The Air Assault Expeditionary Force (AAEF) Experiment: Examining the Impact of Technology on Battle Command Using Live, Virtual and Constructive Simulation

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Abstract

The AAEF Campaign of Discovery Experiments is the principal series of prototype discovery experiments conducted within the US Army. The campaign was originally approved for four annual excursions, 2004-2007, but has been tentatively extended through 2013. Spiral C, the most recent event in the campaign, was third in the series of ten events, and was designed to examine, evaluate and implement, as appropriate, new technologies into today's transforming forces. Using a combination of live, virtual and constructive elements, the Soldier Battle Laboratory at Ft. Benning, GA, is tasked with assessing the impact of technology on Battle Command, and other implications within the Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities (DOTMLPF) domains. The experiment consisted of a live infantry company headquarters element; a live, MILES-equipped infantry platoon on the ground; a live battalion TAC; the remainder of the company elements represented in the Joint Conflict and Tactical Simulation (JCATS); a green cell playing friendly adjacents and higher headquarters; and a white cell providing experiment over-watch and control. ATEC provided the analytical lead, and was responsible for identifying and publishing the initial insights brief as well as generating the final report.

1. BACKGROUND.

In 2003 a Senior Advisory Group (SAG) lead by GEN (R) Gorman proposed a campaign of experiments to integrate emerging C4ISR technologies into the current force. The selected methodology came from concepts outlined in Air-Mech-Strike: Asymmetric Warfare for the 21st Century.[1] Based on that proposal, the TRADOC Futures Center (now the Army Capabilities Integration Center (ARCIC)) issued a directive to conduct the AAEF Campaign of Discovery Experiments, Spirals A-D, during fiscal years 2004-2007. The purpose of the campaign is to:

- determine whether emerging C4ISR and other technologies increase the survivability of a small, modular combat unit.
- inform FCS and modular force development by experimenting with a small mounted unit, using emerging C4ISR technologies, in a live, force-on-force field experiment within an IBCT/JTF context.
- identify capabilities/technologies ready to be spiraled forward to current force, while providing recommendations on candidate technologies for spiraling, further testing, or discarding.
- examine operational vertical maneuver of mounted forces enhanced with emerging C4ISR technologies and networked fires within an IBCT/JTF.

In 2006 experiment objectives were expanded to include a broader DOTMLPF focus with plans tentatively approved to extend the campaign through 2013. Current guidance requires restructuring of campaign objectives to:

- promote Future Modular Force interoperability with the FCS BCT.
- fully integrate Soldier as a System (SaaS) into experimentation.

[1] Air-Mech-Strike: Asymmetric Warfare for the 21st Century; BG David L. Grange, U.S. Army (Ret.)
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- complement the efforts of the Future Force Integration Directorate (FFID) and Future Combat System (FCS) Program of Record experimentation.

2. ORGANIZATION.

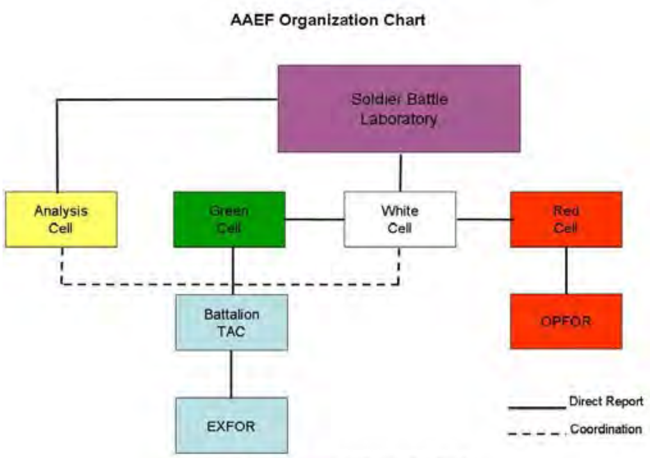

Figure 1. AAEF Experimental Organization Chart

The Soldier Battle Laboratory (SBL) at Ft. Benning, GA, has the responsibility for experiment design, organization and execution. Also resident at Ft. Benning is the Experimentation Force (EXFOR), organized within the 1st Battalion, 29th Infantry. The EXFOR was comprised of the A Company, 1/29 headquarters element, and its first platoon was the live, on-the-ground force. The remaining company elements were simulated in a Joint Conflict and Tactical Simulation (JCATS) wrap-around simulation.

The Opposing Force (OPFOR) organization and structure was coordinated with and approved by the TRADOC Intelligence Support Activity (TRISA)-Threats Directorate at Ft. Leavenworth, KS. The on-the-ground organization represented Special Purpose Forces (SPF), insurgents (SAPA), and civilians on the battlefield (COBs). COBs comprised a changing mix of neutrals, friendlies and hostiles. Local people were hired as OPFOR role players; the majority of which had previous military experience. This approach allowed for a thinking and adaptive enemy, controlled by senior retired military personnel, but not hampered by a scripted fight. The Red Cell provided an on-the-ground presence with the OPFOR and controlled all threat activity in the live and simulated environments. They were responsible for the development and training of OPFOR elements, control of all OPFOR counter-tasks, and provided operational control to all COBs.

Operational control of the EXFOR was administered through a Green Cell, which represented the brigade and slice elements over-seeing and supporting the 1/29 Infantry. The White Cell had oversight of the entire experiment, ensuring experimental and analytic requirements were met and issues of rules of engagement (ROE), effects and other adjudications were resolved with consistency and operational integrity.

The analytic cell, under the supervision and control of the Army Test and Evaluation Command (ATEC), was responsible for answering the SBL's essential elements of analysis (EEAs), to include the creation and execution of the data collection management plan, all data collection efforts, oversight of the analysts' observations and insights, and packaging of the initial insights brief and the final report.

3. THE SPIRAL C EVENT.

Spiral C was the third of what are now ten scheduled events. It was designed to build on lessons learned from Spirals A and B. The experiment addressed and answered specific questions within the DOTMLP domains. Facilities implications were not addressed during this spiral. Analytical focus revolved around these specific questions/challenges:

Doctrine.

- How does the information made available through the implemented C4ISR architecture impact decision making at company and platoon levels?
- How is the quality of information at company and platoon levels impacted by the suite of sensors, implemented fusion processes and information management protocols?

Organization and Personnel.

- What organization, equipment and personnel changes are required in the Company Headquarters and in the Infantry Platoon to properly conduct sensor planning, sensor employment and recovery, sensor fusion and security?

Training and Leader Development.

- What is the impact on leaders (increased mental demands and complexities) from enhanced situational awareness, the requirements of sensor planning, employment and management, and accelerated decision cycles in a network-enabled force?
- What are the training requirements of new technologies (UGVs, UAVs, sensors, battle command systems and communications)?

Materiel.

- What battle command interface functionality and decision aids are essential at the company, platoon and squad levels?

- How well does the network enable the flow of data and information throughout the experimental force? Which technologies enhance the effectiveness of the network and contribute to increased lethality and survivability?

To ensure each of these questions was properly addressed, ATEC, as the analytic lead, developed nine EEAs. These elements were the foundational basis against which all analytic observations and insights were vetted. Those EEA were:

- EEA 1: Which technologies enhance the effectiveness of the network and contribute to increased survivability?
- EEA 2: Which technologies enhance the effectiveness of the network and contributed to increased lethality?
- EEA 3: How well does the network enable flow of data and information throughout the EXFOR?
- EEA 4: What battle command interface functionality and decision aids are essential at company, platoon, and squad levels?
- EEA 5: How is the quality of information at company and platoon levels impacted by the suite of sensors, implemented fusion processes, and information management protocols?
- EEA 6: How does information made available through the implemented C4ISR architecture impact the decision making and mission execution at the experimental company and platoon levels?
- EEA 7: What are the impacts on leaders (increased mental demands and complexities) from enhanced SA, requirements of sensor planning, employment and management, and accelerated decision cycles in a network-enabled force?
- EEA 8: What organization, equipment and personnel changes are required in the Company Headquarters and Infantry Company/Platoon units to properly conduct sensor planning, sensor employment and recovery, sensor fusion and security?
- EEA 9: Codify training requirements of new technologies (UGVs, UAVs, Sensors, Battle Command Systems (BCS), and Communications Systems).

The Spiral C scenario was written under the supervision of the SBL in coordination with TRISA-Threats. Set in the 2014 timeframe, it was flexible enough to support a wide range of tactical missions. Vignettes were written to bring to bear a mix of SPF and Insurgents; represent a cluttered battlefield (COBs, no fire areas, protected sites, urban terrain); establish a restrictive set of Rules of Engagement (ROE); and be broad enough to support future spiral efforts, decreasing or increasing robustness and fidelity, as required. The missions featured a mix of day and night operations; deep vertical operations; the platoon in attack and defensive postures; and urban operations (Figure 2, following). These missions were initially conducted without advanced C4ISR technologies (two pilot test missions and ten base case missions), followed by a six week reset period for operator level technology training and insertion of advanced C4ISR technologies, and concluded with an advanced case (three pilot missions and ten advanced case missions).

BASE CASE MISSION NUMBER	ADVANCE CASE MISSION NUMBER	TERRAIN	MISSION	VISIBILITY
Mission 1	Mission 1	Wooded Hills	Attack	Day
Mission 2	Mission 2	Urban	Defense	Day
Mission 6	Mission 3	Urban	Attack	Night
Mission 7	Mission 4	Urban	Defense	Night
Mission 3	Mission 5	Wooded Hills	Defense	Day
Mission 4	Mission 6	Urban	Attack	Day
Mission 5	Mission 7	Urban	Attack	Day
Mission 8	Mission 8	Woods/ Clearing	Defense	Night
Mission 9	Mission 9	Urban	Attack	Night
Mission 10	Mission 10	Wooded Hills	Attack	Night

Figure 2. Spiral C Mission Sets

Selected technologies underwent testing and integration under the supervision of the C4ISR Test-bed from June through September; followed by on-the-ground emplacement and integration at Ft. Benning, GA. The AAEF base case occurred during the entire month of August; with the advanced case following in October and November.

4. LIVE, VIRTUAL, AND CONSTRUCTIVE INTEGRATION.

One of the biggest challenges in an experiment examining new technology is the integration of the Live, Virtual and Constructive simulations used to create a suitable integrated environment. Overcoming conflicting or mismatched Distributed Interactive Simulations (DIS) enumerations, ensuring connectivity and proper representation of entity state Protocol Data Units (PDUs), and ensuring entities are not duplicated, and thus doubly counted across environments, are a few of those challenges. In the AAEF, the challenge was the integration of a MILES-equipped infantry platoon and company headquarters element; two platoons being played in JCATS; indirect fires planning, execution and adjudication by way of FIRESIM; and a host of live and virtual technologies – all generating DIS PDUs. The White Cell e mployed a co mbination of restrictive fires, masking terrain, operational boundaries, and white cell control to ensure a level playing-field, while protecting the integrity of the experiment. For instance: the live players, through the MILES equipment, generated a DIS PDU th at could be detected by entities in the JCATS wrap-around. If detected and acquired, JCATS could then engage the live en tities with direct or indirect fires. The engagement would be adjudicated in simulation but would not "trip" the MILES devices. Thi s would cause an inconsistency in data between that captured in sim ulation and that captured in the MILES log. Additionally, the live entities had no way of m utually engaging the simulated forces. Therefore, interventions were executed using the White Cell control measures mentioned above to avoid this type of engagement.

This year's technologies included everything from robotic helicopters (the Broad area, Unmanned, Responsive Vehicle - UAV R – BURR O), to Class I and II UAVs (Raven and Buster); mobile and dynamic air and ground sensors; armed ground sensor systems; enhanced night vision devices; sense through walls techno logies; Future Force Warrior; dismounted Battle Command systems; and surrogate command and control vehicles. Al l these technologies were integrated to c ommunicate over the Soldier Radio Wave (SRW) network.

5. ANALYSIS METHODOLOGY.

ATEC provided the analytic lead, oversight and integration of the analysis effort. A variety of tools and methods were used to address the EEAs previously listed. Digital data was harvested from the simulation and MILES log using the Digital Collection Analysis Tool (DCAT). DCAT captured all digital traffic th at crossed the network, and filed that data for p arsing, query and anal ysis. Information provided included usage data; message completion and timeliness; screen cap tures on discrete systems at specific tim es or related t o specific events – crossing the LD, first contact, etc.

Observations and data from Human in the Loop (HITL) events is historically the most difficult to gather and use in quantitative and qualitative assessment. To g et to this data, a combination of data collectors/observers, analysts, a nd a collection tool called the Event Support System (ESS) were utilized. ESS is a proven tool for capturing HITL input and provides data to a wide spectrum of users in a m anageable fashion (parsing, collating and cross-referencing). Figure 3 shows how ESS was used in support of the AAEF.

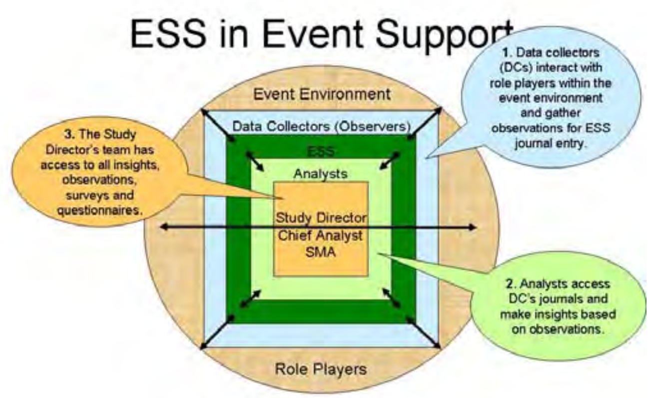

Figure 3. ESS Support of the AAEF

ATEC analysts used the raw data provided by the data collectors and d igital information provided by simulation and MILES v ia DCAT to form their insights and observations. The st udy director and a nalytic lead then oversaw the compiling, analysis, and organization of that data to answer the nine EEAs.

The analysis process included the correlation of the observations and assessments (made by military an alysts, EXFOR leadership, and the OPFOR) regarding EXFOR lethality/survivability, with information collected from the instrumented emerging technologies and by manual data collectors. The base case provided the context for i nsights regarding the "goodness" of the emerging technologies and CONOPS used in the advanced case. The analysis explored potential relationships between the emerging technologies, information made available to decision-makers over time, and the actions of the EXFOR unit. It ex amined in detail the level of system knowledge available to unit leaders over time, and ass ociated influencing factors (for e xample, OPFOR actions and emerging technologies capabilities). Analysis focused on how availab le information influenced key decisions of leaders and ulti mately force effectiveness. The synthesis process developed answers to the EEAs and supporting measures once the data and information was collected. T his process looked for defined trends and patterns as well as for outliers and anomalies to understand the actions and reactions of the EXFOR un it in light of the prevailing tactical co nditions. ATEC used the lens-evaluation approach outlined at Fi gure 4 to analyze the experimentation data a nd to evaluate how well each EE A was answered in this experiment.

Figure 4. Lens-Evaluation Approach

6. FACTORS CONFOUNDING THE ANALYSIS.

In all experimentation venues, especially those involving HITL, there are factors which confound both quantitative and qualitative analysis efforts; the better job done identifying, isolating and minimizing those factors, the more rigorous and credible the outcome. Following is a list of some of the confounding factors encountered in the AAEF Spiral C experiment.

- Learning curve for EXFOR and OPFOR personnel (Tactical and Technological Proficiency).
- Civilians on the Battlefield (COBs). Civilians mixed in with the OPFOR, limited the EXFOR's ability to engage detections with indirect fires; even when recognized and identified by C4ISR systems.
- Extended Reset Periods. The division of the experiment into base case and advanced case necessitated an extended reset period for technology training and other enabling activities; creating the opportunity for experimental factors to change.
- Technology Insertion & Mix (e.g. numbers and types of systems). Generally, every available technology was expected to be employed by the EXFOR for every mission, impacting unit performance and confounding analysis of individual system contributions and impacts.
- Weather. Change in weather may have played a role in unit performance, increasing the analytic difficulty when comparing specific missions in the base and advanced cases.
- CL III/IV UAV-Live vs. Simulation. A Class III UAV was used in simulation only, since no live Class III UAV or surrogate was available, precluding exploration of its impact on the OPFOR.
- Compliance & Safety Testing (e.g. radio interference issues). Although all technologies participating in Spiral C were supposed to undergo compliance and safety testing prior to execution, late additions to the technological mix created a lack of compatibility, inhibiting the employment of a number of systems.

7. TECHNOLOGICAL IMPACTS.

The experiment strongly suggests that, with new technology added, a more detailed look at organizational structure is needed. Technologies, though bringing added value to the platoon fight, may require additional manpower at appropriate echelons, so as not to detract from the infantryman's primary mission – to close with and engage the enemy. Though Battle Command on the Move (BCOTM) assists effective C2, the current state of dismounted BCOTM technology challenges current doctrine. An example of this dilemma is how we use our platoon leaders during the execution of combat. When faced with the deluge of raw information, that may become intelligence, does the platoon leader continue to direct the platoon fight, or does he become the fusion point and decision maker of what becomes actionable intelligence? Trends from this experiment would indicate that he can't do both. Current doctrine is pretty clear regarding the platoon leader's duty. So the question is, do we change doctrine or do we change the organizational structure of the platoon and provide an Intel/Fusion NCO to assist the platoon leader in his data fusion process?

The experiment revealed a need to develop and define ROE for robotic technologies. Some of the sensor technologies were very effective, but easily neutralized. A thinking OPFOR very soon ascertained that a fifty-cent plastic bag could nullify the sensing advantage of a $20,000.00 robot. In several instances the OPFOR was able to sneak up behind a sensor and throw a garbage bag over the sensor's "head". So the question becomes, what are the ROE for protecting a robot? When can a soldier use deadly force to protect an unmanned/robotic ISR asset?

There have been recent articles in the press reference discussions within Japan and the United Kingdom concerning a bill of rights for robots. The United States military does not leave our comrades on the battlefield. If it is determined that robots have a certain level of "rights", will ROE be extended to afford that consideration to robotics? These are all interesting questions, and in some cases, dilemmas that must be addressed.

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Some of the operational and modeling and simulation lessons garnered through this experiment include:

- live experimentation needs to take a continued look at organizational requirements as they relate to emerging technologies.

- as technology becomes an increasing factor in the battlespace, doctrine, materiel solutions, and ROE must keep pace.

- data indicates network-enabled C4ISR technologies enhance small unit effectiveness, survivability & lethality.

- the impact and relative importance of technologies changes depending on the phase of the combat mission. Figure 5, following, illustrates this phenomenon.

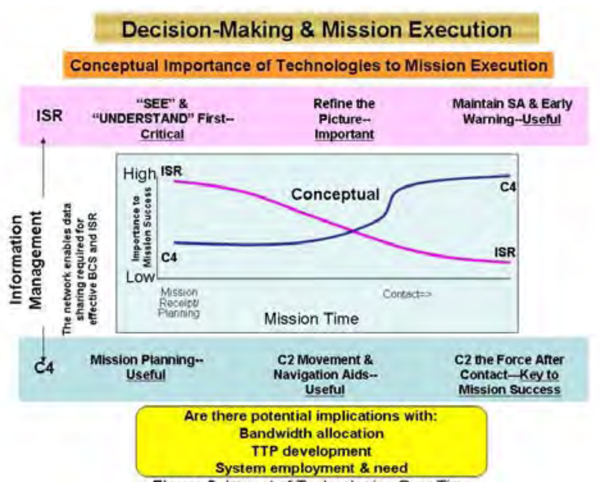

Figure 5. Impact of Technologies Over Time

- the impact of C4 and ISR technologies is dependent on the experience level of the unit with those technologies (e.g., the unit has developed TTP and SOPs to effectively leverage these technologies), in addition to the traditional factors of METT-TC.

Modeling and Simulations lessons learned include:

- Early integration of all technologies, simulations and devices is a must for successful execution.

- Every effort spent in pre-execution development, cross-referencing and deconflicting of operational databases, pays huge dividends during the event.
- Even the best plans and technical solutions never account for all possibilities. A planned and responsive human intervention cell must be prepared to implement operationally sound work-arounds.

- That which works in virtual and constructive environments does not always work with a live force. All technology and force structure paradigms must eventually undergo the scrutiny of an on-the-ground test.

- Anomalies are abundant; be prepared to discuss implications and applications to analysis.

- Beware and aware of the domino effect within LVC environments. Making a change in one environment may result in unexpected and undesirable effects in another.

8. SUMMATION AND THE WAY AHEAD.

Observations from the AAEF Spiral C confirmed the need for trained personnel at the company and possibly platoon to effectively receive, process, and disseminate the additional information ISR assets provide. Additionally, player feedback and observations agreed that any robotics requiring a human operator should have an assigned operator, effecting a change to the Modified Table of Organization and Equipment (MTO&E). Using riflemen or gunners as dedicated technology operators neutralizes "trigger pullers" and reduces the robustness and integrity of the squad. If the "ideal" dismounted squad has nine members, taking any squad member away to operate robotics during a mission has a negative impact on that squad's war-fighting capability. For embedded robotics, the consensus is that the squads are capable of transporting, emplacing, and operating the technology without significant impact on their war-fighting capability, since the operator is integrated into squad operations and can execute either role as rifleman or technology operator.

In any team sport, the lower the incidence of personnel and equipment turbulence, the higher the possibility of success. This maxim holds true for Army experimentation. Every attempt should be made to stabilize personnel for participation in the base and advanced cases. This action minimizes differences in learning curves – conceptually, operationally, and technically. Additionally, identifying how much technology is too much technology is critical in isolating technology's impact on battle command. Information over-load can be just as crippling as a blind assault. The Live-Virtual-Constructive model provides the best paradigm for sorting out questions concerning operational, human factor and technology interfaces.

Army and TRADOC leadership have approved the continuation of the AAEF campaign of experiments through 2013. The SBL will continue to define requirements for each spiral, which will drive what technologies are to be evaluated, formation of the EEAs and, ultimately, which emerging technologies are dropped from consideration, recommended for further evaluation, or spiraled into the current force.

BIOGRAPHIES.

Mr. Mike Lehnherr, an Associate with Booz Allen Hamilton, has over 30 years of professional experience in Department of Defense-related operations and consulting. He holds a B.S. in Speech Communications from Oregon State University and an M.A. in Theology from the Masters International School of Divinity, Evansville, IN. His professional military education includes the Basic and Advanced Field Artillery Courses, the Organizational Effectiveness Staff Officer and Consultants' Course, and the Command and General Staff Officers' Course. He joined Booz Allen Hamilton in December of 1997 after retiring from the United States Army.

At Booz Allen, Mr. Lehnherr provides management, analytical, technical, and operational support to the modeling and wargaming community throughout the Army. Most recently, Mr. Lehnherr has been the operational analyst in support of the Air Assault Expeditionary Force experiment at the Soldier Battle Lab, Ft. Benning, GA. Prior to that, he was the client-site job manager for the TRADOC Analysis Center – Ft. Leavenworth (TRAC-FLVN) ACDEP and ABCA effort. During that time, Mr. Lehnherr provided subject matter expertise in the areas of operational orders, scenario development, tactical vignette creation and execution and MSEL planning and implementation. As a Systems Engineer and Technical Analyst/Trusted Agent, Mr. Lehnherr supported the National Simulation Center in the area of simulation/stimulation; including requirements definition, integration of multiple simulations with tactical command and control systems (C4ISR), recommendations for options for simulation backbone, identification of specific tasks to be trained and messages to be generated.

Mr. Steve Strukel is an Associate with Booz Allen Hamilton and has over 28 years of tactical-level Army and operations research experience. He holds a B.S. in Mathematics from the University of Kansas (awarded in 1983) and an M.S. in Operations Research/Systems Analysis (with Distinction, awarded in 1992) from the Naval Postgraduate School, Monterey, CA. His professional military education includes Armor Officer Basic and Advanced Courses and the Command and General Staff Officers' Course. Mr. Strukel joined Booz Allen Hamilton in December of 2002 after 24 years of military service.

As a Booz Allen consultant, Mr. Strukel provides analytical support to Army and Joint experimentation and studies. In his most recent project, Mr. Strukel served as the analysis integrator in support of the Air Assault Expeditionary Force experiment at the Soldier Battle Lab, Ft. Benning, GA. In this role, he worked with the Army Test and Evaluation Command in finalizing their data collection management plan, developed guidance for the human and instrumented data collection efforts, provided analytic leadership during execution of the AAEF experiment, and was a primary author of key experiment deliverables (the Initial Insights Briefing and Final Report). Previous key projects include supporting the data collection and analysis effort for CERDEC's C4ISR On-the-Move experiment in 2005, the Joint Expeditionary Force Experiment in 2004, the FCS Key Performance Parameter and Milestone B study (in support of the TRADOC Analysis Center) in 2003, and was the Deputy Study Director and Lead Analyst supporting the Army/Joint experiment "Millennium Challenge" in 2002. Mr. Strukel is a former RAND Fellow (1999-2000) and is a recipient of the Army Chief of Staff's award for Excellence in Operations Research.