DEFINING DECISION TYPES IN A COMBATING WEAPONS OF MASS DESTRUCTION SIMULATION

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ABSTRACT

Current theories of decision making, from classical models of risk and utility to frameworks of Naturalistic Decision Making, emphasize uncertainty and complexity within the decision process (Klein, 1993). John Boyd's Observe, Orient, Decide, Act loop; Critical Decision Methods (Wong, 2006); and frameworks and models like Klein's Recognition Primed Decisions model (1989) succeed in defining and describing their topic. However, they fail to adequately confront the *type* of decision made. Most studies of decision-making have lumped together several types of decisions in their analysis (Nutt, 1993; Bryson et al., 1990). Decision type has yet to be studied empirically (Nutt, 2001) and has not been defined with the intent to prescribe appropriate training and instructional strategies.

The goal for this effort is to support decision making training for Combatting Weapons of Mass Destruction (CWMD) using a Decision Support Simulator (DSS). Outcomes of this goal were realized in two ways: 1) gaps in decision-making literature and research were identified; and 2) assessment of decision-making performance was achieved by matching two theorized decision types to an instructional domain involving a CWMD exercise. A database of decisions, a way to identify decision types, and a means to capture performance metrics were also realized.

Empirical study of these hypothesized decision types within a contextualized Instructional Systems Architecture support the hypothesized definitions of "Procedural" and "Tactical" decision types. This paper asserts that by delineating these types of decisions, designers, developers, and instructors of decision-making exercises can readily identify the appropriate learning domains and, by extension, the instructional strategies best suited for delivery of training. Addressing a gap in decision making literature, this paper extends discussion beyond process, methods, and models, and into the realm of application. Furthermore, this paper provides use case for formal school house training for the US Army and US Marine Corps.

ABOUT THE AUTHORS

Daniel Barber, Ph.D. is an Assistant Research Professor at the University of Central Florida's Institute for Simulation and Training. Dr. Barber has extensive experience in the fields of robotics and simulation, developing virtual platforms and tools for synchronization, processing, and streaming of data from multiple physiological sensors (e.g. Eye Tracking, Electrocardiogram, and Electroencephalography) within experimental and training environments supporting real-time adaptations to user state. His current research focus is on human system interaction and training assessment including multimodal communication, user interaction devices, teaming, decision-making, and adaptive systems.

Martin S. Goodwin, Ph.D. is a Research Associate at the University of Central Florida Institute for Simulation and Training. Dr. Goodwin has an extensive background in the design, development, and evaluation of integrated training systems to support complex learning. His current research efforts focus on improving the performance of human-in-the-loop simulations within synthetic training environments through investigation of the efficacy of system technical attributes on learning, engagement, and task/mission execution. His other research areas include intelligent adaptive learning systems, game-based training, live/virtual/constructive (LVC) simulation integration, and cognitive fidelity of instructional simulation (training/system complementarity).

Scott Harris is a Faculty Research Associate at the Institute for Simulation and Training in the Prodigy Lab of the University of Central Florida in Orlando, FL. In February of 2017 Scott retired after serving on Active Duty for 28 years as a Pilot in the United States Marine Corps. In 2010 Scott was assigned by Headquarters Marine Corps to serve as the Program Manager for all Marine Corps Aviation Training Systems at PMA-205. Prior to his assignment as the PM for USMC Aviation Training Systems, Scott served on the staff of the Chairman of the Joint Chiefs in J8 as the Vertical Lift Strategic Funding and Requirements Analyst for General Glen Walters (Retired, Assistant Commandant of the Marine Corps).

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DEMAND SIGNAL

Military leaders are faced with many challenges with respect to countering weapons of mass destruction (CWMD), particularly concerning decision making and crisis response to WMD events. The overall chemical, biological, radiological, and nuclear (CBRN) community has focused on the development of improved methods, tools, and information to support CBRN operational risk assessment and management (ORM) at lower levels of decision making authority (e.g., company or team levels up to battalion/brigade levels). Initiatives to integrate CBRN concerns into the broader range of military ORM at these levels are in a nascent stage. Although the need to enhance military leader CWMD decision support is well-acknowledged, limited efforts in this area have been undertaken. Moreover, the increasing complexity of CWMD challenges (e.g., the increasing concerns over non-state actors and apparent increasing assertiveness displayed by putative state adversaries) as well as the rapid expansion of interactive simulation/virtual environment technologies, strongly support the need for innovative approaches in this area. Additionally, the factors that are central in such decision making are not clearly defined. This significantly inhibits the development improved decision support tools and impedes effective crisis response. Thus, a needed first step to enhancing the effectiveness of military leader CWMD decision making is an improved understanding of the structure and factors in the decision support process informed by knowledge of evolving, innovative approaches to improving such processes.

BACKGROUND

The Defense Threat Reduction Agency (DTRA) sponsored the University of Central Florida Institute for Simulation and Training (UCF IST), through the Army Research Lab (ARL), to develop a prototype decision support system framework for improved senior leader theater-level decision making in combating weapons of mass destruction (CWMD). This effort focused on five key areas: 1) optimize senior leadership in CWMD decision making; 2) build understanding of the issues in CWMD operational environments; 3) improve resiliency; 4) explore "what if" and worst-case scenarios in a virtual operational environment; and 5) improve outcomes in CWMD operations and crisis management. The goal for this effort is to produce a prototype simulation based trainer, known as the Senior Leader Combating Weapons of Mass Destruction (CWMD) Training (SELECT) Tool, capable of providing improved senior leader decision making skills for CWMD. The Marine Corps Tactics and Operations Group (MCTOG) at the Marine Corps Air Ground Combat Center (MCAGCC), Twentynine Palms, CA participated as the testbed for the SELECT Tool. Based on MCTOG's scope of responsibility, the SELECT Tool prototype focused on the role of an operations officer in a battalion combat operations center responding to a CBRN event. The SELECT Tool is designed to align with the competencies and learning outcomes for an Operations and Tactics Instructor (OTI) in the MCTOG Tactical Marine Air Ground Task Force (MAGTF) Integration Course (TMIC). The specific focus is on those competencies and learning outcomes that relate to problem definition and evaluation, alignment of decisions within commander's guidance/higher level intent, and timeliness of decision making. Targeted decision-making learning objectives include:

- Demonstrate an understanding of the situation to identify critical factors, develop a problem statement, and a shared understanding among the staff to anticipate future actions.
- Incorporate critical factors to exploit the environment, adversary vulnerabilities, and protect friendly vulnerabilities.

- Inform the commander's understanding of the situation to facilitate timely and appropriate guidance, intent, and decision making.
- Develop an adaptive plan that anticipates changes in the operating environment, flexible in response to unexpected changes in the operating environment, and achieves the desired end state.
- Assess the plan during execution by using measures of performance and measures of effectiveness to identify when to adapt the plan.

The first phase of the prototype development effort focused on a review of decision-making science and interviews with subject matter experts (SME) and MCTOG CBRN training instructors to establish decision types and their application within the SELECT Tool. This paper reports on the results of that effort.

TYPES OF DECISION MAKING

Current theories of decision making, from classical models of risk and utility to frameworks of Naturalistic Decision Making, emphasize uncertainty and complexity within the decision process (Klein, 1993). John Boyd's Observe, Orient, Decide, Act loop; Critical Decision Methods (Wong, 2006); and frameworks and models like Klein's Recognition Primed Decisions model (1989) succeed in their attempts to define and describe their topic. However, they fail to adequately confront the *type* of decision made. Most studies of decision-making have lumped together several types of decisions in their analysis (Nutt, 1993; Bryson et al., 1990). Hickson's efforts at categorizing decisions are focused on types in terms of technology, reorganizations, and controls (Hickson, 1986). Decision type has yet to be studied empirically (Nutt, 2001) and has not been defined with the intent to prescribe appropriate training and instructional strategies.

Decision Types

A key factor in the situation being confronted is the type of decision to be made (Nutt 2001). Most studies of decision-making have lumped together several types of decision in their analysis (Nutt, 1993; Bryson et al., 1990; Soelberg, 1967). Early attempts at categorizing or delineating types were human-centric and differentiated types of decision makers, not the type of decision or, as in the case of Bridges' 1914 study, types of decision based on subject characteristics (e.g., non-suggestible, positively suggestible, etc.) not types of decisions. Hickson (1986) categorizes decision types in terms of technology, reorganizations, and controls.

Study of decision types have not approached the question from the domain perspective. That is, identification of decision types with the intent to prescribe appropriate training or instruction strategies. Literature is lacking when it comes to determining the *types* of decisions that could or should be made in response to different events in a given instructional scenario. As previously reported by the authors' review of Decision Support Systems literature (Barber et. al., 2018), systems that support decision-making have historically been associated with managerial or industry-centric long-term decision-making (Alter, 1980) and typically do not leverage scenario-based simulation technologies to support complex and time sensitive decision-making. Decision Support Systems is also an academic field of research that involves designing and studying systems in their context of use (Schuff, 2011).

Ward Edwards, founder of research on decision-making, highlighted a vital distinction between decision-making process and decision outcome. The former refers to what the decision maker actually does, whereas the latter depends on factors often unrelated to the decision, including environmental influences and chance occurrences (Vlek, 1984).

Procedural and Tactical Decisions

Finding inspiration in Peterson's (2008) definitions of effective and transformative decisions at the root of his Non-Bayesian decision theory, the authors propose a division of decision types into two domains: procedural and tactical. Specifically, this division emphasizes the separation of decisions into these two groups based on the differences between decisions that conform with doctrine or standard operating procedures (procedural; see Figure 1) and decisions that, due to higher complexity, require higher order thinking skills (tactical; see Figure 2). Secondary distinguishing characteristics include results that do not violate expected outcomes (procedural) and results that significantly impact ongoing conditions, creating a new paradigm (tactical).

The procedural and tactical decision types emphasize differences between decision-making processes and decision outcomes. Procedural decisions are made based on available information and follow rules that are prescriptive in nature. They are the result of declarative knowledge and typically do not violate expected outcomes. Conversely, tactical decisions are not based on prescribed or known actions. Instead, they involve more complex or conflicting elements, require higher order thinking skills, and may result in outcomes that significantly impact or alter ongoing conditions (Peterson, 2008).

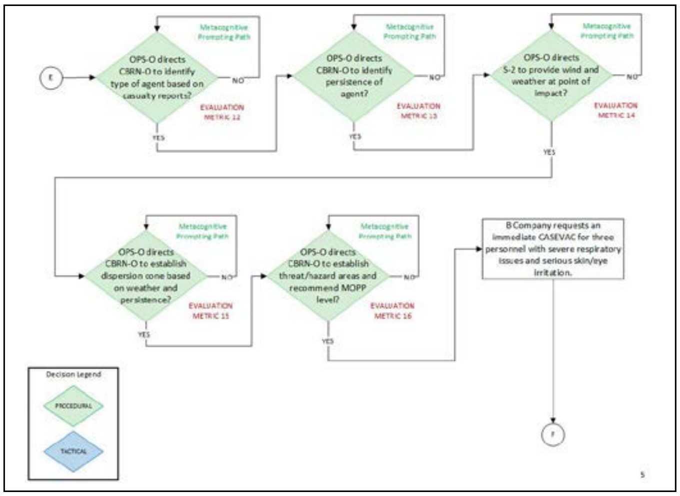

Figure 1. Example of Procedural Decision Flow

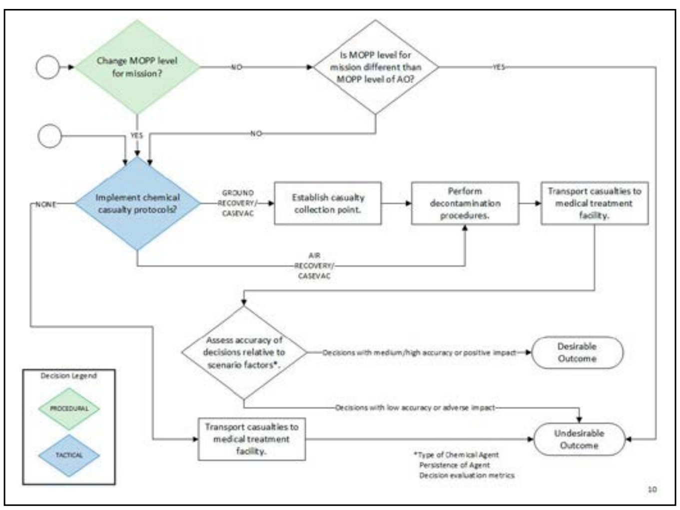

Figure 2. Example of Tactical Decision Flow

SELECT Tool

The SELECT Tool decision support system prototype was conceived with the goal of supporting upper-echelon decision-making, providing users highly complex scenarios to practice different types of decision making, with a focus on tactical decisions. To meet the objectives of MCTOG, the SELECT Tool is being constructed to support decision making training as a supplement to Service Level Training Exercises (SLTEs). It is anticipated that the SELECT Tool will become a part of the Academic Support Package (ASP) provided to select Marines prior to each SLTE. It may also be used as a stand-alone trainer between SLTEs to provide practice with different types of scenarios to help maintain decision making competencies. Specific SLTEs where the SELECT Tool is expected to be applied include exercises which emphasize individual Marine and small team procedural decision making; exercises that support team and integrated unit procedural decision making moving toward transformational learning; and exercises that support integrated MEU transformational learning and wisdom development. Other objectives for the SELECT Tool include achieving Technology Readiness Level (TRL) 3, the proof of concept validation as demonstrated through technical feasibility using implementations exercised with representative data; and TRL 4, component/subsystem validation in laboratory environment–standalone prototyping implementation and test.

The intent for the SELECT Tool prototype is to enable decision makers to develop basic Courses of Action (COAs) in response to a crisis event. In this specific case, that event is built around a CBRN scenario. The SELECT Tool uses simulated personnel and provides logistics information, doctrine, tactics, and procedures across collaborating units. During the WMD scenario, at decision points, direct metacognitive prompts can help users “think about their thinking” and measures of effectiveness (MOE) provide traceability to decision points and comprehensive after action review. Existing operational tools are leveraged to facilitate realistic scenario interactions.

The current SELECT Tool prototype uses a CBRN scenario modeled on the Chemical Release/Attack battle drill (Figure 3) validated by MCTOG and executed during previous TALONEX battalion-level exercises as a foundation for facilitating decision making competency development.

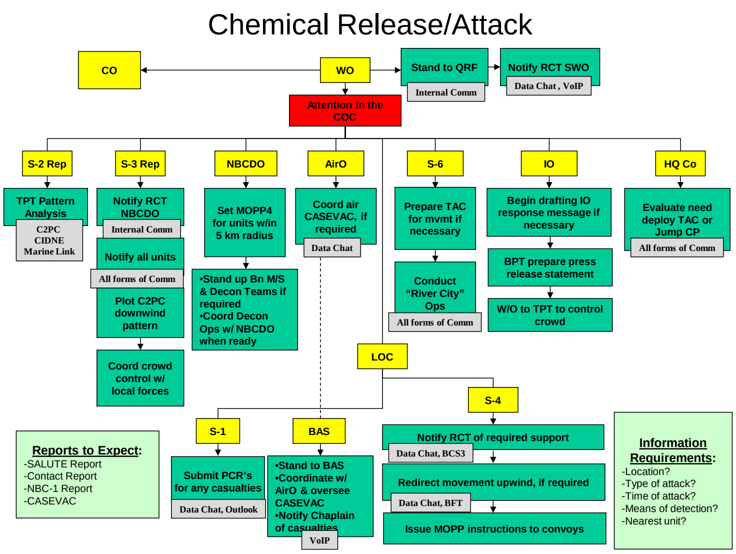

Figure 3. TALONEX Chemical Release/Attack Battle Drill

The SELECT prototype scenario is designed around the role of a United States Marine Corps (USMC) Operations Officer (OPSO) operating within a Battalion Combat Operations Center (COC). The OPSO is responsible for execution of the Commanding Officer's intent, and is able to take action to enact decisions. The SELECT Tool simulates personnel within the COC that communicate, model, and function according to the scenario and include the following roles:

- Commanding Officer (CO)
- Personnel (S-1)
- Intelligence (S-2)
- Operations (S-3)
- Logistics (S-4)
- Communications (S-6)

The SELECT Tool also provides scripted communications between these roles and the OPSO, and delivers resources and intelligence reports similar to those used in live exercises for the training. The goal is to unify disparate technologies and resources through a web interface (Figure 4) that is extensible to multiple areas of expertise when dealing with WMD threats.

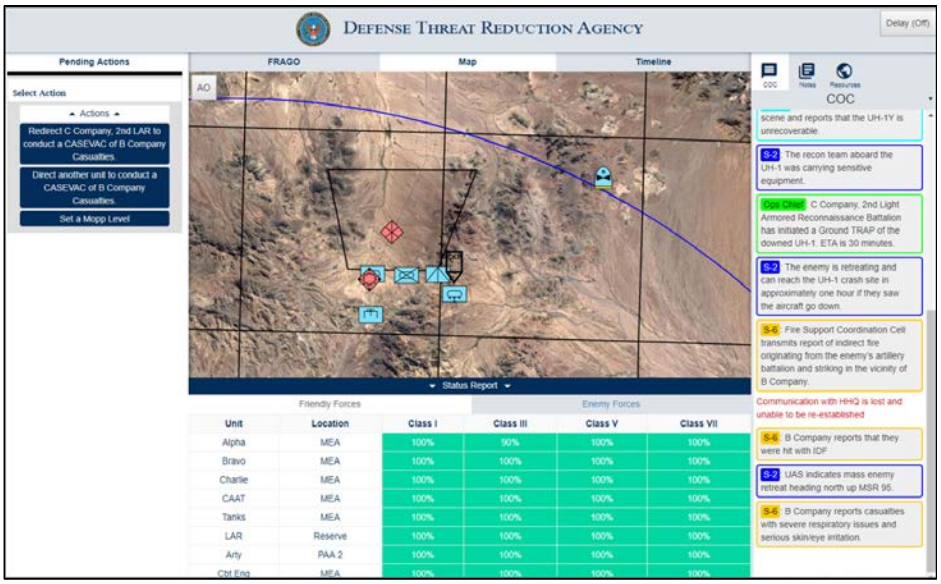

Figure 4. SELECT Decision Support Tool Interface. Decision options for the user are listed on the left, C2PC Common Map for the COC top-middle, Status Reports shown bottom-middle, COC & One-on-One communications provided on the right side of screen, with notes and other COC resources/doctrine available top-right.

Decision Development

The Observe, Orient, Decide, Action (OODA) Loop was used as guiding framework for identification of places for decision making inputs. Input data was developed using the 5W (who, what, where, why and when) methodology. The 5Ws that exist pre-decision may or may not be valid post-decision, and may result in a new set of 5Ws as the scenario progresses. This type of situational shift and the degree of difference between the two situations points to the impact of the decision. Any of the Ws can move in the desired direction while the others move in an undesired direction. The ideal result is that all 5Ws move to the desired state, but due to the dynamic and fluid unknowns there may not be a guarantee that they will remain there (Barber et. al., 2018).

In a live exercise, the many branches described by the 5Ws will occur organically. The SELECT Tool prototype scripting process supports multiple branches, however the current scenario under testing is configured to capture more binary (Yes/No) results that, in turn, reduced back-end scripting workload for early iterations and proof-of-concept development. An example of this binary decision-tree and results is shown in the table below. Note that arrows indicate direction of communication (Barber et. al., 2018).

Table 1. Binary Decision Example

	Event	Role	Description	Note
1	Communication	S6→ WO → OPSO	"Company X reports that they were hit with indirect fire, and now they're really confused, they're missing four or five Marines, and they're having trouble breathing."	A condition that requires a decision is presented.
2	Communication	OPSO	Recommend appropriate MOPP level	Simulated personnel recommends action.
3	Decision 2 (Y/N)	OPSO	Set MOPP level	Decision root.
4	Derived Action: (Y)	OPSO → WO	"Set MOPP level # for Company X and supporting units."	Positive –action is taken.
5	Result: Optimal	OPSO	Casualties are minimized.	Positive result.
6	Derived Action: (N)	OPSO	MOPP level is not established.	Negative –action is not taken.
7	Result: Undesirable	OPSO	Higher number of casualties are sustained.	Negative result.
8	Feedback	SELECT	As appropriate	SELECT delivers appropriate feedback.

By defining and matching decision types to instructional domains, trainee performance can be aligned to levels of complexity that progressively challenge, motivate and instruct. Using embedded metrics captured at decision points, After Action Reviews can include quantitative results (decision made, response time), enabling instructors to identify areas for further instruction and to resource decision types so that instruction can be effectively framed. For example; a trainee has performed each procedural decision correctly, but tactical decisions that require analysis, synthesis, or other higher order skills are made with less certainty and the results are less than optimal. In this way, an instructor can efficiently target these gaps and can do so objectively.

At the heart of the SELECT Tool is a scenario that drives user interactions in response to events that require complex and time-sensitive decision-making. The scenario forms the basis of the user experience and is one of the main determinants of user performance outcomes. It contains the key stimuli required to facilitate complex interactions while maintaining plausibility and realism. It also accurately incorporates personnel, logistics, and doctrine information to integrate the proper tactical elements involved in CWMD response efforts.

The scenario development effort is a systematic, iterative process focused on designing interactions that engage the user in meaningful and instructive decision-making activities. The scenario development process consists of the following seven key steps:

1. Development of a scenario outline
2. Identification/engagement of subject matter experts to guide scenario development
3. Definition of scenario elements to provide realism
4. Identification/development of decision nodes (tasks/decisions/interactions)
5. Analysis of alternatives at each decision node
6. Identification/development of scenario assessment metrics
7. Development of scenario outcomes

The opening portion to the scenario script that served as the basis of the system design, including a preceding narrative referred to as a "Road to War", was developed with the input from a Blue Ribbon Panel from 29 Palms Battle

Simulation Center. After the opening narrative, the scenario continues as a crisis chemical event that required a coordinated response from battalion and supporting units. To achieve a realistic scenario, a high level of SME input is required for authoring the narrative and understanding the process flow in which an eventual user will have to work through. The SELECT Tool takes into consideration all aspects of the scenario and information that is required to make decisions in a CWMD situation.

The SELECT Tool scenario is designed to simulate an actual crisis in order to appropriately tailor the user experience to support the actual decisions and CoAs that would be employed in real-world crises. CoA development is based on the pre-decision and post-decision conditional states of the 5Ws and is focused on decision parameters for conducting a CWMD mission. Sample CoAs are listed below:

- Conduct the mission in a clean area if the mission can be accomplished while staying out of contamination.
- Conduct the mission in a contaminated area using a higher Mission Oriented Protective Posture (MOPP) level, but this may take more time.
- Conduct the mission in a contaminated area using a higher MOPP level, but use more Marines or equipment to compensate for time and energy.
- Delay the mission until the contamination has weathered.
- Conduct the mission in the same amount of time with same amount of Marines, but take a greater risk by using a MOPP level that does not provide maximum protection.

MOEs were developed based on the type of feedback trainees receive during a live exercise. This feedback is triggered dependent on MOE outcomes and an appropriate script is delivered to the trainee. MOEs identified for SELECT included time-to-decide and right/wrong decision. Scripted feedback with metacognitive prompts were also developed to be given as augmentation to the decision made as feedback. One thing to note, metacognitive prompts developed do not necessarily correlate with a "correct" decision, as there may not always be one. Instead, they promote thinking about why the user chose a specific decision.

Marines at MCTOG, as well as Marines participating in the TALONEX SLTE, highlighted the requirement to analyze the effects of chemical agents given realistic weather information of temperature and wind. Currently, Marines only have the ability to modify radar range fans in the Command and Control Personal Computer (C2PC) software to depict the effects of chemical agents on the battlefield. This information is currently emulated using the shared map, Figure 4. A new system, Joint Effects Module 2.0, has been purchased by the Marine Corps and the Army to provide the ability to analyze the effects of wind and temperature on the dispersion of chemical agents and project that information for military leaders to make the procedural and tactical decisions that are required to defeat our enemies and reduce the loss of life for friendly forces. Future iterations of SELECT will incorporate this type of data aide for the decision-making process.

ASSESSMENT

Assessment of the applied decision types within the SELECT CBRN scenario is in the early stages. Overall, there are three desired outcomes for the assessment of the prototype SELECT Tool: 1) the scenario, as instantiated, captures the realism of the live training that is delivered to the Operations Officer of a COC; 2) instructors identify correctly the hypothesized decision types thus supporting theoretical basis; 3) embedded metrics provide quantitative data to support decision-making performance, instruction, and scenario design.

To evaluate the accomplishment of mission objectives and achievement of desired results, quantitative data in the form of MOEs will be collected by embedded software. To assess the SELECT Tool's capability and contribute to the first two outcomes mentioned above, initial qualitative data was collected from a panel of SMEs provided by the Commanding Officer for MCTOG and instructors from the Training Support Center at 29 Palms, Marine Air Ground Task Force Training Center (MAGTFTC). During a recent working group, these SMEs and instructors were provided with definitions of the decision types and given the scenario script at the each decision point. They assessed if the SELECT Tool had sufficiently captured the conditions of the decisions; decision based on declarative knowledge, or standard operating procedures (SOPs), where outcome is relatively certain, or decisions based on analysis and accommodations, where outcome alters the downstream conditions. This assessment will be used to verify decision types. To support hypothesized decision definitions, and decision-making performance, quantitative data in the form of performance metrics will be collected to provide objective feedback and enable deeper analysis for downstream applications. This data includes: decision/no decision made, time-to-decide, correct/incorrect decision. (Barber et al 2018). Additionally, In this way procedural decisions may be identified by short time to decide correctly and tactical decisions identified by increased time to decide with undesirable outcomes.

The goal for the SELECT Tool is to enable decision makers to develop courses of action in response to crisis events by simulating response cells, logistics information, doctrine, tactics, and procedures in a real-world context. At critical decision points during SELECT Tool scenarios, direct feedback and metacognitive prompting are presented as appropriate and key performance metrics are recorded for comprehensive after action review. (Barber et al, 2018)

RESULTS

The panel of SMEs and instructors who provided the initial review of the SELECT Tool prototype validated the proposed decision types captured within the scenario. They also recommended the following three specific learning objectives that the SELECT Tool should measure for procedural/tactical decision making: 1) team work; 2) communication; and 3) technical proficiency. Additional recommendations included working with the MAGTF Integrated Training Systems Center (MISTC) to review the MISTC validated battle drills for conducting tactical recovery of aircraft and personnel (TRAP) missions at the battalion combat operations center (COC) level. Additional recommendations emphasized the requirement for Marines to have the capability to depict the effects of the chemical attack and accurately display the danger area on the Common Operational Picture (COP) to provide senior Marine Corps leaders the information they need to make accurate procedural/tactical as well as analytical/transformative decisions. Having an accurate picture of the hazard area is mandatory for Marines to make decisions on the appropriate MOPP Levels for each unit.

The review panel also recommended that the SELECT Tool could be expanded to capture other validated scenarios, for example a Marine unit in contact or missing Marine Sniper team. Status metrics for different units within the scenario were also discussed. The capability for the current CBRN scenario as well as future additional scenarios to have the capability to track Bomb Damage Assessment (BDA) data for both friendly and enemy forces was recommended. Important matrixes to track should include available vehicles and aircraft as well as unit strength and casualties. Additionally, the review panel recommended adding the following resources to the SELECT Tool for the CBRN scenario:

1. Definitions of the MOPP Level 0-4
2. All CBRN report templates
3. 9 Line template at a minimum
4. MCTOG Operations and Tactics Instructor Competencies
    a. Critical Thinkers
    b. Problem Solvers
    c. Decision Makers
    d. Leaders
    e. Tacticians

NEXT STEPS

Following completion of prototype testing, SELECT Tool developers will facilitate working groups with Marine and Army stakeholders to expand the scenario and consider ways the SELECT Tool can be utilized to better prepare military instructors to train students to make informed decisions faster with improved outcomes in realistic operational scenarios. The focus of this effort will be on identifying ways the SELECT Tool can help military schoolhouses develop training that will address the rising threat of an enemy (state actor) intentionally using Weapons of Mass Destruction (WMD) during Major Theater of War battles with the United States. Additional requirements for utilizing the SELECT Tool during training for OTI students during the Tactical MAGTF Integration Course (TMIC) will be explored. Additionally DTRA desires to work with the Army Maneuver Support Center of Excellence (MSCoE) to discuss ways the SELECT Tool can address learning objectives for the Army CBRN School and Chemical Captains Course.

Commented [HS1]: Following up on our meeting with Gen Spiese on 11 Jan, I recommend we add the following to the Next Steps section.
1.Training and Education Command (G3, MCSTE), Quantico, VA.
2.Expeditionary Warfare School (EWS), Quantico, VA.
3.Training Support Centers (TSC) I MEF, and II MEF
4.CBRN Warfare School, at Ft. Leonard Wood
5.Tactical Training Exercise Control Group (TTECG), 29 Palms, CA.
6.Marine Corps Logistics Operations Group (MCLOG), 29 Palms, CA.
Rationale: Working with Gen Spiese will help UCF plan for a professional and well attended Transition Workshop in Apr.

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