have a range of up to 3,500km. TBMs are designed to carry not only conventional warheads but also chemical, nuclear, conventional, or improved conventional warheads. Older systems are retained from the Cold War Era by some nations; other systems are the product of more current development and fielding. At least 20 nations hold

[14] ROE are rules or directives to military forces that define the circumstances, conditions, limitations, procedures, and manner in which the use of force can be initiated or continued. For example, prior to hostilities, ROE may be very restrictive to prevent the engagement of a potentially unfriendly aircraft until the aircraft commits an aggressive act or penetrates into a friendly territory beyond the limits possible due to simple navigation error.

operational Land Attack Cruise Missile (LACM) systems. Most LACMs have variants that are both surface (land or sea) and air launched. A few models can be submarine launched. LACMs also vary in range with short-range systems reaching out to 300km while others have a 1,000km range. They also vary from the more common subsonic systems (similar to the U.S. BGM-109 Tomahawk), to supersonic systems (some held by China [PRC] or Russia). Additionally, Russia and India are jointly developing a hypersonic system reported to travel at least five times faster than the speed of sound (Indian Defense Update, 2016). LACMs may also deliver a full array of warhead types.

Similarly, over 100 nations of the world possess inventories of aircraft classified as combat aircraft and combat helicopters (Flightglobal, 2013). These air forces vary in capabilities, training, and platform operational availability. Fixed wing combat aircraft include bombers, fighters/interceptors, fighter-bombers, or multi-purpose. These Air-Breathing Threats (ABTs) are armed with a wide array of cannon and/or machine gun systems and may be purpose designed or modified to carry air-to-surface missiles and bombs with chemical, nuclear, conventional, or improved conventional payloads. Modern ABTs generally travel at high speeds, and must be detected and reported by satellite, airborne, and/or surface based radars and sensor systems. Based on radar signature, ABTs are designated as friend or foe, and are accurately tracked for successful engagement. As an example, the Korean People's Army Air Force (North Korea) retains more than 570 combat aircraft and 150 combat helicopters. While some of their aircraft are obsolete, operational availability of other platforms is suspect, and proficiency training in some units is minimal, the North Korean Air Force holds modern aircraft in trained front line priority units. By today's standards, North Korea poses a very credible threat to U.S. Forces and our allies in the region.

TBMs and LACM share some common characteristics. While a few older versions require fixed sites for launch, most modern ground launched systems are fired from modified heavy truck or tracked carriers, fully integrated transporter-erector-launchers. Most transporter-erector-launchers can be readied or fueled in a short time and may be accompanied by support and reload vehicles, dramatically reducing the time required to displace, reload, and fire again. Launch locations can be purpose prepared sites, a stretch of highway, a field, or an accessible clearing in a forest. Most have improved accuracy designs and more modern systems have integrated counter measures. TBMs have short flight times (medium range systems are +/- seven minutes; shorter range systems are +/- 160 seconds) and low launch and flight signatures that complicate detection, tracking, and classification. Reentry speeds for some long range TBMs approach Mach 25, but atmospheric friction or deliberate deceleration systems slow the reentry vehicle and warhead in the lower atmosphere.

Hostile air and missile attacks would seldom come from a single system or platform. Air offensive operations are coordinated efforts employing varied types of combat aircraft and missile systems in diverse roles. Generally air and missile attacks are massed against critical command and control facilities, fixed installations, specific maneuver units, or terrain restricting the maneuver of the opposing force. Specialized systems may be targeted against air and air defense systems. The effective suppression of enemy air defense (SEAD) has become a key aspect for winning the air battle in modern era conflicts (Department of the Army, 2006). Air defense systems, such as Patriot, become critical/high payoff targets for the enemy as they strive to gain air supremacy[15] and dominance in the sky. A weapon frequently employed in SEAD operations is the anti-radiation missile (ARM). ARMs are specialized air-to-surface missiles designed to detect and home in on an active radio emission source, typically an opponent's ground-based air defense radar. Tailored SEAD strike packages frequently include specialized ARM launchers as well as jammers and escort aircraft armed with cluster bombs to destroy air defense command posts, launchers, and support equipment. A SEAD strike package has the objective of destroying or disrupting one or more of the opponent's air defense sites and inflicting sufficient damage to keep them out of operation for an extended period.

[15] Air supremacy is a position or state in armed conflict where a side holds complete control of air warfare and air power over opposing forces. It is defined by NATO and the United States Department of Defense as the "degree of air superiority wherein the opposing air force is incapable of effective interference.

APPENDIX B

Example Scenarios and Decision Points

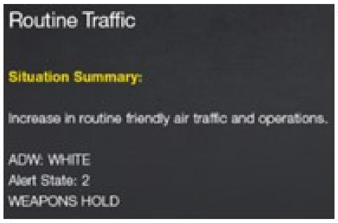
Summary of Cognitive Skills Training

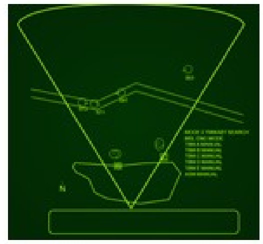
- The training is organized into three progressively more difficult sections. As training scenarios become more complex, trainees are provided less direct feedback after each decision, prediction, or prioritization they make. Instead, the consequences of their decisions are allowed to play out and they are given an opportunity to try again. At the end of each section—including multiple decision points—trainees are provided feedback summarizing the similarity of their responses to those of the SMEs for that section of the training.

- At the end of a section, auditory feedback is provided that includes an explanation of how SMEs arrived at their decisions, predictions, and prioritizations. This feedback also includes suggestions for how trainees may better align their cognitive processes with those of the SMEs.

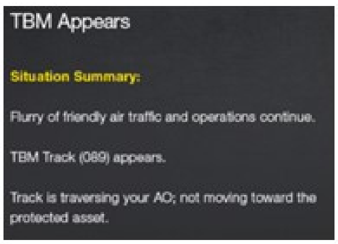
Crawl Scenario Example

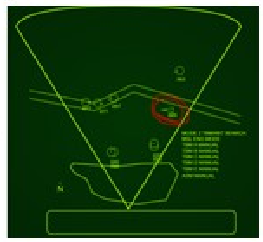
Crawl Scenario Part I



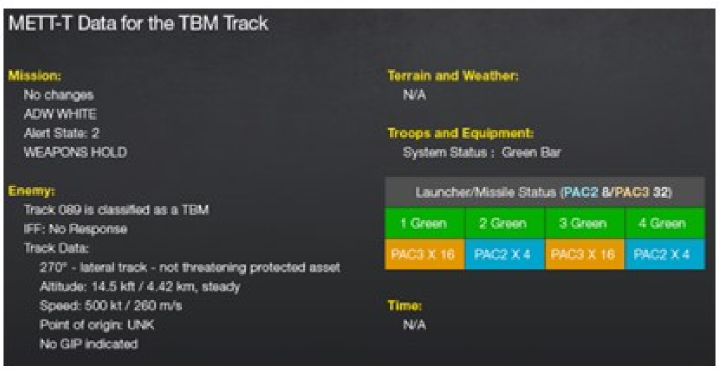


(1) Routine Traffic



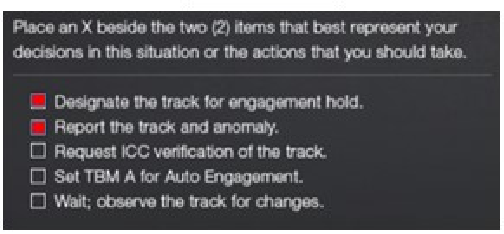


(2) TBM appears, but not moving toward protected asset



(3) Trainee provided summary of situation.

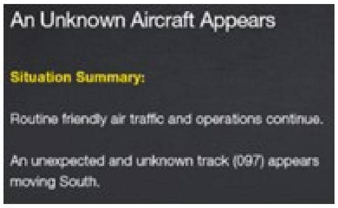
Decision



(4) Trainees asked to select two items best representing their decisions. They are also asked to identify three items of information that most contributed to their decision(s). Trainees are provided feedback comparing their decisions and rationale to those of the SMEs.

Reasons for Decision

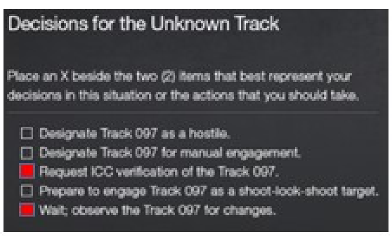
Crawl Scenario Part II



(5) Unknown aircraft moving south toward protected asset.

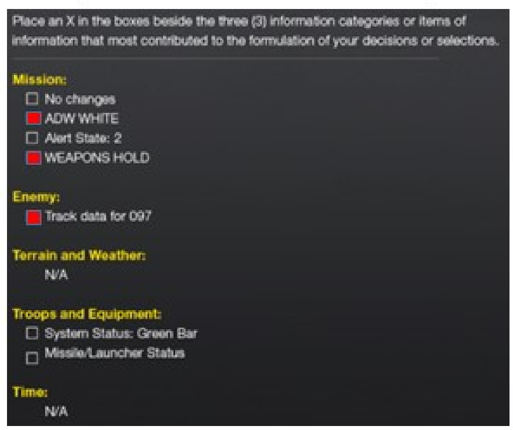
(6) Trainee provided summary of situation concerning unknown track.

Decision

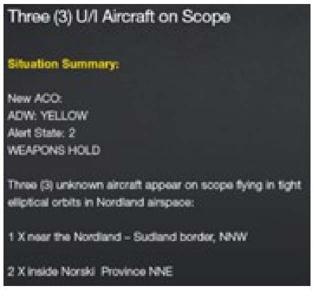


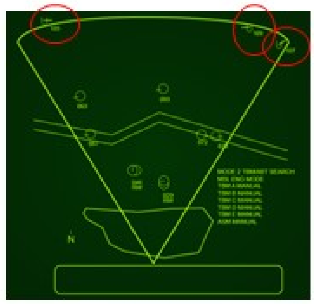
(7) Trainee selects two items that best represent their decisions, and then identify three items of information that most contributed to their decision. Trainees are provided feedback comparing their decisions and rationale to those of the SMEs.

Reasons for Decision



Crawl Scenario Part III

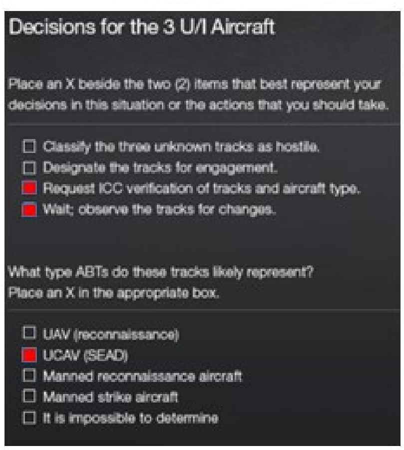




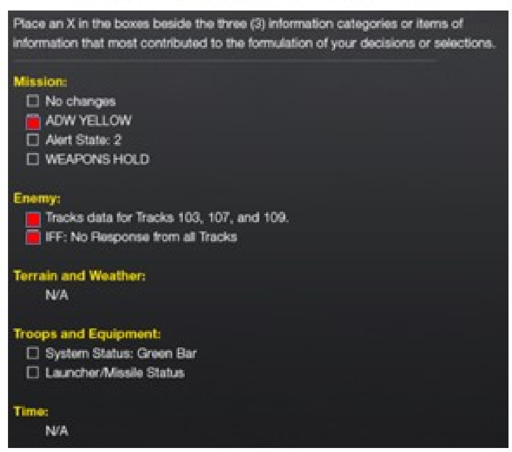
(8) Three unknown aircraft flying in tight elliptical orbit at periphery of scope.

(9) Trainee provided summary of situation concerning the 3 unidentified aircraft.

Decision



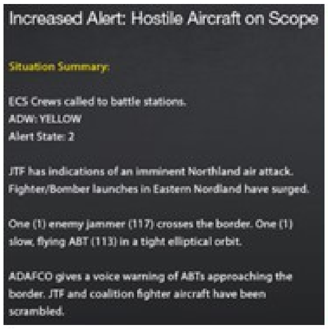
Reasons for Decision

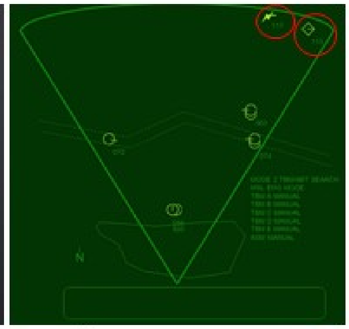


(10) Trainee selects two items that best represent their decisions, and to identify what the U/I tracks could possibly be. Then, they are asked to identify three items of information that most contributed to their decision. Trainees are provided an overall rating of how closely their decisions and selections of critical information matched the experienced SMEs' responses. Additional auditory feedback is provided to assist Trainees in better understanding and aligning their cognitive processes with those of SMEs.

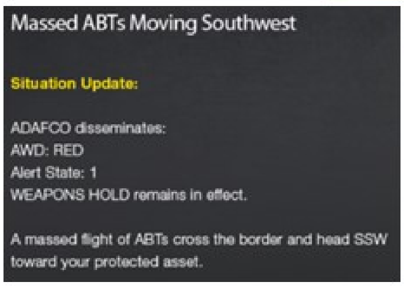
Walk Scenario Example

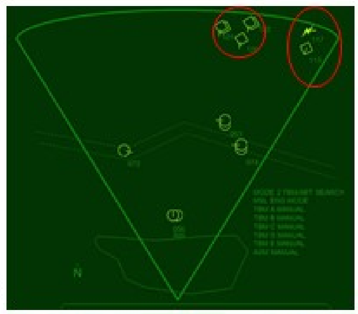
Walk Scenario Part I



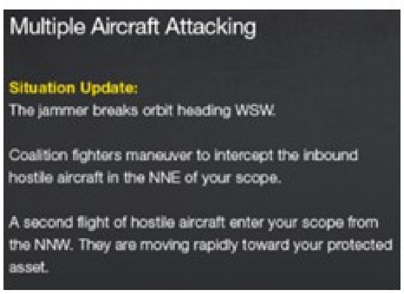


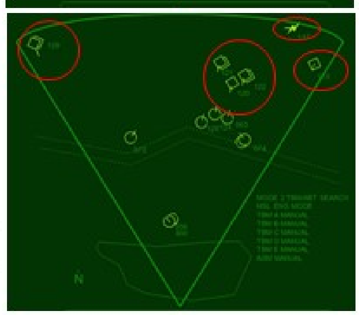
(1) Increased alert. Hostile aircraft on scope, including a jammer and slow flying air-breathing threat (ABT) in elliptical orbit. ABTs approaching border; coalition aircraft scrambled.





(2) Massed ABTs moving southwest toward protected asset.

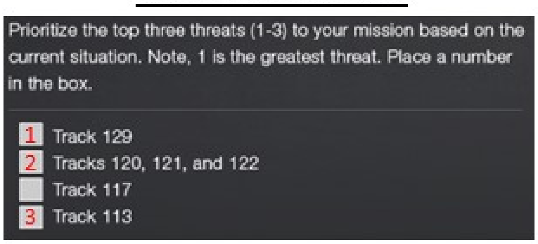




(3) Jammer begins moving west-southwest. Coalition aircraft move to intercept hostile aircraft in north-northeast of scope. Second flight of hostiles enter scope from north-northwest moving toward protected asset.

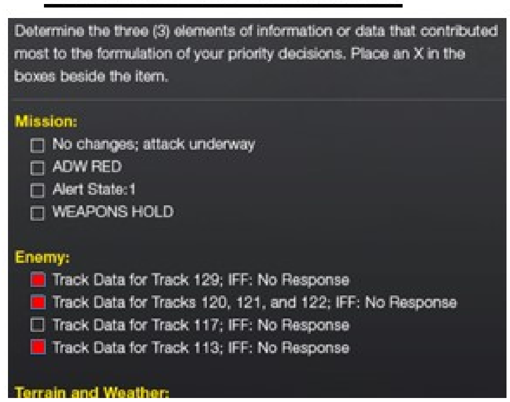
(4) Trainee provided page summarizing the situation. Then asked to prioritize their top three decisions and rationale.

Threat Priorities

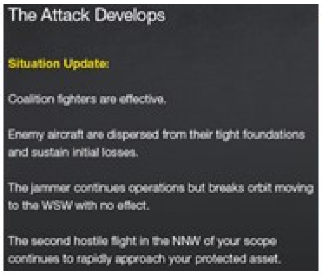


(5) Trainees are provided feedback on their decision priorities and rationale.

Reasons for Priorities



Walk Scenario Part II


The Attack Develops

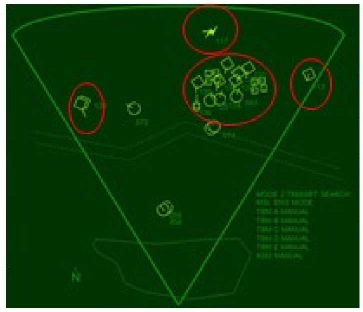
Situation Update:

Coalition fighters are effective.

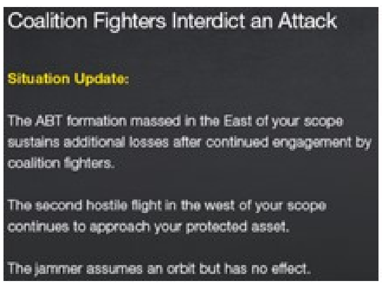
Enemy aircraft are dispersed from their tight foundations and sustain initial losses.

The jammer continues operations but breaks orbit moving to the WSW with no effect.

The second hostile flight in the NNW of your scope continues to rapidly approach your protected asset.



(6) The attack develops. Enemy aircraft are dispersed. Jammer is operating, but with no effect. Second flight continues to approach asset from NNW.

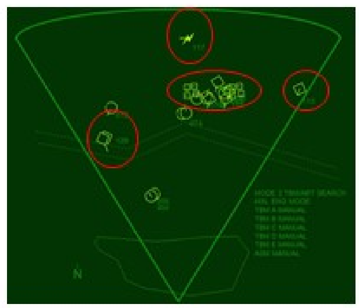

Coalition Fighters Interdict an Attack

Situation Update:

The ABT formation massed in the East of your scope sustains additional losses after continued engagement by coalition fighters.

The second hostile flight in the west of your scope continues to approach your protected asset.

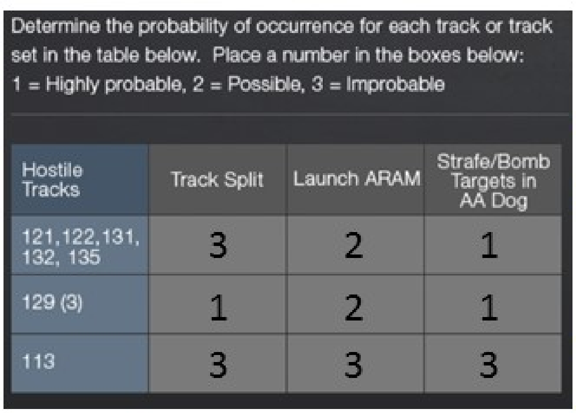
The jammer assumes an orbit but has no effect.



(7) ABT formation sustain additional losses. Second hostile flight continues approach. Jammer assumes orbit, but no effect.

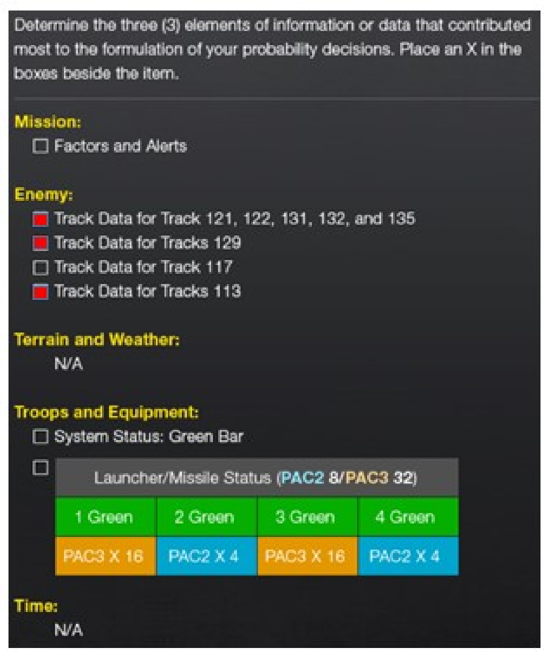
(8) Trainees are provided a summary of the situation. Then they are asked to determine the probability of occurrence for track split, missile launch, and strafe/bomb targets in the protected area for each track.

Probability Ratings


Determine the probability of occurrence for each track or track set in the table below. Place a number in the boxes below:
1 = Highly probable, 2 = Possible, 3 = Improbable

Hostile Tracks	Track Split	Launch ARAM	Strafe/Bomb Targets in AA Dog
121,122,131, 132, 135	3	2	1
129 (3)	1	2	1
113	3	3	3

Reasons for Ratings


Determine the three (3) elements of information or data that contributed most to the formulation of your probability decisions. Place an X in the boxes beside the item.

Mission:
- ☐ Factors and Alerts

Enemy:
- ■ Track Data for Track 121, 122, 131, 132, and 135
- ■ Track Data for Tracks 129
- ☐ Track Data for Track 117
- ■ Track Data for Tracks 113

Terrain and Weather:
N/A

Troops and Equipment:
- ☐ System Status: Green Bar
- ☐

Launcher/Missile Status (PAC2 8/PAC3 32)			
1 Green	2 Green	3 Green	4 Green
PAC3 X 16	PAC2 X 4	PAC3 X 16	PAC2 X 4

Time:
N/A

(9) Trainees are provided feedback on their probability ratings and rationale.

Walk Scenario Part III

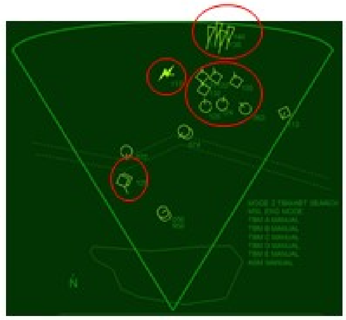
SCUDs on Scope 1

Situation Update:
ADAFCO warns of TBM launces, four (4) SCUDs appear on your scope converging on AA DOG.

The hostile flight in the West continues to rapidly close on AA DOG.

The ABT formation massed in the East of your scope sustains additional losses and appears to be maneuvering to exfiltrate.

The jammer (117) continues in orbit.



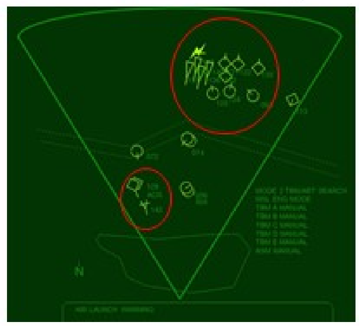
(9) Four SCUDs on scope, headed toward AA Dog. Hostile flight in west continues to close on the protected area. ABT formation appears to be moving to exfiltrate. Jammer continues to orbit.

SCUDs and an Air Launch

Situation Update:

SCUDs continue South and you are directed to engage them.

The system alerts you to an Air Launch.



(10) Directed to engage SCUDs. System alerts an air launch.

(11) Trainees are provided a summary of the situation. Then they are asked to prioritize threats to their mission, ID the theater ballistic missiles, and ID the information that contributed to their decision. (12) They are then provided feedback on their responses.

Decisions

Prioritize the top three threats (1-3) to your mission based on the current situation. Note, 1 is the greatest threat.

- 2 Tracks 137, 138, 139, and 140
- 1 Track 142
- Track 129
- 3 Track 113

Indicate the most probable classification of the inbound TBMs (Tracks 137, 138, 139, & 140). Place an X in the appropriate box.

- [ ] SS-21 Scarab B
- [ ] Hwasong 5 (SCUD B variant)
- [x] Hwasong 6 (SCUD C variant)
- [ ] No Dong 1/No Dong A

Indicate the type of ARM or ASM indicated by the inbound Track 142. Place an X in the appropriate box.

- [ ] C-802KD, KD-88 (CSS-N-8 Saccade) - ASM
- [ ] Kh-23 (AS-7 Kerry) - ASM
- [ ] Kh-58EM (AS-11 Kilter) - ARM
- [x] Kh-31P (AS-17 Krypton) - ARM

Contributing Information

Determine the three (3) elements of information or data that contributed most to the formulation of your threat priority decision. Place an X in the boxes beside the item.

Situation Update:
- [ ] ADW RED
- [ ] Alert State: 1
- [ ] WEAPONS HOLD

Enemy:
- [x] Track Data for Tracks 137, 138, 139, and 140; IFF: No Response
- [x] Track Data for Track 129; IFF: No Response
- [x] Track Data for Track 142; IFF: No Response
- [ ] Track Data for Track 113; IFF: No Response

Terrain and Weather:
N/A

Troops and Equipment:
- [ ] System Status: Green Bar
- [ ] Launcher/Missile Status (PAC2 8/PAC3 32)

1 Green	2 Green	3 Green	4 Green
PAC3 X 16	PAC2 X 4	PAC3 X 16	PAC2 X 4

Time:
N/A

Walk Scenario Part IV

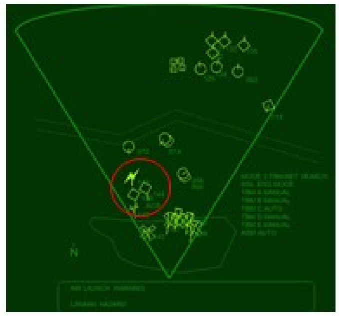
SCUDs on Scope 1

Situation Update:
ADAFCO warns of TBM launces, four (4) SCUDs appear on your scope converging on AA DOG.

The hostile fight in the West continues to rapidly close on AA DOG.

The ABT formation massed in the East of your scope sustains additional losses and appears to be maneuvering to exfiltrate.

The jammer (117) continues in orbit.



(13) SCUDs and inbound ARM have been destroyed. Track split and air launch warning. Hazard warning on Launch Station 3.

(14) Trainees are provided a summary of the situation. Then they are asked to prioritize threats to their mission, ID the inbound ARM/ASM, and ID the slow moving ABT, and to recommend the priority action for the Battery. They then identify information that contributed to their decision.

Decisions

Prioritize the threats (1-3) to your mission based on the current situation. Note, 1 is the greatest threat.

- 2 Tracks 143(JAMMER), 144, and 129 (ACR)
- 1 Track 145
- 3 Track 113

Indicate the classification/type of the inbound slow moving ABT indicated by Track 113. Place an X in the appropriate box.

- ☐ Helicopter
- ☐ ASN-105B UAV
- ☐ Shmel-1 UAV
- ☒ Harpy UCAV

Indicate the type of missile indicated by the inbound ARM/ASM Track 145. Place an X in the appropriate box.

- ☐ C-802KD, KD-88 (CSS-N-8 Saccade) - ASM
- ☐ Kh-23 (AS-7 Kerry) - ASM
- ☐ Kh-58EM (AS-11 Kilter) - ARM
- ☒ Kh-31P (AS-17 Krypton) - ARM

What is your recommended priority for the Battery? Place an X in the box with the highest priority.

- ☐ Reload LS 1
- ☐ Reload LS 3
- ☒ Address the HAZARD on LS 3

Contributing Information

(15) Trainees are provided an overall rating of how closely their decisions and selections of critical information matched the experienced SMEs' responses. Additional auditory feedback is provided to assist trainees in better understanding and aligning their cognitive processes with those of SMEs.

Determine the three (3) elements of information or data that contributed most to the formulation of your threat priority decision. Place an X in the boxes beside the three items.

Mission
- ☐ ADW RED
- ☐ Alert State: 1
- ☐ WEAPONS HOLD

Enemy
- ☒ Track Data for Tracks 143, 144, and 129; IFF: No Response
- ☒ Track Data for Track 145; IFF: No Response
- ☒ Track Data for Track 113; IFF: No Response

Terrain and Weather

N/A

Run Scenario Example

Run Scenario I

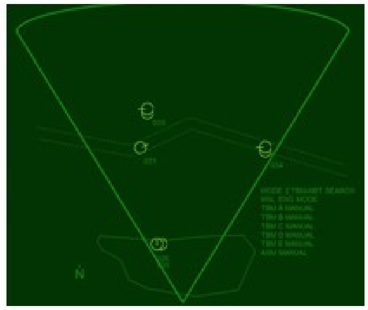
Run Phase Mission 1: Battle Stations

Situation Summary:

ECS Crews are called to battle stations.
ADW: YELLOW
Alert State: 2
WEAPONS HOLD

JTF 526 has indications of imminent Nordland air and missile attacks targeted against U.S. and coalition air and air defense forces. ABT launches in Nordland have surged and TBM forces are on alert and at a high state of launch readiness.

ADAFCO provides warning of hostile aircraft approaching from the North and announces that JTF and coalition fighter aircraft have been scrambled.



(1) Crews called to battle stations. Attack imminent. Warning of hostile aircraft approaching. Coalition aircraft scrambled.

ABTs on Scope

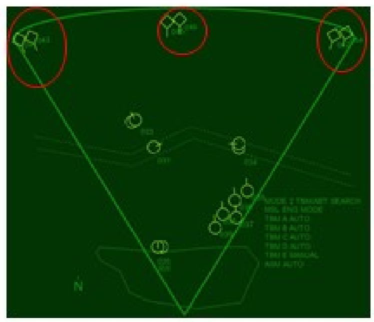
Situation Update:

ADAFCO disseminates:
ADW: RED
Alert State: 1
WEAPONS HOLD remains in effect.

You are directed to engage TBMs targeted against AA DOG and Missile Engagement Modes have been updated to AUTO.

Three (3) hostile flights appear on your scope advancing toward AA DOG.

Coalition fighters appear on scope.



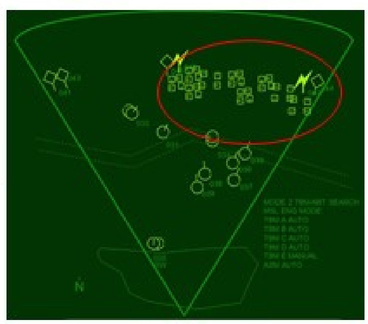
(2) ABTs and coalition fighters on scope. Directed to target TBMs targeted at AA Dog.

Threat Aircraft Initiate ECM

Situation Update:

Inbound hostile aircraft initiated ECM.

Coalition fighters maneuver to intercept hostile aircraft.



(3) Threat aircraft initiate electronic countermeasures. Coalition fighters maneuver to intercept.

(4) Trainees are provided a summary of the situation.

CONTINUED ON FOLLOWING PAGE

Run Scenario I

Decisions

Prioritize the threats (1 – 3) to your mission based on the current situation. Note, 1 is the greatest threat. Place the number in the appropriate box.

- ☐ Inbound ABTs
- ☐ Jammers and ECM
- ☐ TBMs

Which action should be your highest priority at this stage of the air battle? Place an X in the box beside the appropriate item.

- ☐ Prepare to engage ABTs.
- ☐ Prepare to engage the inbound jammers only.
- ☐ Implement all available PATRIOT Electronic Counter Countermeasures (ECCM).

(4) Trainees are asked to prioritize threats to their mission, and then to identify the highest priority at this point in the air battle.

Contributing Information

Determine the three (3) elements of information that contributed most to the formulation of your priority decision. Place an X in the boxes beside your selected items.

Mission:

- ☐ No change; air attacks are underway and missile attack warnings have been issued, targets are US/coalition air and air defense forces.
- ☐ ADW RED
- ☐ Alert State: 1
- ☐ WEAPONS HOLD

Enemy:

- ☐ Data for Tracks 041 and 043; IFF: No Response
- ☐ Data for Tracks 045 and 046; IFF: No Response
- ☐ Data for Tracks 042 and 044; IFF: No Response

Terrain and Weather:

N/A

Troops and Equipment:

- ☐ System Status : Green Bar
- ☐

Launcher/Missile Status (PAC2 8/PAC3 32)			
1 Green	2 Green	3 Green	4 Green
PAC3 X 16	PAC2 X 4	PAC3 X 16	PAC2 X 4

Time:

N/A

(5) NO DIRECT FEEDBACK IS PROVIDED.

Run Scenario I (Continued)

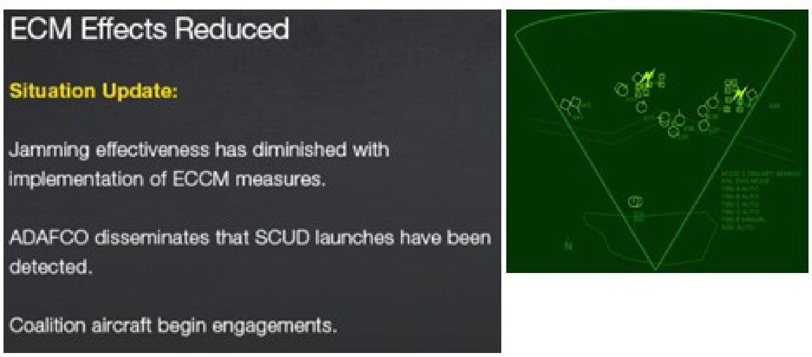
The next step in the scenario is based on how trainees answered the previous questions.

Negative Outcome: Decision to Engage ABTs or Jammers

(6a) Enemy ECM are effective. SCUD launches detected. Coalition aircraft begin engagements.

(7a) Continued ECM effects. SCUDs on scope. Air launch detected.

Positive Outcome: Decision to Employ ECCM



(6b) Jamming effectiveness diminished. SCUD launches detected. Coalition aircraft begin engagements.

(7b) ECCM localized effect of jamming against radar. SCUD missiles on scope. Air launch detected.

Run Scenario I (Continued)

(8) Trainees are provided a summary of the situation.

Air and TBM Attacks Are Underway

Mission:
No changes; air and missile attacks are underway.
ADW RED
Alert State: 1
WEAPONS HOLD

Terrain and Weather:
N/A

Troops and Equipment
System Status: Green Bar

Launcher/Missile Status (PAC2 8/PAC3 32)			
1 Green	2 Green	3 Green	4 Green
PAC3 X 16	PAC2 X 4	PAC3 X 16	PAC2 X 4

Time
N/A

Enemy:
Tracks 047, 052, 053, and 054 are classified as hostile TBMs
GIPs: Southern area of AA DOG and your battery location
IFF: No Response
Track Data:
- Heading S (168°) toward the protected asset
- Steep dive angle from extreme altitude
- Speed: 6,800 kt/ 3,500 m/s
- Point of origin: BMOA 10

Tracks 041 and 043 (ACR) are classified as a hostile ABTs.
IFF: No Response
Track Data:
- Heading SSE (150°) toward protected asset
- Altitude: 48.5 kft/ 14.8 km, steady
- Speed: 425 kt/ 210 m/s
- Point of origin: Roach
- Length: 16.8 meters

Tracks 048, 049, 050, and 051 are classified as a hostile TBMs
GIPs: Southern area of AA DOG and your battery location
IFF: No Response
Track Data:
- Heading S (193°) toward the protected asset
- Steep dive angle from extreme altitude
- Speed: 6,800 kt/ 3,500 m/s
- Point of origin: BMOA 8

Track 055 is classified as a Hostile ASM (potential ARM)
IFF: No Response
Track Data:
- Heading SSE (150°) toward the protected asset
- Altitude: 46 kft/ 14 km, diving
- Speed: 1,470 kt/ 760 m/s
- Point of origin: Track 043
- Length: 5 meters

Decision

Prioritize the top three threats (1 – 3) to your mission based on the current situation. Note, 1 is the greatest threat. Place the numbers in the boxes beside the item.

- ☐ Tracks 047, 048, 049, 050, 051, 052, 053, and 054
- ☐ Tracks 041 and 043
- ☐ Track 055

Contributing Information

Determine the three (3) items or elements of information or displayed data that contributed most to the formulation of your threat priority decision. Place an X in the boxes beside the items.

Mission:
- ☐ No change; air and missile attacks are underway.
- ☐ ADW RED
- ☐ Alert State: 1
- ☐ WEAPONS HOLD

Enemy:
- ☐ Data for Tracks 047, 052, 053, and 054; IFF: No Response
- ☐ Data for Tracks 048, 049, 050, and 051; IFF: No Response
- ☐ Data for Tracks 041 and 043; IFF: No Response
- ☐ Data for Track 055; IFF No Response

Terrain and Weather:
N/A

Troops and Equipment:
- ☐ System Status : Green Bar
- ☐

Launcher/Missile Status (PAC2 8/PAC3 32)			
1 Green	2 Green	3 Green	4 Green
PAC3 X 16	PAC2 X 4	PAC3 X 16	PAC2 X 4

Time:
N/A

(9) NO DIRECT FEEDBACK PROVIDED.

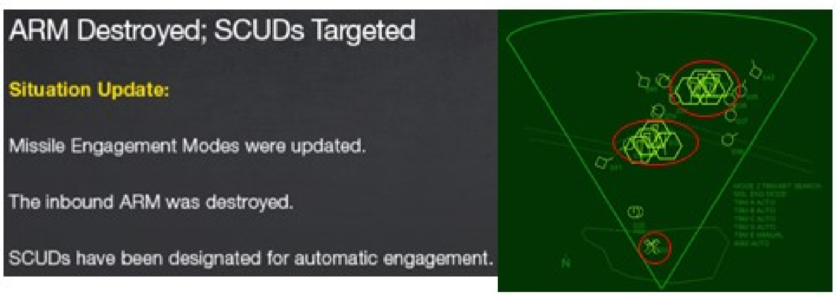
Run Scenario I (Continued)

The next step in the scenario is based on how trainees answered the previous questions.

Negative Outcome:
Decision to Engage SCUDs

(10a) SCUDs engaged. ARM is about to impact.

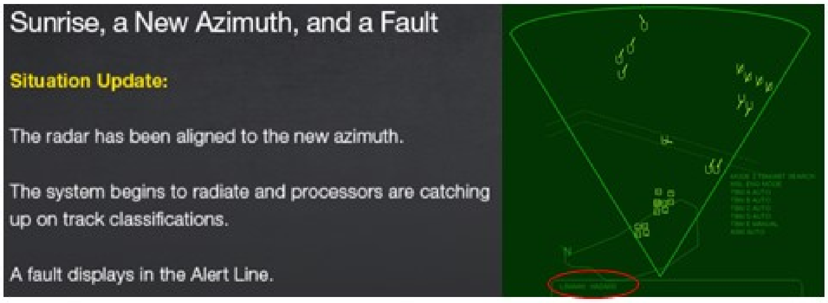
Positive Outcome:
Decision to Engage ARM



(10b) ARM destroyed. SCUDs designated for engagement.

(11) SCUDs destroyed. New threat from eastern flank; reorient 35°

Run Scenario I (Continued)

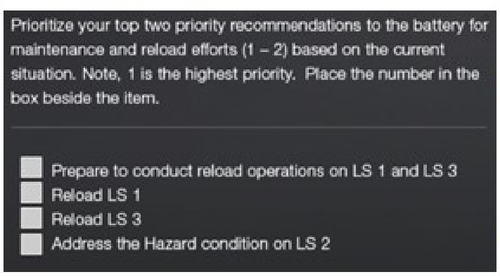


(12) New azimuth. Fault detected.

(13) Enemy aircraft on right flank. Fault detected.

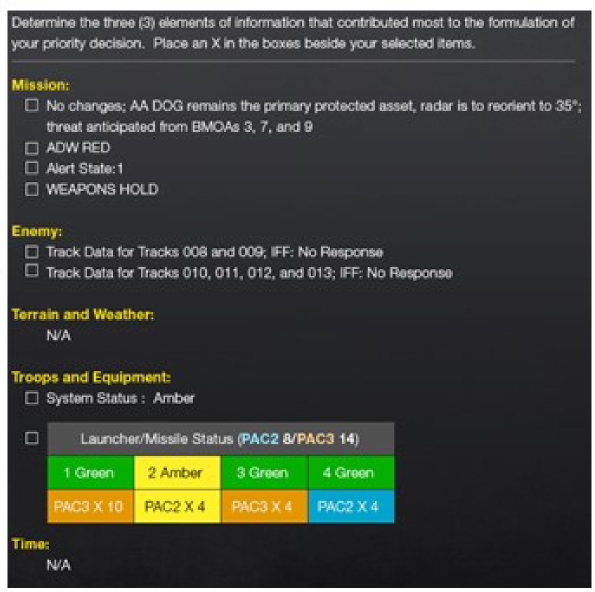
(14) Trainee is provided a summary of the situation.

Decision



(15) Trainee are asked to prioritize recommendations to the Battery for maintenance and reload efforts. Then, they are asked to identify what information they relied on to determine this prioritization.

Contributing Information



Run Scenario I (Conclusion)

(16) Trainees are provided an overall rating of how closely their decisions and selections of critical information matched the experienced SMEs' responses. Additional auditory feedback is provided to assist them in better understanding and aligning their cognitive processes with those of SMEs.

APPENDIX C

Pre-Training Demographic and Training Survey

Pre-Training Demographic and Training Survey (v3)

1. Rank: ________ 2. (WO)MOS: _________

3. Current assignment and duty position: (i.e. TCO, TCA, etc. ________________________

4. How long (months): ___________

5. Using Table 2-1 below, please circle ◯ the highest Patriot Gunnery Table that you have been externally evaluated as having attained and the recital aim level (RAL) that you have attained.

Level	*Table*	*Subject Matter*	*Corresponding RAL*
Basic Gunnery Tables	I	Basic System Skills	
	II	Ready-for-Action Drills	
	III	Basic Air Battle Management	1, 2, 3, 4, 5
	IV	Basic Gunnery Certification	5
Intermediate Gunnery Tables	V	Air Battle Management/Missile Reload	6, 7, 8, 9
	VI	Daytime March Order and Emplacement	
	VII	Precertification Tables V and VI	1 through 10, 11
	VIII	Intermediate-Level Gunnery Certification	11
Advanced Gunnery Tables	IX	Advanced-Level Air Battle Management and Missile Reload	12, 13
	X	Nighttime MO&E Under Varying CBRN Conditions	
	XI	Precertification Tables IX and X	14, 16, 17
	XII	Advanced-Level Gunnery Certification	17

Table 2-1, FM 3-01.86 Air Defense Artillery: Patriot Brigade Gunnery Program, 23 Dec 08 w/CH1.

6. Place an “X” in the appropriate box for each question:

	Item	Never	Occasionally	Often	Always
A	The Patriot engagement training received in my unit has been focused on remembering and understanding procedures.				
B	My Patriot engagement training has focused on applying the procedures that I can recall and understand.				
My Patriot training has provided information that my crew and I were required to analyze and evaluate information and data in order to: (See C – N below)					
C	Set work and task priorities				
D	Review and modify priorities				
E	Set engagement priorities for tracks or targets on my scope				
Anticipate:					
F	Track separations				
G	Launch of ASMs or ARAMs				
H	Jamming				
I	The intent of a track or a hostile formation				
J	Launcher reload requirements				
K	Need to alter system settings on the Patriot				
L	The probable sequence of events during a hostile attack				
Act to counter:					
M	Erroneous classification of tracks				

N	Coordinated SEAD directed against my battery					

7. I have been provided models or methods for problem solving and engagement problems:

YES: _____ NO: ______

8. I have been provided scenarios and situations to assess my critical thinking and problem solving and given feedback.

YES: _____ NO: ______

9. I have been trained in situations to practice my critical thinking and problem solving skills.

YES: _____ NO: ______

APPENDIX D

Results of the In-Route Training Assessment

In the following Tables D-1 through D-3, Soldiers' responses to the training scenarios are reported. The highlighted responses indicate the SME consensus responses against which individual trainees' responses were scored.

Table D-1

Crawl Phase Training Module In-Route Assessment Results

Module	Decision/Factors	n of 20
Decisions for the TBM Track		
	Decision	
	Designate the track for engagement hold	14
	Report the track and anomaly	14
	Request ICC verification of the track	9
	Set TBM A for auto engagement	1
	Wait; observe the track for changes	4
	Factors	
	Mission:	
	No Change	8
	ADW WHITE	12
	Alert State 2	3
	WEAPONS HOLD	6
	Enemy:	
	Track Data for 089	15
	Troops:	
	System Status: Green Bar	2
	Launcher/Missile Status: All Green	2
Decisions for an Unknown Track		
	Decision	
	Designate track 097 as a hostile	2
	Designate track 097 for manual engagement	2
	Request ICC verification of the track 097	18
	Prepare to engage Track 097 as a shoot-look-shoot target	3
	Wait; observe track 097 for changes	13
	Factors	

	Mission:	
	No changes	8
	ADW WHITE	14
	Alert state 2	1
	WEAPONS HOLD	9
	Enemy:	
	Track data for 097	17
	Troops and Equipment:	
	System Status: Green Bar	0
	Missile/Launcher Status: All Green	1

Decisions for the 3 Unidentified Aircraft		
	Decision:	
	Classify the three unknown tracks as hostile	1
	Designate the tracks for engagement	1
	Request ICC verification of tracks and aircraft type	18
	Wait; observe the tracks for changes	18
	UAV (Reconnaissance)	9
	Type of Aircraft:	
	UCAV (SEAD)	8
	Manned reconnaissance aircraft	1
	Manned strike aircraft	1
	It is impossible to determine	0
	Factors:	
	Mission:	
	No changes	2
	ADW Yellow	15
	Alert State 2	0
	WEAPONS HOLD	4
	Enemy:	
	Tracks data for Tracks 103, 107, and 109	16
	IFF: No response from all tracks	12

	Troops and Equipment:	
	System status: Green Bar	0
	Launcher/Missile Status	0

The average reported time to complete crawl phase of training was 34 minutes.

Table D-2

Walk Phase Training Module In-Route Assessments

Module	**Decision/Factors**	**n of 19**		
Multiple Aircraft Attacking		**Rank 1**	**Rank 2**	**Rank 3**
	Decision			
	Track 129	13	3	1
	Tracks 120, 121, and 122	7	6	2
	Track 117	2	1	4
	Track 113	5	4	7
	Factors			
	Mission:			
	No changes; attack underway	3	--	--
	ADW RED	9	--	--
	Alert State 1	4	--	--
	WEAPONS HOLD	1	--	--
	Enemy:		--	--
	Track data for Track 129; IFF: No Response	12	--	--
	Track data for Tracks 120, 121, and 122; IFF: No Response	8	--	--
	Track data for Track 117; IFF: No Response	2	--	--
	Track data for Track 113; IFF: No Response	9	--	--
	Troops and Equipment:		--	--
	System Status: Green Bar	0	--	--
	Launcher/Missile Status: All Green	0	--	--

Probable Enemy Actions	Soldier asked to rate 'probability': 1=Highly Probable; 2=Possible; 3=Improbable	Track Split	Launch ARM n of 19	Strafe/Bomb Targets in AA Dog
	Hostile Tracks: 121, 122, 131, 132, & 135	Highly Probable = 6 Possible = 4 Improbable = 6	Highly Probable = 2 Possible = 7 Improbable = 7	Highly Probable = 9 Possible = 5 Improbable = 3
	129 (3)	Highly Probable = 8 Possible = 5 Improbable = 4	Highly Probable = 9 Possible = 7 Improbable = 1	Highly Probable = 7 Possible = 6 Improbable = 3
	113	Highly Probable = 2 Possible = 3 Improbable = 11	Highly Probable = 2 Possible = 7 Improbable = 7	Highly Probable = 5 Possible = 6 Improbable = 7
	Factors:			
	Mission:			
	Factors and Alerts	6	--	--
	Enemy:			
	Track data for Tracks 121, 122, 131, 132, and 135	16	--	--
	Track data for Tracks 129	16	--	--
	Track data for Track 117	2	--	--
	Track data for Tracks 113	16	--	--
	Troops and Equipment:			
	System Status: Green Bar	1	--	--
	Launcher/Missile Status: All Green	1	--	--

Decisions and Factors: SCUDs and an Air Launch		**n of 19**	
	Rank 1	**Rank 2**	**Rank 3**
<u>Priorities</u>:			
Tracks 137, 138, 139, and 140	4	11	2
Track 142	18	0	0
Track 129	5	2	9
Track 113	2	0	2
<u>Classification of TBMs</u>:			
SS-21 Scarab B	2	--	--
Hwasong 5 (SCUD B variant)	7	--	--
Hwasong 6 (SCUD C variant)	8	--	--
No Dong 1/No Dong A	4	--	--
<u>ARM or ASM indicated by Track 142</u>:			
C-802KD, KD-88 (CSS-N-8 Saccade) – ASM	2	--	--
Kh-23 (AS-7 Kerry) – ASM	1	--	--
Kh-58EM (AS-11 Kilter) – ARM	6	--	--
Kh-31P (AS-17 Krypton) – ARM	12	--	--
<u>Factors</u>:			
Mission:			
ADW Red	4	--	--
Alert State: 1	0	--	--
WEAPONS HOLD	1	--	--
Enemy:			
Track data for Tracks 137, 138, 139, and 140; IFF: No Response	16	--	--
Track data for Track 129; IFF: No Response	14	--	--
Track data for Track 142; IFF: No Response	15	--	--
Track data for Track 113; IFF: No Response	1	--	--
Troops and Equipment:			
System Status: Green Bar	0	--	--

Launcher/Missile Status: All Green	0	--	--

The average reported time to complete the walk (intermediate) phase of training was 36 minutes.

Table D-3

Run (Advanced) Phase Training Module In-Route Assessments

Module	Decision/Factors	n of 17		
		Rank 1	Rank 2	Rank 3
Training Scenario 1				
Problem 1: Multiple Aircraft Attacking				
	Priority of Threats to the Mission:			
	Inbound ABTs	9	4	2
	Jammers and ECM	8	5	3
	TBMs	7	3	7
	Highest Priority Action:			
	Prepare to engage ABTs	3	--	--
	Prepare to engage the inbound jammers only	0	--	--
	Implement all available Patriot Electronic Counter-countermeasures (ECCM)	15	--	--
	Factors:			
	Mission:			
	No change; air attacks are underway and missile attach warnings have been issued, targets are US/Coalition air and air defense forces	1	--	--
	ADW Red	2	--	--
	Alert State: 1	0	--	--
	WEAPONS HOLD	0	--	--
	Enemy:			
	Data for Tracks 041 and 043; IFF: No Response	14	--	--
	Data for Tracks 045 and 046; IFF: No Response	15	--	--
	Data for Tracks 042 and 044; IFF: No Response	14	--	--
	Troops and Equipment:			
	System Status: Green Bar	1	--	--
	Launcher/Missile Status: All Green	0	--	--
Problem 2: Multiple Aircraft Attacking		**Rank 1**	**Rank 2**	**Rank 3**
	Prioritized Threats:			
	Tracks 047, 048, 049, 050, 051, 052, 053, and 054	3	11	2

	Tracks 041 and 043	2	2	11
	Track 055	17	0	0
	<u>Factors</u>:			
	Mission:			
	No change; air and missile attacks are underway	2	--	--
	ADW Red	0	--	--
	Alert State: 1	0	--	--
	WEAPONS HOLD	0	--	--
	Enemy:			
	Data for Tracks 047, 052, 053, and 054; IFF: No Response	13	--	--
	Data for Tracks 048, 049, 050, and 051; IFF: No Response	12	--	--
	Data for Tracks 041 and 043; IFF: No Response	6	--	--
	Data for Track 055; IFF: No Response	14	--	--
	Troops and Equipment:			
	System Status: Green Bar	0	--	--
	Launcher/Missile Status: All Green	0	--	--
Problem 3: Maintenance and Reload		Priority 1	Priority 2	
	<u>Maintenance and Reload Priorities</u>:			
	Prepare to conduct reload operations on LS1 and LS3	2	9	--
	Reload LS1	3	0	--
	Reload LS3	2	3	--
	Address the hazard conditions on LS 2	16	2	--
	<u>Factors</u>:			
	Mission:			
	No changes; AA DOG remains the primary protected a radar is to reorient to 35 degrees; threat anticipated from BM 7, and 9.	11	--	--
	ADW RED	2	--	--
	Alert State: 1	1	--	--
	WEAPONS HOLD	1	--	--
	Enemy:			
	Track data for Tracks 008 and 009; IFF: No Response	13	--	--
	Track data for Tracks 010, 011, 012, and 013; IFF: No Response	12	--	--
	Troops and Equipment:			
	System Status: Amber	8	--	--
	Launcher/Missile Status: 2 Amber	6	--	--
Training Scenario 2 Problem 1: Assessment of Current Threats and Probable Actions		**Rank 1**	**Rank 2**	**Rank 3**
	<u>Probability Ranking of Threat</u>:			
	ARMs launched by inbound MiG-29s and MiG-23s	12	3	2
	Jamming from MiG-29s	2	1	5

	Harpy UCAVs	5	5	3
	TBMs from BMOAs 3, 7, & 9	2	6	5
	Hostile Tracks or Capability:			
	008 & 009: Attack Your Battery & Patriot Radar	11	--	--
	008 & 009: Attack Maneuver Forces in AA DOG	8	--	--
	010, 011, 012, & 013: Attack Your Battery & Patriot Radar	10	--	--
	010, 011, 012, & 013: Attack Maneuver Forces in AA DOG	9	--	--
	014, 015, 016, 017, 018, & 020: Attack Your Battery & Patriot Radar	12	--	--
	014, 015, 016, 017, 018, & 020: Attack Maneuver Forces in AA DOG	8	--	--
	022 & 023: Attack Your Battery & Patriot Radar	11	--	--
	022 & 023: Attack Maneuver Forces in AA DOG	6	--	--
	Factors:			
	Mission:			
	No changes; reorientation of radar; missile and air attacks against U.S./Coalition air and air defense expected	1	--	--
	Enemy:			
	Track data for Tracks 008 & 009	10	--	--
	Track data for Tracks 010, 011, 012, and 013	8	--	--
	Track data for Tracks 014, 015, 016, 017, 018, & 020	12	--	--
	Track data for Tracks 022 & 023	3	--	--
	Troops and Equipment:			
	System Status: Green	0	--	--
	LS 3 out of action for reload	4	--	--
	Time:			
	10 minutes until LS 3 is reloaded and ready to fire	4	--	--
Problem 2: Multiple TBMs on Scope				
	Identify Highest Probability Action:			
	Designate the initial volleys of the seven TBMs (032, 033, 034, 035, 036, 037, & 038) for engagement	13	--	--
	Specify the follow-on volleys, three TBMs (046, 047, & 048) for engagement hold	3	--	--
	Await additional IFF confirmation of the ten TBM tracks as hostile before designating them for engagement	3	--	--
	Cease engagements until the IFF interrogation capability is restored and the HAZARD fault is cleared	0	--	--
	Factors:			
	Mission:			
	No change; missile attacks are underway	2	--	--
	ADW RED	1	--	--
	Alert State: 1	1	--	--

	WEAPONS HOLD	1	--	--
	Enemy:			
	Data for Tracks 032, 033, 036, 037, & 038; IFF: No Data	13	--	--
	Data for Tracks 034 & 035; IFF: No Data	8	--	--
	Data for Track 046; IFF: No Data	6	--	--
	Data for Tracks 047 & 048; IFF: No Data	2	--	--
	Troops and Equipment:			
	System Status: Amber = both TARGET EVALUATION and TGTID (IFF) are DEGRADED; a HAZARD is detected on LS 2	9	--	--
	Launcher/Missile Status: 2 RED	4	--	--
Problem 3: Quickly Recover Mission Capabilities				
	Identify Reload Priorities:			
	LS 1	12	2	--
	LS 2	6	0	--
	LS 3	4	5	--
	LS 4	0	1	--
	Factors:			
	Mission:			
	Recover for continued operations; reorient radar to 360 degrees; prepare to continue the mission; defend against air and missile attacks	11	--	--
	ADW RED	3	--	--
	Alert State: 1	1	--	--
	WEAPONS HOLD	0	--	--
	Enemy:			
	No hostile tracks on scope	7	--	--
	Troops and Equipment:			
	System Status: Amber – both TARGET EVALUATION and TGTID (IFF) are DEGRADED; a HAZARD is detected on LS 2	10	--	--
	Launcher/Missile Status: 2 RED	8	--	--
Training Scenario 3				
Problem 1: Multiple Aircraft Attacking		Priority 1	Priority 2	Priority 3
	Prioritized Threats to Your Mission:			
	Inbound massed formation of ABTs (Tracks 007, 008, 009, 010, & 011)	4	2	3
	Maneuvering flight (Tracks 015[ACR] & 014) heading S	7	5	4
	Maneuvering flight (Tracks 016 & 017) heading SSW	7	2	1
	Inbound UNKNOWNs (Tracks 018 & 019)	10	1	2
	Probable Type of Missiles for Tracks 018 & 019:			
	AS-7 Kerry ASM	1	--	--
	KD-88 Saccade ALCM	4	--	--
	AS-11 Kilter ARM	3	--	--

	AS-17 Krypton ARM	9	--	--
	Factors:			
	Mission:			
	No change; air attacks underway; ASMs launched	1	--	--
	ADW RED	1	--	--
	Alert State: 1	1	--	--
	WEAPONS HOLD	0	--	--
	Enemy:			
	Data for Tracks 007, 008, 009, 010, & 011; IFF: No Response	10	--	--
	Data for Tracks 014 & 015; IFF: No Response	13	--	--
	Data for Tracks 016 & 017; IFF: No Response	10	--	--
	Data for Tracks 018 & 019; IFF: No Response	10	--	--
	Troops & Equipment:			
	System Status: Green; LS 3 – PAC Canister Problem	2	--	--
	Launcher/Missile Status: 3 Yellow	0	--	--

Problem 2: Multiple Aircraft Attacking		**Priority 1**	**Priority 2**	**Priority 3**
	Crew Task Prioritization:			
	Prepare to engage the inbound TBMs (Tracks 026, 027, 028, 030, 031, & 032)	9	4	4
	Prepare to engage the ALCMs (Tracks 034 & 035)	9	4	2
	Prepare to engage the "leakers" from the massed formation (Tracks 007, 009, 010, & 011)	7	4	6
	Factors:			
	Mission:			
	Air and missile attacks are underway	2		
	ADW RED	0		
	Alert State: 1	1		
	WEAPONS HOLD	2		
	Enemy:			
	The locations and actions of:			
	ABT Tracks 007, 009, 010, & 011	15		
	ABT Track 013	4		
	TBM Tracks 026, 027, 028, 030, 031, & 032	15		
	ALCM Tracks 034 & 035	13		
	Troops & Equipment:			
	System Status: Green Bar	0		
	Launcher/Missile Status: 3 Yellow	0		

Problem 3: Multiple Inbound TBMs				
	Decision Priorities:			
	Prepare to engage Tracks 035 & 036	10	5	2
	Prepare to engage Track 013	5	5	5
	Begin reloading procedures	7	3	6
	Factors:			
	Mission:			
	Missile attack is underway	1		

ADW RED	0
Alert State: 1	2
WEAPONS HOLD	2
Enemy:	
Track data for Tracks 027, 031, & 032; IFF: No Response	8
Track data for Tracks 026 & 030; IFF: No Response	3
Track data for 013; IFF: No Response	9
Track data for Tracks 035 & 036: IFF: No Response	11
Troops & Equipment:	
System Status: System GREEN; LS 3 has a PAC 3 Misfire	6
Launcher/Missile Status	3

The average reported time to complete the run (advanced) phase Module 1 of training was 23 minutes; Module 2, 28 minutes; and Module 3, 12 minutes. The total average reported time to complete the three Run phase modules was 63 minutes.

APPENDIX E

Post-Training Survey for the Patriot Cognitive Skills Trainer

Post-Training Survey for the Patriot Cognitive Skills Trainer

Part I. Answer the following questions based on your experiences with the Patriot Cognitive Skills Trainer.

1. The Cognitive Skills Trainer provided models or methods for problem solving and engagement problems:

YES: _____ NO: ______

2. The Cognitive Skills Trainer provided scenarios and situations to assess my critical thinking and problem solving.

YES: _____ NO: ______

3. The Cognitive Skills Trainer provided a means to practice my critical thinking and problem solving skills.

YES: _____ NO: ______

4. The scenarios presented were realistic.

YES: _____ NO: ______

5. The scenarios presented were challenging.

YES: _____ NO: ______

6. The scenarios presented were frustrating.

YES: _____ NO: ______

7. The scenarios presented were too difficult.

YES: _____ NO: ______

8. The scenarios presented were too easy.

YES: _____ NO: ______

Instructions: The matrices below permit you to self-assess your pre- and post-training understanding and skills. In the matrix below, rate your before-training skills and your after-training skills as these skills relate to critical thinking and decision making in uncertain situations. In the spaces provided above the scale place a "**B**" to indicate your level of skill and understanding **BEFORE** training with the Tool. Additionally in the space provided below the scale, place an "**A**" to indicate your level of skill and understanding **AFTER** experiencing training with the Tool. See the example below:

EXAMPLE								
Before "B"			B					
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"					A			

Considering your previous training, <u>to what degree</u> did the desktop Patriot Cognitive Skills Trainer improve on your understanding of the following?

9. Setting work and task priorities

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

10. Reviewing and modifying priorities

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

11. Setting engagement priorities for tracks or targets on my scope

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

12. Self-assess your understanding and skills when reviewing Patriot system data and anticipating:

12a. Track separations

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

12b. Launch of ASMs or ARAMs

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

12c. Jamming

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

12d. The intent of a track or a formation of hostile aircraft

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

12e. The need to alter system settings on the Patriot

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

12f. The probable sequence of events during a hostile attack

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

13. Self-assess your understanding and skills when reviewing Patriot system data and acting to counter:

13a. Erroneous classification of tracks

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

13b. Coordinated SEAD directed against my Patriot system and my battery

Before "B"								
Scale	0	1	2	3	4	5	6	7
Associated phrase	No experience	Can get by			Pretty good			Can train others
After "A"								

14. Please briefly describe three ways you might apply to your job what you learned from using the Cognitive Skills Trainer?

(a)

(b)

(c)

14b. Of the three ways you anticipated using what you learned (listed above), which would be the most important for us to focus on when further developing the Cognitive Skills Trainer?

APPENDIX F

Training Module Rating Questionnaire

Training Module Rating Questionnaire

INSTRUCTIONS: Please indicate the degree to which you are in agreement with each of the statements below.

Item	Number of Participants (Out of 20)				
	Strongly Disagree	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**
(Quality of Learning Experience)					
1. I would recommend that this training module be made available to all Patriot ECS crews.	0	3	2	8	7
2. I would use this training module to refresh my skills at a later date.	1	2	1	9	7
3. I feel I have a better understanding of the task after completing the training module.	0	2	5	8	5
4. I preferred this training module to others I have used in the past.	1	2	6	7	3
5. The training module interactively helped my learning process.	1	3	1	13	2
6. On the basis of this training module, I could execute the task(s) trained as part of an ECS crew.	0	1	8	9	2
7. I feel this training module was able to meet my individual learning needs.	1	4	3	9	2
(Quality of Design and Content)					
8. The displays on the screen were clear and legible.	0	0	1	12	7
9. The graphics supported the material being presented.	0	0	1	12	7
10. Prompts and cues in the training module assisted me in navigating through the material.	0	2	2	9	7
11. The information presented seemed accurate and doctrinally correct.	0	2	5	9	4
12. I felt like I was in control of my learning process.	0	2	4	6	8
13. The information presented seemed up-to-date.	1	3	2	10	4
14. I could easily track where I was in the training module.	0	0	2	14	4
(Continuity of Topics)					
15. There was a good connection between the topics.	0	0	1	12	6
16. The sequence of topics seemed to build on each other.	0	0	1	13	6
17. Training module content was grouped to facilitate learning.	1	2	2	12	3
18. There was a clear focus of topics in the training module.	0	1	2	10	6
19. Grouping of content allowed me flexibility in accessing material.	0	0	4	9	7
(Credible Examples)					
20. Examples contributed to my learning.	1	2	2	9	6
21. The examples made sense.	1	1	3	10	5
22. I learned a lot about the task from the examples.	1	1	3	11	3
23. Examples were presented in a realistic mission context.	1	2	3	9	5

24. Repetition of examples was helpful.	0	0	6	8	6
(Focus and Relevance)					
25. Sections of the training modules were of the right length to allow me to complete them without needing a break.	0	0	2	12	6
26. Questions asked within the training modules were reasonable and helped me to understand the topic.	0	1	4	10	5
27. The questions asked within the training module focused on what was being taught.	0	0	4	10	6
28. The overall focus of the training module was right on target.	1	1	2	8	6
(Tracking Progress)					
29. If I took a break during the learning process, I could easily resume learning when I returned.	0	0	0	11	9