Challenges of Future Battle Command Experimentation: An Analyst's Perspective

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ABSTRACT: *As millions and millions of dollars are spent on developing the Future Combat System (FCS), one area that is in the forefront of experimentation is how the FCS network will enable battle command and increase force effectiveness. In order to study these issues Training and Doctrine Command (TRADOC) has developed an aggressive experimental schedule to attempt to gain insights into certain objectives. The FY04 theme of the Army Concept Development and Experimentation Program (ACDEP) was Networked Battle Command. Integrating Event 2004 (IE04), which was the culminating experiment in FY04 had two compelling drivers: the Networked Battle Command Key Performance Parameter and User's Functional Description (UFD) product development. This paper will use IE04 as an illustrative example of some of the basic challenges being encountered in battle command experimentation from an analyst's perspective. It will give an overview of the culminating experiment during FY04 for the Army and provide lessons learned that must be considered in future experiments dealing with future battle command systems. The end state for the reader is to gain an appreciation that experimentation in future battle command systems is difficult and provide considerations and recommendations on how to do it better.*

1. Introduction

In June 2003, Headquarters, Department of the Army (HQDA) tasked the TRADOC Analysis Center to conduct the Future Combat System (FCS) Key Performance Parameter (KPP) analysis. The Unit of Action (UA) Development II Experiment at the Unit of Action Maneuver Battle Lab (UAMBL) in January 2004 was the first in a series of experimental efforts to attempt to inform the KPP analysis; it established a foundation for investigating the effects of a degraded network on executing Battle Command in a human-in-the-loop environment.

Nested within TRADOC's overall theme of networked Battle Command experimentation in Fiscal Year 2004, IE04 was the second experimental effort in support of informing the Networked Battle Command KPP analysis. Two compelling drivers motivated the conduct of IE04: inform the Joint Requirements Oversight Committee (JROC) and the Milestone B (MS B) Update decision processes (*Networked Battle*

Command KPP) to inform UA product development. Understanding that Future Force commanders will be empowered with a robust suite of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) capabilities and that the C4ISR architecture will provide a volume of information to these commanders, the Battle Command challenges and cognitive demands placed on the Future Force commanders are not fully understood and have not yet been fully explored.

The "human-in-the-loop" environment of IE04 was originally designed to enable just such an exploration. The essence of the experiment was to observe how well a live UA Commander and staff, supported by an appropriate representation of subordinate command elements and the proposed C4ISR architecture, could conduct effective Battle Command under reduced network functionality conditions in a stressful scenario. Numerous experimental design challenges that will be discussed later in this paper prevented the complete exploration and analysis of the Battle Command objectives. Several factors contributed to this, not the least of which was a very ambitious schedule with unforeseen time constraints. The intent of this paper is not to provide the insights and observations developed during the conduct of the experiment, but to provide the issues that arose during the experiment and to provide a foundation of recommendations and insights for planning and executing future battle command experimentation.

2. Experiment Overview

The FY04 theme of the Army Concept Development and Experimentation Program (ACDEP) was Networked Battle Command. Networked Battle Command is a foundational concept that enables the Future Force to "See First, Understand First, Act First, and Finish Decisively." Based on this foundational premise, TRADOC pursued and conducted an aggressive experimentation schedule whose experimental events informed critical decisions, enabled product development, and supported critical Future Force studies. IE04 was TRADOC's culminating experiment for FY04. IE04 was designed to integrate the experimentation efforts throughout the year and establish a base of knowledge for FY05 experimentation efforts and beyond.

TRAC developed and TRADOC approved the IE04 objectives shown in Figure 1.1, which are focused around the Networked Battle Command theme. These objectives permitted an assessment of critical Battle Command concepts, while also exploring and informing the tasks and tools that enable effective Battle Command. However, the scope of this effort was limited to informing critical decisions (JROC, FCS MS B update) and key products (UFD, doctrine, MTP), as a complete exploration of Networked Battle Command is planned throughout the next several years of experimentation.

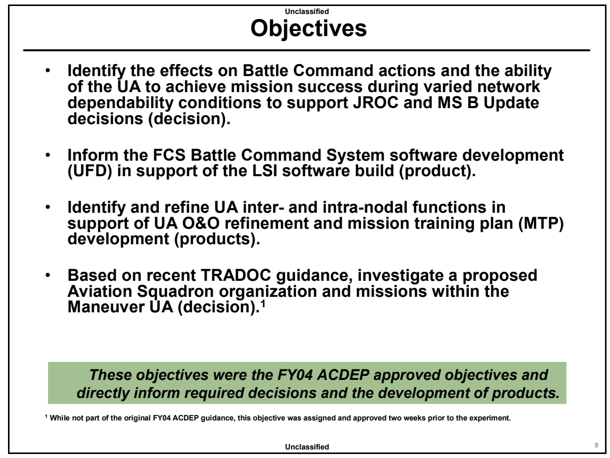

Figure 1.1

The overarching issue of the experiment focused on the ability of the UA to execute Battle Command and achieve mission success under varying levels of network functionality conditions. This overarching study issue was derived from the experiment purpose statement and the first objective of the experiment as shown in Figure 1.2.

A review of the overarching issue revealed three sub-issues that were used to further define the focus of the experimental effort. First and foremost, the key concept under investigation is Battle Command. Second, the focus is on Battle Command at the UA level. Third, the intent is to examine how the network enabled or degraded the Battle Command process and, ultimately, the capability of the UA to successfully accomplish all assigned missions. Underpinning the analytic approach to this effort was the basic premise that there are certain functions of Battle Command that endure across tactical operations no matter how those operations are phased. These functions include the requirement to develop and maintain situational awareness (SA), to conduct mission assessment - to compare the current state to the planned state (running estimate), to execute dynamic replanning when deviations to the plans or unexpected opportunities are identified, and to direct subordinates in order to implement those changes to the plan. From this premise, the study team derived the first sub-issue.

From this, the study team then conducted a deliberate process to develop supporting essential elements of analysis (EEA), measures of merit (MOM), and data elements to enable the generation of insights that would inform this sub-issue. The second sub-issue focuses on the decision-making process of the UA Commander. Within this sub-issue, the Study Team incorporated the elements of mission assessment and dynamic replanning. This iterative process allowed the team to develop and define the EEA, MOM and data elements for this and each successive issue in the study. The third sub-issue focuses on the force effectiveness of the UA. Force effectiveness was defined to be a function of the essential and key tasks derived from the UA mission statement and the commander's intent. Utilizing these tasks as a foundation, measures were derived to assess mission success and characterized the effectiveness of the UA under varying levels of network functionality. These measures defined the data elements that were intended to be collected by observers and from the simulation output data.

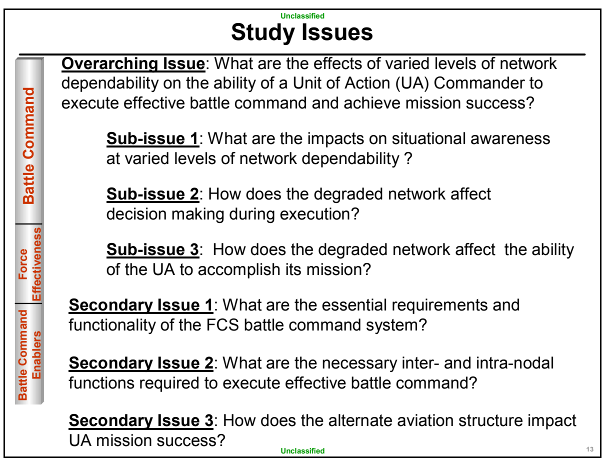

Figure 1.2

In addition to the overarching issue, there were two additional Battle Command enabling issues that were examined. The first additional issue captured future Battle Command System requirements and functionality that were observed by players and observers in order to inform the refinement of the Battle Command UFD. The second Battle Command enabler was to assess and refine the inter- and intra-nodal staff functions and tasks required to execute effective Battle Command. As Battle Command enablers, these two secondary issues permitted an investigation and analysis of the technical enablers and processes that better allow the UA Commander and staff to execute effective Battle Command. These secondary issues also permitted UAMBL's development and refinement of critical software and training products. Besides these two Battle Command enabling secondary issues, there was a secondary issue associated with the objective for investigating the potential capability gaps associated with the Comanche (RAH66) program cancellation decision.

2.1. Battle Command Methodology

Figure 2.1 provides the Battle Command methodology intended to be used for this experiment. It depicts how the message completion rates and message timeliness rates were intended to be set as independent variables within the study, while assessing the dependent variables of battle command and force effectiveness. For comparative baseline purposes, a "degraded run" at the network Threshold Performance Level (TPL) was designed to be one experiment run, while a second run of the network at the expected performance level (EPL) was also planned.

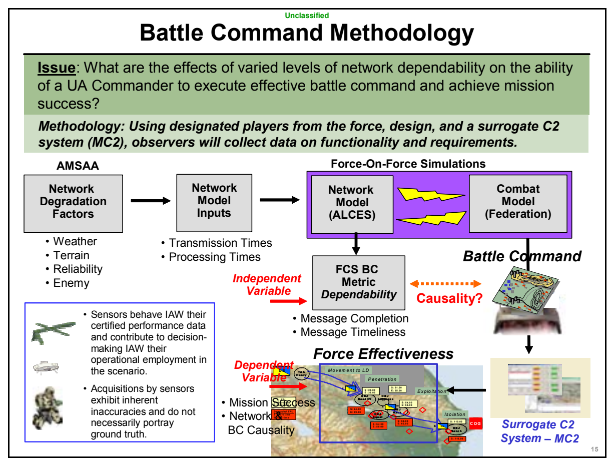

Figure 2.1

However, due to scheduling and technical challenges, this methodology was not fully employed during IE04. Some of the limiting factors that prevented this implementation included:

- The communications architecture was not properly represented, causing artificial loads across the network.
- All forms of communications (digital, voice chat, graphics) could not be explicitly controlled and degraded through the communication effects model (ALCES).
- Message rates could not be controlled, and therefore, "Network Dependability" measurements could not be accomplished.
- Objective force effectiveness measures could not be relied on due to invalid and incomplete model output data.

As a result of these limitations, the data collection effort refocused its analytic methodology and data collection process during experiment execution to investigate and assess critical Battle Command processes associated with UA mission execution under varying METT-TC conditions. This methodology was based on the premise that the battle command process centered around decision making. In order to ensure a more robust data collection opportunity, METT-TC conditions, specifically the mission, threat, and terrain, were varied to create various tactical dilemmas for the UA Commander and staff. Based on these controllable conditions Battle Command task threads such as ISR management, networked fires, and information dissemination management were assessed to determine their contribution to effective Battle Command and the management and application of UA combat power.

2.2. Analytic Approach

The IE04 experiment schedule shown in Figure 2.2 is meant to highlight that analytic requirements drive the experimental design. Given a problem, objectives are developed and an approach is chosen taking into consideration assumptions and constraints. This approach assists in defining the technical environment, the scenario, and the data requirements.

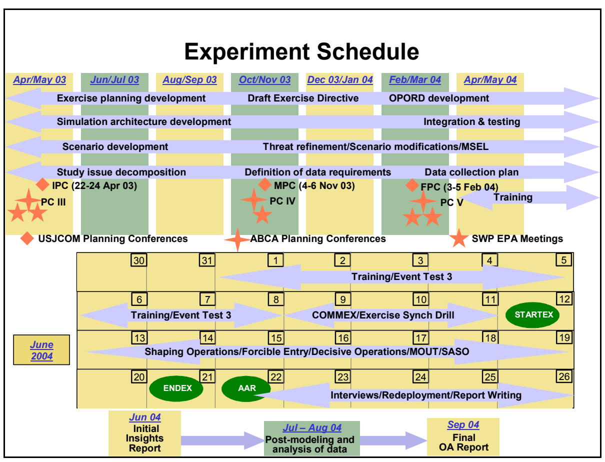

Figure 2.2

As shown in the figure the Study Director developed five planning lines of operation to ensure visibility on these critical areas. Each of the areas has there challenges, but three primary ones will be discussed as they specifically relate to future battle command experimentation: the technical environment, training, and maturity of experimental concepts.

3. Challenges to Experimentation

Over the last decade, TRAC has led or supported the analysis of every major Army and Joint experiment. This "proving ground" has enabled the codification and maturation of an effective, adaptive analytic approach, but every experiment has been different and has required flexibility to execute.

Event	Issue	Simulation Support	Player participation			Duration
			Blue	Red	White	
Division Advanced Warfighting Experiment	Capture the impact of information as an element of combat power within the division construct	Full training federation including CBS & TACSIM	All divisional C2 nodes to include division Main, TAC and rear, all brigade CPs and selected battalion CPs	Complete WCOPFOR team	Supplemented BCTP team, TRADOC SMEs, TRAC Analysis Team and CAP team	10 days + several train-up exercise and rehearsals
Strike Force MAPEX	Investigate four alternative SF force designs	None	Four teams of TRADOC SME plus one serving Bde Cdr - 50 players	4 representatives from TRADOC DCSINT	TRAC Analysis Team, Ft Knox Proponent rep, Greybeard to facilitate AARs	1 week
Strike Force Headquarters Rockdrill	Investigate information exchange requirements within the headquarters	LAN enabling email exchange	Representative manning of SF headquarters - 75 players	4 representatives from TRADOC DCSINT	TRAC Analysis team, TPIO Architecture representatives, Ft Knox Proponency rep	1 week
Strike Force Headquarters STAFFEX	Investigate capability of SF commander to exercise battle command with proposed HQ design in varying scenario settings	Eagle-Modsaf plus live adjudication - scenario team	Complete manning of one shift of the SF headquarters - 125 players	10 representatives from TRADOC DCSINT	TRAC Analysis Team, BCTP OC team, Greybeard for conceptual oversight, TRADOC SF team	2 weeks
SBCT CAMEX	Investigate alternative SBCT design options	JANUS	Two teams of TRADOC Commandants, Deputies & staff - 30 players	6 representatives from TRADOC DCSINT	TRAC Analysis Team, CAC OC Team	2 days
FCS UA C4ISR experiment	Investigate capability of UA commander to exercise battle command given proposed C4ISR architecture	JVB	One shift of UA headquarters plus all subordinate battalion headquarters and selected company-level elements - 85 players	50 representatives from TRADOC DCSINT - role playing Corps to Brigade level commanders	TRAC Analysis team, White Cell to adjudicate gaming, Green cell to represent higher headquarters	3 weeks of training plus 2 weeks of gaming

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Figure 3.1

Although there are many challenges to experimentation and whole books have been written on how to conduct a proper experiment, this paper's aim is to highlight the top three that should be considered when dealing with future battle command experimentation. The first of the three issues that will be discussed includes the complex environment that must be established. This environment is made up of the technical environment to include the models and simulations necessary to drive the experiment and the C2 surrogates that are representing the Future Battle Command systems. This complex environment also includes the operating environment that establishes the forces played and the scenario, which is part of the experimental design. The second issue that lead to challenges is the immature concepts, and the third issue discussed for consideration addresses the players involved in the experiment.

3.1. Complex Environment

The experiment was designed to provide as robust a C2 environment as possible for the UA Commander and staff. Three cells, the Red, Green and White cells, were created to generate the appropriate operational setting. The Red cell, manned by representatives from TRADOC Deputy Chief of Staff for Intelligence (DCSINT), role-played the OPFOR and adaptively executed plans intended to stress the UA. The Green cell represented the Unit of Employment (UEx) and the UA higher headquarters, responding to any requests for support, including information that the UA generated. This cell also fulfilled some of the support that might be provided from the Army Forces (ARFOR), Combined Joint Forces Land Component Commander (CJFLCC) or Joint Task Force (JTF) level. This cell additionally represented those units adjacent to the UA. The White Cell served as the experiment's arbitration body chartered to insure that all tactical operations were conducted within the context of the UA O&O Plan and that the experiment's analytic objectives were being appropriately investigated.

The UA organization was based on the 30 June 2003 UA O&O Plan (Increment 1) and contained those elements portrayed in the wiring diagram shown in Figure 3.2. For the UA headquarters, both the Deployed Command Post and the Mobile Command Groups were represented. The nodes of the Deployed Command Post (TACP) were manned at about 90% strength, suggesting a staffing level that might be expected during sustained high tempo operations. MCG1 was fully staffed, while MCG2 had one player as a response cell. Each subordinate battalion was represented by a command element. One battalion, 2nd CAB, was represented to the soldier level and required response cells down to squad level. The Brigade Intelligence and Communications Company (BICC) was only represented by a command element and essential section lead elements. The organizational design structure of the UA Aviation Squadron was in accordance with the guidance received from GEN Byrnes.

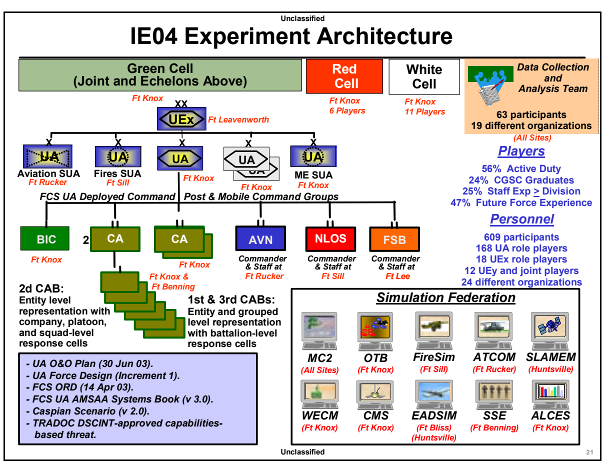

Figure 3.2

3.1.1. Modeling and Simulation Environment

The Battle Laboratory Collaborative Simulation Environment (BLCSE), which is a complex and distributed "toolbox" capable of supporting multiple models and human-in-the-loop simulations, was the means for stimulating the players and driving the experiment. Incorporation of the BLCSE as the means for distributing the model federation at a number of different locations is, by far, one of the major accomplishments of this effort. More than ten unique simulation models and federation support tools passed data between eight different locations supporting hundreds of players in order to examine Networked Battle Command and Battle Command enabling objectives. It required the synchronized integration of a number of disparate simulations as well as the development of new algorithms and software modules to address the emerging concepts articulated in the UA O&O Plan. The success of this effort hinged upon the initiative and mission focus of several organizations from across government, industry, and academia brought together in a cooperative environment.

The majority of combat entities were modeled in the Objective Force OneSAF Test Bed (OF OTB). Also included in this federation was the Warfighter Electronic Collection and Mapping (WECM) model that simulated the signal intelligence (SIGINT) capability of UA software-defined radios; Aggregate Level Communications Effects Server (ALCES) which replicated communications effects; the Advanced Tactical Combat Model (ATCOM) that represented Rotary-wing aircraft, Red air defense, and UAV capabilities; and the Comprehensive Mine and Sensor (CMS) simulator that represented mines, IMS, IEDs, and unattended ground sensors with imaging, infrared, acoustic, seismic and magnetic sensors. Also, Extended Air Defense Simulation (EADSIM) modeled joint effects and blue air defense systems, and FIRESIM represented indirect fire assets and counter-battery radars. Finally, the suite included the Simulation of Location and Attack of Mobile Enemy Missiles (SLAMEM) model, an entity-level simulation that modeled joint and UEx sensors. These simulations, when federated, were supposed to enable the analysts and combat developers to better gauge the impact of information on force effectiveness. While these simulations in the federation attempted to provide the ability to model battlefield entities at varying levels of resolution, limited time prevented a valid integration and testing period and as a result, interactions between these models were not validated.

Three successes of the experiment from a technical standpoint included the addition of a federation quality control tool (Exercise Manager), a robust data collection and storage tool (TRAC-ESS), and a post processing capability based on SQL Server. While technical limitations prevented the full potential contribution of these tools, these three new additions were designed to enable a higher level of analytical and technical assurance in the input, collection, retrieval, storage, processing, and synthesis of data. In the future, the growing maturity of these tools will increase the validity of the data and improve the efficiency and responsiveness of the analysis.

3.1.2. The C2 Surrogate

The primary Surrogate C2 system used in the experiment was MC2. Also the FIRESIM GUI was an additional system that was utilized to execute networked fires tasks.

MC2 is a temporal and geospatial planning and execution system that allows a user to plan and wargame COA's as well as provide a current situation display of the COP. It can plan up to UEx and down to the platform level displaying unit composition for the individual platforms

The MC2 system is an Objective Force C2 system. As such it provides features for the following essential C2 requirements [1]:

- *Planning*. MC2 captures the commander's plan in a way that permits the software to understand the plan in sufficient detail to permit it to draw conclusions about the plan's potential execution.
- *Rehearsal*. The plan may be rehearsed through a set of animation features designed to give the commander as sense of the plan's execution over time.
- *Collaboration*. All MC2's are able to connect to a collaboration server which acts as the central repository for the plan or execution information for a particular collaboration session. Many sessions may be started on a single collaboration server, each with its own unique collection of plan/execution data. Any MC2 may join one of the available sessions and receive the current operating picture when they join.
- *Execution and monitoring*. MC2 is able to show current situation information for both friendly and enemy forces. In addition it is able to show the relationship between current situation and the plan to alert the commander to potentially evolving risks and opportunities.
- *Stimulation*. Any MC2 can be put into stimulation mode, where a previously constructed plan of friendly and enemy forces can be run and the resulting movement of the entities is converted into heartbeats for the friendly and spot reports for the enemy. The spot reports are only generated if a friendly sensor has a range that covers the position of the enemy. All of the SA information is from the stimulator is collaborated to all clients in the same collaboration session as the stimulator.
- *Re-planning and commanding*. The MC2 system supports a facility to change the existing plan and effect commanding to other human or automated systems as a result of the re-plan.

The challenge with using these surrogate systems for C2 stem from the fact that they are new technologies. With new technologies, integration and familiarity will be at issue. From observations from the players, many of the capabilities of MC2 are very complex to execute or do not exist. The legacy C2 systems have more capability and are more user friendly then these future surrogates. The players will gravitate to what they know to accomplish the mission and will not exercise the networked battle command capabilities that should be assessed.

3.1.3. Experimental Design

Finally, the last part of the complex environment deals with the operational environment and the experimental design, which was defined by a number of reference documents. These included the UA O&O Plan and the April 2003 version of the FCS Operational Requirements Document (ORD). In addition, the scenario was compliant with the Defense Planning Guidance (DPG) and all performance data (other than the urban data) for the systems represented in the simulations were defined in the Army Materiel Systems Analysis Agency (AMSAA) Systems Book, version 3.0. Adherence to these references was to insure a level of coherence and validity in the experimental design such that confidence could be achieved in the experiment insights and recommendations. However, as previously discussed, the limitations of the experiment design and schedule prevented complete adherence to these documents and did not allow for a verification and validation (V&V) of the experiment architecture:

- An increment 1 UA force design was utilized as opposed to the required Increment 1 Threshold.
- All implemented performance data was not in accordance with the most current version of the AMSAA system book.
- The implemented threat lay-down was not in accordance with the tenets of the Future Operating Environment (FOE) and did not receive TRADOC DCSINT approval.

The IE04 construct was intended to provide a valuable opportunity to explore the capabilities and limitations of the UA based on the experiment objectives and study issues previously discussed. However, the experimental environment was not fully representative of the required tactical environment. As a result of the shortcomings in the exercise design and technical execution, the Study Team could not draw conclusions that were supported by valid output data with a high degree of confidence. Consequently, the main sources of data supporting the observations and insights in the final report were qualitative in nature.

The primary experimental design limitations that precluded the achievement of the experimental objectives include:

- The UA was represented with a force effectiveness capability that was greater than the capability defined in Increment 1 (Threshold). This resulted in overstating the UA performance. Additionally, lethality and survivability functionality were both overestimated and underestimated in different models of the federation, resulting in the same systems having different killing and vulnerability performance.
- The information dissemination concept was too immature to represent in the experiment architecture. The attempt to represent the information dissemination system resulted in numerous message types being broadcast to all stations, which overloaded some systems creating significant delays in information delivery. These delays resulted in different cells having different levels of situational awareness and understanding. Additionally, the Message Completion Rate and Message Timeliness Rate were not accurate, as technical limitations prevented all forms of communications from being affected by degrading the network.
- The compression of the experimentation schedule prevented large-scale integration testing of the federation, which contributed to other technical issues. The most serious of these issues was inconsistency in performance data for the same mission threads, which invalidated most of the output data. This made it impossible for the analysts to follow the flow of actions and analytically substantiate conclusions. The compressed schedule also resulted in only one record run, instead of the two runs that were planned, reducing the data collection by 50% and eliminating a comparison of the run results.
- Other technical issues included fewer threat entities being represented than the FOE tenets required, as threat capabilities were removed to accommodate technical limitations. Some Blue entities were grouped (aggregated), but still possessed entity-level behaviors and performance data.

As stated in the Experimentation Code of Best Practices published by the Command and Control Research Program, "Many experiments have been less valuable than they could have been."[2] From an analytic view point IE04 definitely falls into this category. As a result of these limitations, the planned analytic methodologies were dynamically modified to enable a collection of battle command processes and enablers under different conditions.

3.2. Immature Concepts

The concepts for how to fight in this future environment are immature and not fully staffed within the Army, let alone the Joint arena. With concepts that are not documented and systems with capabilities that are not fully defined, it is difficult to establish a baseline in which to assess.

3.3. Untrained Players

As shown in Figure 3.2 above, the experience of the players was quite impressive and probably exceeds what might be expected in most operational units. It is unlikely, for example, that a UA would have the benefit of over a quarter of the players having Division staff experience, with 20% having Corps staff experience. This profile was consistent for a significant number of participants including the UEx and UA players; the Red cell team leaders, the analysis team, and the many software engineers and technicians who participated in the development and implementation of the various simulations within the federation.

Although the experience of the players was quiet impressive, when anyone is working in a complex environment with many unknowns and attempting to implement immature concepts, it turns out to be an uncontrolled environment that is not conducive to experimentation with analytic rigor.

While training is not explicitly depicted as a limitation, current experimentation training strategies did not produce sufficient levels of player proficiency. As a result of insufficient understanding of Future Force concepts and surrogate system functionality, experimental outcomes and subsequent analytic efforts were negatively affected.

4. Recommendations

While IE04 provided some opportunities for maturing the base of knowledge of Future Force concepts, much more could have been learned. IE04 was a large-scale discovery experiment that required a significant number of resources. As a forcing function for learning and maturing our experimentation efforts, IE04 demonstrated that we must do a better job of improving the return on investment for this type of experiment.

The productivity of an experiment of IE04's scope depends on the successful planning and integration of six major components: Concept, Scenario, Schedule, Training, Technical, and Analytical. Lack of optimization of any of these components will effect the other components and reduce the overall potential of the experiment to provide qualitative and quantitative insights. IE04 produced problems in every major component of experiment design:

- Concept: the attempt to replicate immature concepts prevented a realistic assessment of the UA's capabilities. Communications capabilities were misrepresented resulting in artificial loads being placed on the communications system. A capability greater than Increment 1 (Threshold) was represented in the UA and adherence to the threat FOE was not achieved.
- Scenario: the limited architecture induced local hardware loading that caused required force structure and capabilities to be removed from the scenario. This reduction decreased the robustness of the planned METT-TC conditions, the availability of Battle Command tactical dilemmas, and ultimately the data collection opportunities.
- Schedule: the short development schedule resulted in eliminating large-scale integration testing. This prevented the federation from being ready for player training. As a result, the schedule was slipped and only one of two record runs was executed, reducing data collection opportunities by 50%.
- Training: the vast majority of players scored less than 70% at the end of the experiment on an assessment of their understanding of the O&O and MC2 basic capabilities. Valid insights during these experiments critically depend on the players having an adequate understanding of the Future Force doctrine and its capabilities.
- Technical: lethality and survivability performance characteristics were misrepresented in different M&S. Model output data was found to be invalid as critical mission threads were inappropriately represented. Fewer threat entities were represented and some Blue entities were "grouped", yet possessed improper entity-level behaviors. Significant latency resulted in different cells having different levels of situational awareness. MCR and MTR were not accurate, as all forms of communications were not equally affected.
- Analytical: rigorous data collection of all objectives could not be achieved. Model output data was found to be invalid as different models produced different data for the same mission threads. Entity-level behavior and data issues produced inaccurate data.

In order for these experiments to contribute to future force development, changes are required. An experimental design and integrated timeline must be adhered to and drive further development and refinement of the concept, scenario, schedule, training, technical integration, and analytic planning efforts. Although it is understood that concepts will never be fully mature, training never fully completed, and the complex technical environment fully without issues; but what must be the goal is an understanding by all involved of the capabilities, limitations, maturity, and training level so that proper insights can be drawn. A campaign planning approach with integrating qualities would improve the experimental design and enhance the validity of the analytic results.

5. Conclusions

With a complex environment, immature concepts, and players that are not fully trained, this will ultimately lead to an uncontrollable environment from a standpoint of being able to apply analytic rigor. Without analytic rigor, the study will continue to default to doing a discovery type experiment with little or no analytic underpinning, and will never graduate to the more rigorous hypothesis testing. If you are not going to get analytic underpinning, you do not need to invest in the resources it takes to develop a complex environment. Also, whether you utilize a complex environment or not, you must limit and focus your experimental objectives in order to focus your environment, concepts, and player training.

Despite several challenges highlighted throughout this paper, IE04 did enable the maturation of several different areas, while facilitating the development and refinement of numerous products. It accelerated the maturation of several concepts and enabled additional UA O&O refinement. Particularly, it enabled significant maturation and understanding of the Support UA (SUA) concepts, as Sustainment, Fires, Aviation, and Maneuver Enhancement SUAs achieved more potential learning growth than was originally planned. Similarly, as TRADOC develops and executes the ACDEP, those concepts that still require additional analysis and experimentation should be the focus of the experiments that each of the TRADOC Battle Labs is planning. The experiment also served to motivate the refinement of the distributed experimental design environment. While the developmental challenges were demanding, the accomplishments of the distributed environment were equally impressive. The distributed federation simulated a significant number of entities, capturing the elements of a UEx supported by joint assets and a robust suite of sensor capabilities; it also replicated a threat corps-size element over a large terrain set.

Finally, the experiment did enable an assessment of the Battle Command challenges associated with commanding the UA in an adaptive, dynamic environment. Even in the reduced number of vignettes exercised, it became clear that the demands faced by the UA Commander were, in some sense, different from those experienced by today's commanders and, in other ways, similar, but much more pronounced than today's commanders encounter. The size of the area of operations, the number of sensor assets under the control of the commander, the unimpeded access to joint fires and effects, and other observed characteristics require modifications and refinement to future training and leader development strategies.

6. References

[1] MC2 Operators Manual, Release 1.0, 13 May 2004.

[2] Code of Best Practice for Experimentation, DoD Command and Control Research Program, July 2002.

Author Biographies

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