Flexible Method for Developing Tactics, Techniques, Procedures, and Training for Future Capabilities

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ABSTRACT

As new technologies are developed and "spun out" to the U.S. Army, effective training of its Soldiers, leaders, and units to employ these technologies will be essential. To support the timely development of new technology training, initial Tactics, Techniques, and Procedures (TTP) will need to be developed before the capabilities are actually produced. Because of this, traditional methods for developing TTP may not be adequate. Thus, there is a need to investigate TTP development methods to augment traditional methods. These new TTP development methods must provide structured activities to measure, assess, and guide the TTP development process, but must also be flexible enough to respond rapidly to a wide range of conceptual constructions. The goal of the research described in this paper was to create a future-focused method for developing TTP. The approach harnessed knowledge elicitation methodology and simulation-based vignettes to provide a flexible set of tools to structure and guide the TTP development process. As a proof of concept, the methodology was used to develop TTPs focused on the combined employment of the Future Combat System Class I Unmanned Aircraft System (UAS) with existing (and Spin Out 1) capabilities. The resulting developer's support package was implemented with Soldiers to obtain feedback and ideas for improving the method. Facilitating TTP development via the structured knowledge elicitation (KE) process was productive across four wide-ranging simulation vignettes. The effectiveness of the method was measured by participant ratings as well as the research team's ability to implement the process. A majority of participants and researchers rated all aspects of the KE method highly, with the only exception being the technical aspects of the simulation. The method produced high-quality TTP that could provide a firm foundation for developing future training. Lessons learned and future recommendations are provided.

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INTRODUCTION

With the U.S. Army's rollout of the Future Force and Future Combat Systems (FCS) over the next several years, many new technologies will be introduced to the field (Welch, 2003). The FCS family of systems will provide unprecedented capabilities for Soldiers in the U.S. Army. However, Wass de Czege and Biever (1998) state: "Combat power is not the sum of machine performance; it requires individual and organizational competence and synergy" (p. 19). Shadrick, Lussier, and Hinkle (2005) also state that, "A change in technology creates corresponding changes in the operational and cognitive systems – resulting in the transformation of existing roles, processes, and procedures and the development of new ones" (p. 1).

As new technologies are developed and inserted into the U.S. Army, Soldiers and units are often on their own to determine how to best employ the technology and how the new technology impacts their existing tactics, techniques, and procedures (TTP). Even if operator training is provided, the lack of employment training reduces the likelihood that the unit will readily use or fully exploit the new technology in combat. If the unit does attempt to integrate the technology, the lack of proper guidance and tools for developing new TTP or revising existing TTP reduces the unit's training effectiveness and combat effectiveness. By developing initial tactics, techniques, and procedures (TTP) before equipment capabilities are actually produced, a baseline of information on changes to or development of new TTP can be developed and tested. This, in turn, will aid in the development and refinement of training products based upon these new TTP well before Soldiers require them. However, the Army needs an innovative method—one that is structured, flexible, and measurable—to support rapid development of initial TTP.

Traditional methods for developing TTP rely on the exploration and testing of new doctrine and training. Yet these approaches are often less effective than desired when real world implementation is impossible. To address this problem and help ensure effective fielding and training of new technologies, TTP development methods that provide structured activities to measure, assess, and guide the process are needed. Shadrick, Lussier, and Hinkle's (2005) flexible method of cognitive task analysis (FLEX) provides a promising approach for TTP development. The FLEX method is an iterative, interview-based, and vignette-driven approach that provides a structured process for developing future concepts. The goal of this research and development effort was to expand, implement, and document the FLEX method as a TTP development tool for future systems.

This paper describes the methodology developed to support the establishment of future-focused TTP and the results of a trial implementation of the methodology. It is intended to help system and training developers as they work to make the Army's Future Force vision a reality.

Background

Shadrick, Lussier, and Hinkle (2005) have identified two primary methods of concept development traditionally used by the U.S. Army. The first method is an expert analysis of new concepts and technologies, which often provides general information about the integration and impact of future systems. The second method involves developing a replica of a new system and testing it through either a unit exercise or a simulation.

Both of these methods pose disadvantages. With the first method, the resulting analysis is typically quite general in scope and not aimed at developing TTP. It is also limited in that it represents the views of one or few experts. Also, the resulting analysis does not undergo testing through implementation. The second method offers the advantage of actual implementation, but it is often expensive to conduct. Also, there are limited opportunities to manipulate variables related to the future systems and to iteratively develop and agree upon the impact of such systems. A method is needed that will address the disadvantages of these two systems. Such a method needs to provide a measurable process for eliciting expert knowledge that is iteratively developed and reviewed by a range of Soldiers.

Various methods for eliciting the knowledge of experts in the U.S. Army have been used (e.g., Klein, 1996), and most have focused on task analysis-based approaches. With traditional task analysis, the focus is on understanding how an expert or experts perform a job as well as the knowledge, skills, and attitudes required to perform the job (Department of Defense, 2001). Also, job performance has a specific start and end point and must be observable.

The use of cognitive task analysis (CTA) as an approach to eliciting expert knowledge (e.g., Schraagen, Chipman, & Shalin, 2000) has been increasing because the approach facilitates capturing non-observable behaviors as well as tacit knowledge and processes. This is particularly valuable with future concepts since the systems and technologies have not yet been developed. In using CTA, we can go beyond procedural knowledge and the behavioral aspects of an individual's job in order to understand the "cognitive map" that guides his/her work processes.

The FLEX method developed by Shadrick, Lussier, and Hinkle (2005) employs CTA methods to elicit Soldiers' expertise via structured processes involving interactions with simulation-based vignettes. The vignettes facilitate making decisions about how to employ future equipment in light of specific factors related to mission, enemy, terrain/weather, troops, time, and civilians (METT-TC). The decisions form the basis for developing TTP in support of future concepts. Resulting TTP are iteratively reviewed and refined until a baseline foundation for the new systems and technologies has been developed. This approach was the focus of this research.

The FLEX method was designed to consider and capture future capabilities and their implementation by Soldiers in the field who have practical warfighting experience. It harnesses knowledge elicitation (KE) methodology to examine how Soldiers would employ technologies in different types of missions. By working with Soldiers from different military occupational specialties (MOS), as well as varying years of service and types of field experience, we can develop a rich perspective of how Future Force concepts and technologies would be used, adapted, and advanced by expert Soldiers.

Developed as an iterative interview and vignette-based KE approach, the FLEX method is designed to explore future concepts. The basic features of the method are outlined below and illustrated in Figure 1.

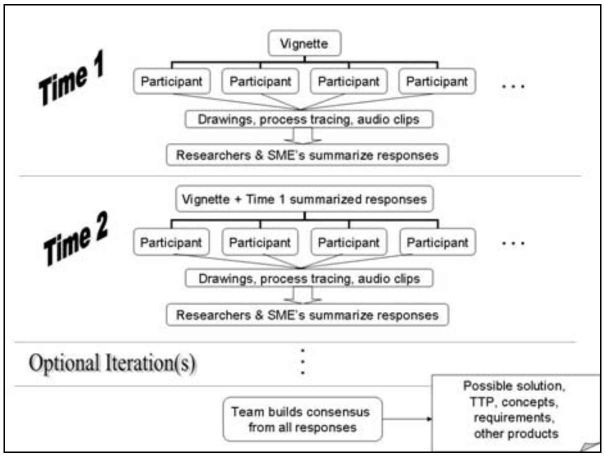

Figure 1. The FLEX process (taken from Shadrick, Lussier, & Hinkle, 2005).

1. Expert participants are provided with a potential future situation and are asked to solve a complex problem using the anticipated capabilities.
2. Participants are asked to verbalize their responses by thinking aloud.
3. Responses from participants are provided to subsequent participants.
4. A semi-structured interview is used to probe expert knowledge and gain a deeper understanding of the participant's reasoning.
5. Responses are reviewed and refined by subsequent participants.
6. Finally, a small group of experts is used for interactive discussions allowing for consensus building and validation.
7. The consensus outcomes can then be used to design training or write formal TTP.

Since the FLEX method is grounded in CTA approaches, the focus is on facilitating and capturing decisions made by Soldiers as they interact with complex problems and environments. Within complex systems, there are often multiple, interconnected problems and variables (Funke, 1991). Since decision makers often have to respond rapidly, typically under the pressure of limited resources and information, it can be challenging to identify how technology impacts roles, processes, and procedures. By examining decisions made for taking a specific course of action, we can also examine the decision makers' assumptions, perceptions/misperceptions, and their use and adaptation of the technologies within the larger system.

To facilitate decision making within complex environments, simulations offer powerful tools for TTP development. Because they facilitate the capability to visualize, interact with, and manipulate variables within an authentic environment (Gredler, 2004), they are used as part of the FLEX method as a way for Soldiers to "interact" with future capabilities and technologies. Since most Soldiers and even Future Force experts have not been immersed in a networked system of systems, they have limited understanding of employment and integration of these new technologies. Thus, simulations provide valuable tools for helping envision the impact of such technologies on warfighting TTP.

METHOD

Overview

The goal of this project was to develop, implement, and examine the usability of a new method for developing TTP for FCS Spin Outs, as well as other system development and acquisition programs. This led to conducting the research in the following stages:

- Development of simulation vignettes;
- Development of KE process and instruments;
- TTP development and review/refinement during implementation;
- TTP finalization; and
- Assessment of the TTP development/ refinement method.

The research approach combined military subject matter expertise, behavioral science knowledge, CTA expertise, and computer-based simulation expertise to execute these stages. We relied on Future Force documentation to create the simulation-based vignettes that reflected the latest concepts. The KE process was developed based on the FLEX method (Shadrick, Lussier, & Hinkle, 2005). Specific KE approaches and instruments were shaped to ensure that KE sessions were grounded in the Future Force concepts and that they would facilitate both TTP development and review/refinement. Additionally, the KE approaches were fashioned to ensure balanced contributions of individual Soldiers as well as small group interactions. The newly created method was evaluated by examining specific outcomes and variables, such as how many TTP were produced and revised, key differences between those in various roles, and the overall success factors related to the implementation of the method.

Development of Simulation Vignettes

In accordance with the proof-of-concept framework, the development of TTP-focused simulation vignettes concentrated on FCS Spin Out 3, a family of Unmanned Aircraft Systems (UASs). Vignettes focused on the company echelon and below, reflected the employment of Spin Out 3 UASs in combination with Spin Out 1 and 2 capabilities, and accommodated a variety of Soldier backgrounds and qualifications.

To provide an overall context for the vignettes, a Road to War was created to set the stage for the current tactical conditions. Descriptions of friendly and enemy forces, events, timelines, and images were provided to help participants understand the big picture. To provide a range of tactical conditions, different types of missions, units, terrain, enemy, and uncertainty of enemy knowledge were used across vignettes. An additional vignette focusing on company security patrol served as a practice vignette before executing the ones below.

Each vignette was designed to provide approximately 15 to 20 minutes of interaction for the participants. A battalion operation order (OPORD) set the stage for the family of missions. Accompanying each vignette was a battalion fragmentary order (FRAGO) to prompt mission planning and accomplishment. Also provided were event guides for exercise controllers and terrain sketches.

Vignettes were developed using the Objective Force-OneSAF Objective System (OF-OOS) software platform (Version 1.0.2). This platform is designed to be a composable, next-generation Computer Generated Force (CGF) modeling software that represents a full range of operations, systems, and control processes from the individual combatant and platform level to brigade levels. The version of OF-OOS available during the project was immature, so the operational capabilities were fairly limited. Because of the limited capabilities and difficulty of use, simulation operators had to be used to facilitate execution of vignettes.

Development of Knowledge Elicitation Process and Tools

The KE process and tools developed for this project were based on the stages of the FLEX method as outlined by Shadrick, Lussier, and Hinkle (2005). A CTA framework served as the central foundation for developing the KE process. The primary focus was on harnessing KE methods and developing procedures and tools that would facilitate effective TTP development and subsequent review/refinement in concert with simulation-based vignettes. The core KE facilitation techniques included:

- Interaction with simulation-based vignettes
- Think aloud probes eliciting key decisions as participants role-played during vignettes
- Individual TTP development or review/refinement based on METT-TC factors
- Semi-structured interview regarding TTP outcomes
- Group discussion of overall outcomes

The overall KE process entailed multiple, sequential phases: orientation, interaction with simulation vignette, TTP development (or review/refinement), summary review, and group debrief. The vignette-specific steps (Phases 2, 3 and 4) were iterated until all four vignettes had been completed. The complete sequence of phases was designed to be implemented in a full day, to capitalize on train-up and momentum of a group of participants and to avoid the need for a given group to return later. The multi-phase process formed a systematic, comprehensive methodology for engaging participants in tactical challenges, surfacing tacit knowledge and procedures, and leveraging the participants' expertise to construct TTP for employing UAS capabilities.

The key advantage of the overall KE process stemmed from the use of multiple approaches supporting multiple data outputs. In addition, the process represented our goal of balancing group KE with individual KE, simulation-driven KE with discussion-based KE, and iterative TTP development with iterative TTP review/refinement.

The KE process steps rely heavily on note-taking by facilitators and hand-written constructions by participants to capture raw input for TTP development. In addition, facilitators record participants' verbalizations and discussions using digital voice recorders. The voice recordings supplement the hand-written notes and support subsequent analysis after the KE sessions are completed.

To enable consistent implementation and iteration of the KE process, we developed a family of KE tools in hardcopy format. These tools included an orientation package for bringing the participants quickly up to speed, planning guides for facilitators, sample TTP to serve as a template for participants, and forms to facilitate data capture. The materials were designed to make a future facilitator's job easier while preserving his/her ability to adapt the process and tools to fit specific conditions and requirements.

TTP Development Procedures

When put into action, the KE process with its implementation materials enables the development of vignette-driven TTP. A TTP development session would be conducted with a small group of participants (three to four Soldiers). First, participants interact with a simulation-based vignette while playing an assigned role (e.g., Platoon Leader [PL]). During the simulation, facilitators provide think aloud probes in order to elicit each participant's key decisions as well as factors and cues related to why specific decisions were made. This occurs during the course of participants' interactions with each of the vignettes. The think aloud probes include questions such as "Can you tell me how you are using your UAS?" or "What factors influenced your decision to take this action?" Facilitators record participants' responses, and audio transcripts from the sessions help ensure the quality of the data collected.

Once participants finish role-playing in a vignette, they complete a TTP development worksheet for the vignette. They individually record TTP elements specific to the factors of METT-TC. After participants complete the worksheet, the KE facilitator conducts a semi-structured interview with participants. The participants are interviewed by role, with the senior role-player (Company Commander [Co Cdr]) being interviewed as an individual, and PLs being interviewed as a small group.

After TTP development is completed for each simulation vignette, an overall TTP development session is conducted with the whole group in order to craft a list of overall TTP. These TTP serve as a more generic set that potentially applies across the various missions represented in the vignettes. Once data collection is complete, individual TTP from individual participants' worksheets for each vignette are compiled into a list representing TTP developed by all participants in the day's group. In addition, audio transcripts are analyzed to produce selective additions to the group's vignette-specific TTP lists. Also, the overall list of TTP is compiled by KE facilitators.

After vignette-specific and overall TTP are compiled into a unified set, two SMEs with extensive military experience review each TTP and edit the elements to clarify meaning and translate acronyms. The SMEs are careful to not change the meaning of any TTP, and elements that are similar or repetitive across vignettes remain on the list in their various forms. From this process, a set of TTP emerges that represents one specific group's set of TTP. Additionally, participants' considerations of when and how to use the UAS are also documented.

Because of the large number of TTP that may be developed by each group, we realized the difficulty of reviewing long lists of TTP for each vignette without some understanding of the participants' overall strategy for accomplishing the mission presented in the simulation vignette. Thus, a SME with military expertise reviewed the long list of TTP for each vignette and developed a TTP summary. The purpose of the summary was to provide subsequent participants with a TTP development group's overall strategy for accomplishing the mission.

Such a summary was placed at the beginning of the list of TTP for each vignette. Also, emerging TTP as well as considerations (TTP-C) were kept in their original order, with their original vignette, and grouped by factors related to METT-TC.

TTP Revision Procedures

Two types of TTP review/refinement (vetting) sessions can be conducted—single-source and multiple-source sessions. During a single-source session, participants receive TTP that originated in a single TTP development session. During a multiple-source session, participants receive cumulative TTP resulting from all of the preceding TTP development and single-source vetting sessions.

Single-Source Vetting Sessions

The TTP review/refinement procedure mirrors much of the same process as the TTP development procedure, except that participants receive the outputs from previous groups to establish a starting point for the review/refinement process. As participants role-play during simulation-based vignettes, facilitators provide think aloud probes in order to uncover their decisions as well as why the decisions are made. The think aloud probes include questions such as "Can you tell me why you made that decision?" and "What caused you to choose that course of action?" Again, facilitators record participants' responses, and audio transcripts from the sessions later help ensure the quality of the data collected.

Following the end of a simulation vignette, the participants complete a worksheet asking them to review/refine previously developed TTP. This worksheet gives the vignette-specific TTP preceded by the TTP summary developed by a SME. Participants are asked to first review the TTP summary, rate it for acceptability, and edit it as needed. Then they are asked to review the TTP-C developed for each vignette and to specify whether they should be kept, modified, or deleted. Participants are asked to explain why the specific TTP-C: a) is good and should be kept, b) should be modified and how, or c) should be deleted.

Once participants complete the worksheet, the KE facilitator conducts a semi-structured interview with participants to review each of their ratings and to come to consensus, if possible, on each TTP-C. The participants are interviewed by role, with the senior role-player (Co Cdr) being interviewed as an individual, and PLs being interviewed as a small group. After the TTP review/refinement process is completed for each vignette, participants also review the summary TTP following the same process.

When data collection is complete, results of each participant's TTP-C ratings are compiled and entered into a spreadsheet noting whether each TTP-C is to be kept, modified or deleted. Additionally, edits made by participants to specific TTP-C are compiled. Again, two SMEs with extensive military experience review the revised set of TTP-C to correct for unclear meaning or acronyms. The resulting set of TTP is again reviewed and refined one or more times during subsequent sessions (groups), until each set of TTP-C reaches a desired degree of refinement.

Multiple-Source Vetting Sessions

Multiple-source vetting sessions can be conducted to integrate cumulative TTP and build consensus. Because this approach is more detailed and takes more time to conduct, each group of participants would focus on just two vignettes in a one-day schedule.

In single-source TTP review/refinement sessions, participants review a single TTP summary for each vignette along with a list of TTP-C elements. However, in multiple-source vetting sessions, participants are first asked to review as many TTP summaries for Vignettes 1 and 2 as were produced by the previous development/refinement groups. These summaries are edited by a SME in order to ensure clear meaning. The vetting group then reviews, rates, and refines (when needed) each TTP summary. Then they write their own TTP summary by editing existing ones or by drafting their own. The participants then work together to create one team-based TTP summary that combines the best elements from other TTP summaries and adds new elements as deemed important.

In the next step, the same participants may rate multiple TTP-C developed by different development groups. The multiple TTP-C can be presented again and grouped by vignette and by specific METT-TC factors. Participants rate and review these multiple sets of TTP-C for each vignette and specify whether each one should be kept, modified, or deleted. Again, they also modify/refine any TTP-C that they decide need refinement.

In order to develop a unified set of TTP, independent SMEs can integrate the team-based TTP summaries as well as the vignette-specific TTP to create a final set. This step enhances the quality of the TTP-C so they are clear in meaning and easy to understand. Thus, SMEs who are experienced writers play a critical role in producing high quality TTP.

Assessment of the FLEX Method Implementation

To accomplish an important technical objective of the project, we planned and conducted a series of trial implementations. The resulting KE sessions applied the methods and the KE tools described in the foregoing sections, with Soldiers in the loop. Data collection efforts focused on capturing TTP and documenting the KE process for the purpose of testing the implementation of the FLEX method.

Implementation Procedures

Data collection was conducted over three separate weeks at two different sites, with one site furnishing participants for two different weeks. Each data collection period lasted 3-5 days. At the first site, armor and cavalry leaders (officers, noncommissioned officers) representing platoon and company echelons participated in three KE sessions. At the second site, Army Evaluation Task Force (AETF) leaders and Future Force Integration Directorate (FFID) personnel participated in five sessions, respectively. Each data collection session lasted 6-7 hours, with appropriate breaks provided for participants throughout the day.

In the single-source TTP review/refinement sessions, participants reviewed a single TTP summary for each vignette in combination with a list of TTP-C for each vignette. However, in multiple-source vetting sessions, participants were first asked to review five TTP summaries for Vignettes 1 and 2 (or Vignettes 3 and 4) that were developed by five former development groups. These summaries had again been edited by a SME in order to ensure clear meaning. The summaries from development sessions one, two and three were previously vetted three, two and one times respectively, while the material from development sessions four and five was not previously vetted. Each group then reviewed, rated, and refined (when needed) each TTP summary. Then they were asked to write their own TTP summary by editing existing ones or by crafting their own. The KE facilitator then asked participants to work together to create one team-based TTP summary that would combine the best elements from other TTP summaries and add new elements that were important. These final TTP summaries for each vignette were recorded.

The trial implementation included five TTP development sessions, six single-source vetting sessions, and finally two multiple-source vetting sessions. Once the data collection was finished, all data were cataloged and inventoried to ensure all documentation was complete. Also, audio files were transcribed after each data collection session. All data were grouped and compiled into multiple spreadsheets. Two members of our research team entered data into spreadsheets, with random quality assurance checks performed by other team members.

In order to produce an integrated set of TTP, two of the team's SMEs independently reviewed the team-based TTP summaries as well as the vignette-specific TTP and combined them to create a final family of TTP. Because participants in this project represented different ranks, educational levels, and experience, the quality of the raw TTP-C varied greatly. Quality TTP-C need to be clear in meaning and well written. In fact, some participants expressed concern with their lack of writing and editing abilities. Thus, the role of the research SMEs in editing TTP-C as well as TTP summaries was critical to producing a quality set of TTP for each vignette and for overall purposes.

RESULTS AND DISCUSSION

The effectiveness of the current KE method to develop TTP was assessed through multiple measures. Each measure was designed to address a separate aspect of the methodology.

Participants

A total of 48 participants took part in the research project with 13 assigned the role of Co Cdr and 35 serving as PLs. Military experience varied greatly between the participants in terms of rank, MOS, and length of service. The average number of months in service was 126.90 (*SD*=99.91), with the longest tenure being 420 months and the shortest 14 months. There was a positive correlation between length of service and session order, r=.56, p<.001, indicating that more experienced participants took part in the later KE sessions. Overall, 77.27% of participants indicated they had previous experience developing standing operating procedures (SOP) or TTP, 79.55% reported they were familiar with FCS and Spin Outs, but only 9.09% noted they had prior experience with unmanned vehicles.

Implementation Effectiveness

Participant feedback forms were used to assess the perceived effectiveness of the current KE method. Both groups rated aspects of the KE sessions on a five-point scale (strongly disagree to strongly agree) across several dimensions. As necessary, scores on the five-point scale were transformed so that higher scores reflected positive ratings. As shown in Figure 4, a majority of participants rated the KE method positively, with the exception of the simulation. Less than half the raters gave positive ratings for the simulation. It should be noted that "neutral" responses are not represented in Figure 2.

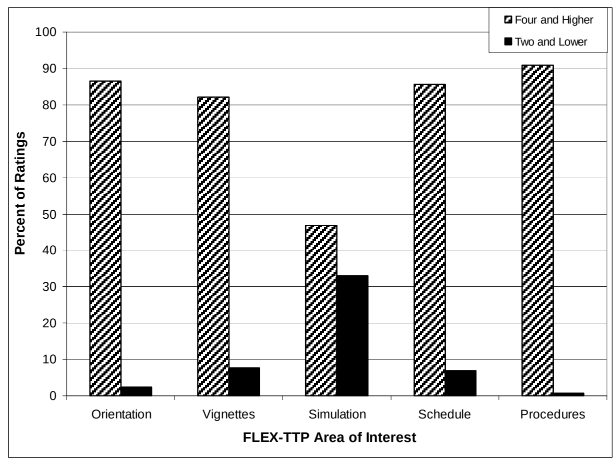

Figure 2. Participant ratings of effectiveness of various methodology components.

Saturation Effects

To determine the point of saturation (Guest, Bunce, & Johnson, 2006) for developing new TTP, we calculated the proportion of TTP items generated during a development session that did not duplicate items generated in a previous development session. For the purpose of the current project, the criterion for saturation was defined at 5%. That is, when the number of new TTP generated during a session fell below 5% the point of saturation was reached. There was no absolute justification for choosing 5% as the point of saturation. Since it is unlikely, and impractical, that all possible TTP will be developed in an infinite number of sessions, future research teams must balance the relative costs and benefits associated with the KE process to determine their own criterion for saturation.

As shown in Figure 3, by the third development session only about 8% of the TTP generated were new

TTP. During the fourth and fifth development sessions the percent of new TTP dropped to 2.5% and 4.5%, respectively. Thus, under the conditions of this research project saturation was reached after three development sessions. Future research should define the point of saturation according to the objectives of the project and weigh the relative importance of any new TTP against the resources required to generate them. For example, the point of saturation might be set higher for TTP related to battlefield conditions and when lives are at greater risk, and set lower for TTP associated with less critical functions.

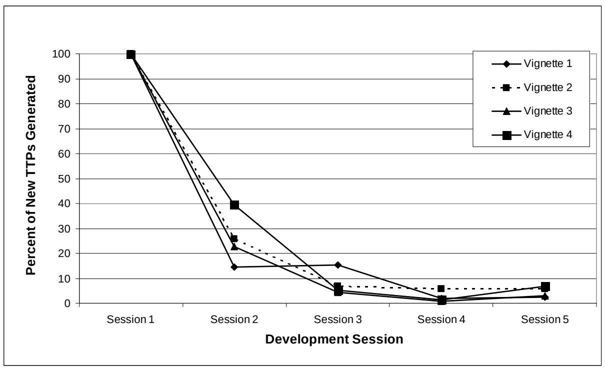

Figure 3. Percent of new TTP generated by development session.

Vetting of TTP

To determine when the point of saturation is reached for vetting TTP during single-source vetting sessions, the participants were asked to rate the TTP summaries generated/vetted for each vignette on a 100-point scale, with higher scores signaling better TTP. It is important to note that participants rated the TTP summaries presented to them, not the resulting TTP summaries they themselves generated. Thus, for single-source vetting sessions the first vetting group rated TTP which had yet to be vetted, the second vetting group rated TTP which were vetted once, and so on. We then calculated the average ratings for TTP quality according to the number of times they were vetted—zero, one, or two times. As shown in Figure 4, after two rounds of vetting the average ratings of the TTP reached 95. In fact, after two rounds of vetting 81.81% of the ratings reached 95 or above. Thus, saturation for single-source vetting sessions occurred after two vetting sessions. Future researchers should select a saturation criterion to meet the goals of the project and weigh the relative importance of any additional TTP refinement against the resources necessary to generate them.

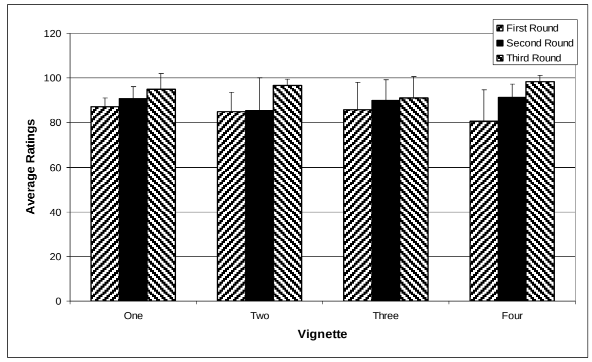

Figure 4. Average ratings (*SD* error bars) of single-source TTP summaries by vignette and round.

Origin of Final TTP

Nearly one-quarter (23.57%) of the final TTP were unrefined from their point of origin. That is, the final statement appeared exactly as it was proposed by the first person/group that developed it. The majority of the remaining final TTP were refined either once (43.31%) or twice (29.30%), with only a small percentage (3.19%) being refined three times. Figure 13 displays the percent of final TTP refined through vetting according to vignette and vetting session. Nearly 75% of the refinements occurred during either the first single-source vetting session (*M*=43.45%, *SD*=6.48) or the multiple-source vetting session (*M*=30.59, *SD*=6.41). Vetting productivity began to drop dramatically between the second single-source session (*M*=19.89, *SD*=3.68) and the third single-source session (*M*=6.07, *SD*=1.69). These results indicate that single-source vetting may hit the point of diminishing returns after two sessions. Additional benefits may occur when a multiple-source session is conducted as a follow-up to two single-source sessions. Once again, it is ultimately up to the KE team members to conduct a cost/benefit analysis to determine if the additional information gained by conducting a third single-source session is worth the time and resources.

The large number of items refined in the multiple-source sessions may reflect both previously unvetted items produced in development sessions 4 and 5, and any new TTP developed during the final single-source vetting session. Alternatively, the spike in number of TTP modified may be a byproduct of the multiple-source comparison process. Providing participants with a larger and more diverse set of TTP may enable them to identify the best aspects of the various TTP and produce refinements that reflect "the cream of the crop." In support of this second alternative, the data reveal that 78.57% of the refinements made to the final

TTP during the multiple-source sessions were revisions of previously vetted TTP, with only 21.43% of the refinements occurring on previously unvetted TTP. Thus, there is some benefit of allowing participants to conduct cross comparisons during multiple-source sessions.

Lessons Learned

Lessons learned were derived from written input provided by researchers and participants on survey-style feedback forms.

Orientation

Participant performance during the first vignette was greatly enhanced by providing a brief practice session as part of the orientation. The practice session familiarized the participants with the apparatus, thinking aloud, and the verbal directions required to instruct the simulation operator. Orientation materials should be provided to participants far enough in advance to impart a frame of reference for the goals of the KE process, the procedures, and the specific vignette missions. To ensure adequate study time, the facilitators may choose to deliver the orientation materials to participants at least one day in advance.

Simulation

High quality simulations play an essential role in producing "buy-in" from participants. Stable, environmentally rich, systems-capable simulations on par with or superior to home video game simulations are needed to effectively immerse the participants in the tactical exercises.

Participants

Participants lie at the heart of any KE session. Participants with military backgrounds congruent with the FCS are necessary to maximize the effectiveness of the KE process. At the same time, having FCS-congruent military backgrounds is not sufficient to guarantee high quality TTP. A motivated, insightful and expressive participant is equally important.

Procedures

A KE-based, simulation-driven FLEX method can effectively and efficiently produce TTP for FCS capabilities. Between two and three development sessions, two single-source and one multiple-source vetting session should be sufficient. Production and vetting of TTP were affected by echelon (role assignment). Increasing the number of echelons represented in future TTP development sessions may enhance FCS employment by generating broader cross-echelon TTP. Some loss of data occurred due to difficulties with reading handwriting and interpreting notations. Having participants enter their responses directly into computers would assist with TTP turnaround, source tracking, avoidance of data loss and errors, and electronic backup.

Methodology Improvements

Our team made one substantive modification of the original FLEX method by formally incorporating multiple starting points through separate initial TTP development sessions. While the original method employed a single point of origin for development, we utilized a multiple-source approach. It is important to note that this modification was not outside the original theoretical framework of the FLEX methodology, but a modification in how the methodology was implemented. We adopted the multiple-source process over concerns that the outcome of a single-track approach could be limited by the simple fact of its narrow origins. Theoretically, multiple starting points would (a) lead to a variety of distinct solutions, each valuable and mature in its own right, or (b) confirm the validity of a single, common outcome achieved with multiple, independent sources. Figure 5 illustrates a multiple-track framework with each track originating at an independent starting point.

For the purposes of this research, the initial development sessions numbered five. For future implementation, we recommend a minimum of two development sessions (i.e., tracks), each followed by a minimum of one single-source vetting session, yielding a "2-by-2" matrix as shown in Figure 5. Depending upon the TTP developer's expectations and objectives, as well as the availability of resources to support TTP development, the matrix can be expanded vertically or horizontally to achieve greater resolution, potential variety and/or more confidence in the results.

Our implementation approach intentionally kept each TTP track separate until the final consensus-building step, in theory to allow each set of TTP to fully mature without external influence. Alternatively, the outputs from each KE session could be shared across tracks, effectively making every vetting session a multiple-source session. While this variation has merit, we did not test it during this effort.

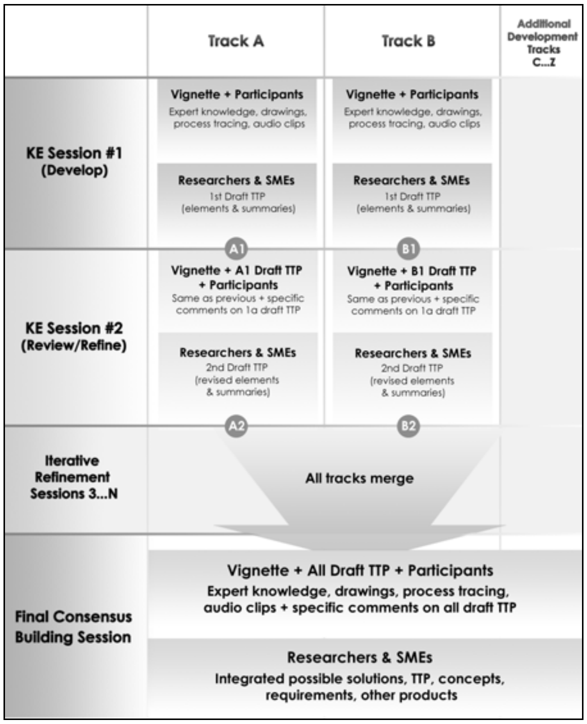

Figure 5. A multiple-track FLEX process.

In all cases, the final step of consolidating and integrating previous outputs is essential to produce one coherent, complete, and feasible TTP or solution.

Conclusions and Recommendations

Future forces empowered with FCS will require streamlined, cost effective, and time efficient methods for developing new TTP. The primary goal of the current research was to develop a simulation-based KE method for forging TTP and to assess the effectiveness of the methodology as a general framework for future TTP development. The results indicate that the KE-based, simulation-driven FLEX method can produce effective TTP as rated by Soldiers. The FLEX method enables researchers to gain the perspective of how the real users, the Soldiers in the field, would employ the technologies in real-world missions. By working with Soldiers from different MOSs as well as levels and types of field experience, investigators can develop a rich perspective of not only how these new technologies would be perceived but also how they would be used, adapted, and advanced by Soldiers.

Established METT-TC factors will remain relevant after the advent of FCS-enabled operations. The manner in which future forces handle METT-TC factors will be greatly affected by FCS technologies that dramatically enhance warfighting capabilities. With the expected number of improvements, innovative approaches will be needed to develop and test the new technologies. Simulation vignettes provide a stable, cost effective environment to explore concepts that involve complex problem solving. They are capable of presenting many of the same types of challenges as real-world environments in real time. In fact, simulations, especially simulation-based games, are powerful learning tools because they enable learners to interact with and engage with environments that pose complex, ill-structured problems. Learners are able to visualize, interact with, and manipulate systems and variables within a complex, authentic environment (Gredler, 2004).

The flexible methodology presented in this report enables effective TTP development sessions to support future forces. The report outlines a CTA-based KE protocol that has been shown capable of producing effective TTP for FCS. It provides benchmarks for the number and type of KE sessions required to develop effective TTP. Naturally, future researchers and developers will always need to consider their specific requirements when creating a TTP development plan. They must take into account their goals, the complexity of the system being assessed, the blending of current and FCS, the likely level of participants' expertise, and other considerations.

This report provides a "proof of concept" and general framework for conducting KE sessions to develop TTP for future capabilities. The following recommendations are offered to promote effective utilization and expansion of the findings.

♦ Users must carefully select a suitable simulation to support TTP development using the FLEX method. Mature traditional simulations or even modified game-based commercial applications may offer advantages over immature simulation software.

♦ Future TTP developers must screen for and select experienced, insightful, expressive participants to optimize TTP production.

♦ Future developers should ensure that participants understand what comprises effective TTP, including the level of detail required.

♦ Future research should be conducted to determine whether TTP could be developed simultaneously for multiple FCS systems/capabilities during the same KE session to accelerate the development of cohesive TTP for the Future Force.

♦ Current ARI research is developing TTP generation instruments and measures that can be easily used by units without external support.

♦ Future ARI research will design methods and guides to assist units in developing training based upon the TTP generated from the FLEX method.

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