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**for the Behavioral and Social Sciences**

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# Identifying Critical Manned-Unmanned Teaming Skills for Unmanned Aircraft System Operators

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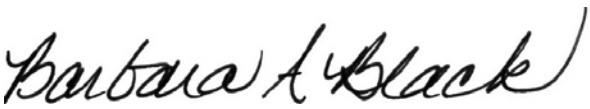

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14. ABSTRACT *(Maximum 200 words)*: Manned-unmanned teaming (MUM-T) requires that unmanned aircraft systems (UAS) interoperate with attack and scout-reconnaissance (SR) helicopters. The objectives of this research were to (a) identify SR skills required for UAS operators, (b) define/prioritize training-critical MUM-T skills, and (c) determine performance indicators for these skills. First, Army doctrine and regulations were reviewed to identify (a) missions in which UAS operators must coordinate with helicopter pilots; (b) tasks required to perform these missions; (c) skills required to execute these tasks. A list of candidate MUM-T skills was compiled, then confirmed by a focus group of Army subject matter experts (SMEs) from both manned and UAS communities. SMEs then identified training-critical MUM-T skills, (a) for which inadequate performance jeopardized the mission, and (b) UAS operators graduating advanced individual training (AIT) performed poorly. Skills were rated and then ranked for training criticality, resulting in a list of 25 MUM-T skills. SMEs proposed indicators for the 20 MUM-T skills deemed most relevant. A total of 140 performance indicators were identified. The results of this research can be used to identify and prioritize training needs, select training methods, and develop means of assessing performance for MUM-T skills.

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IDENTIFYING CRITICAL MANNED-UNMANNED TEAMING SKILLS FOR UNMANNED AIRCRAFT SYSTEM OPERATORS

## EXECUTIVE SUMMARY


Research Requirements:

In 2003, the mission of developing and employing United States (US) Army unmanned aircraft systems (UAS) passed from Military Intelligence to the Aviation branch. The focus of the UAS mission changed from strategic intelligence, surveillance, and reconnaissance to scout-reconnaissance (SR) operations. The shift has produced an increased requirement for coordination between manned and unmanned aircraft. The tactics, techniques, and procedures for manned-unmanned teaming (MUM-T) are still evolving, and there is as yet no common understanding of how manned and unmanned aircraft will interoperate to perform SR missions. Thus, there is a need for understanding (a) the specific skills required for such tasks and (b) the most efficient ways to train those skills.

The overall objective of this research is to specify an empirically-derived set of MUM-T critical skills and benchmark indicators for performance on those skills. Specifically, the research is designed to (a) identify the MUM-T coordination skills required for UAS aircrews, (b) define training-critical MUM-T aircrew skills, and (c) determine benchmark performance indicators of training-critical skills that can be used to develop training metrics. The project concentrates on the RQ-7B Shadow, which is the most numerous UAS currently in service with the Army.

Procedure:

The research began with a review of Army doctrinal material and regulations, other related published materials, and other sources to identify (a) the missions in which UAS operators would need to coordinate with helicopter pilots, (b) the specific tasks required to perform these missions in which manned and unmanned systems would interact, and (c) the MUM-T skills involved in conducting these tasks. The results of this review, a list of training-critical skills, were confirmed as relevant to MUM-T and doctrinally correct in a workshop attended by UAS operators, helicopter pilots, and doctrine developers.

An additional set of workshops was then conducted to establish the training criticality of these skills. Training critical skills were identified on the basis of two criteria: (a) inadequate performance would likely lead to mission failure or would present a serious risk to personnel or equipment, and (b) UAS operators recently graduated from Advanced Individual Training (AIT) do not possess these skills. Ratings of these skills by workshop participants (UAS operators and helicopter pilots) were used to establish an ordering of the skills by training criticality.

A third set of workshops elicited descriptions of performance indicators from a third, similar group of experienced individuals representing both the manned and UAS operator communities. These behavioral indicators signal competency (or non-competency) in the skills

previously identified as being relevant to MUM-T. The workshop also defined the conditions under which these indicators would be likely to occur and be observable.

Findings:

A total of 25 MUM-T skills were initially identified. The average criticality ratings indicated that all the skills were judged to be at least moderately important to attack and reconnaissance missions and to present moderate to serious risks to personnel and equipment if performed incorrectly. Performance levels (i.e., perceived levels of competency required for a given skill) varied greatly, which indicated that some skills were not addressed in AIT including skills important to reconnaissance or attack missions. Others, though important were found to be trained to a relatively high level of competence. A total of 20 MUM-T skills were determined to be training-critical skills.

*Indicators*, *conditions* under which performance was likely to be observable and the environments in which they might be observed (i.e., *sources*) were identified for the 20 training-critical skills that were deemed most relevant to MUM-T. Overall, 140 behavioral indicators were identified during the workshops. In addition, there were 41 responses for conditions and 80 responses for sources. The available training delivery environments should be reviewed to determine more specifically the source where MUM-T performance indicators may be observable. Each of the training delivery environments should be analyzed for content (e.g. scenarios) that contain the conditions under which the indicators may be observable.

Utilization and Dissemination of Findings:

The results of this research can be used to identify training needs, select training methods, and develop ways to assess performance on MUM-T skills. In particular, the training criticality assessments describe the critical MUM-T skills that are not currently being addressed in AIT. In addition, further analysis of the indicators, conditions, and sources should lead to the development of automated and observational approaches to performance assessment. Results of this research effort were briefed to the U.S. Army Aviation TRADOC Capability Managers for Reconnaissance-Attack and for UAS on 10 February 2012.

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## Introduction

In 2002, there were, in all forces (Army, Air Force, Navy, and Marine Corps), a total of 167 unmanned aircraft of all types. Today, the Army alone has over 4,000 unmanned aircraft and has amassed more than one million operational flight hours (United States Army UAS Center of Excellence, 2010). In 2003, the mission of developing and employing unmanned aircraft systems (UAS) passed from the Military Intelligence (MI) branch to the Aviation branch. During this transition, the UAS mission has changed from strategic intelligence, surveillance, and reconnaissance (ISR) to tactical scout-reconnaissance (SR). The shift in mission was made in recognition of the need to integrate UAS more centrally into aviation operations. As a result, there is a growing need for manned-unmanned teaming (MUM-T) during aviation SR missions.

As MUM-T coordination becomes more critical to the missions conducted by UAS, MUM-T should have correspondingly greater emphasis in UAS operator training. However, recent research indicated that initial training of RQ-7B Shadow operators often lacked specific skills required to execute tactical aviation SR missions (Stewart, Bink, Barker, Tremlett, & Price, 2011). The lack of formal SR skills training makes UAS operators less prepared to interact with manned aircrews. Moreover, MUM-T doctrine currently is in its infancy and still evolving. The lack of specific MUM-T training, plus still-emerging MUM-T doctrine lead to a level of uncertainty in how manned and unmanned aircraft will interoperate to perform SR missions. The respective roles of manned aircraft and UAS in MUM-T are also unclear. For example, a recent survey of Army helicopter pilots and UAS operators revealed substantial differences between the two groups regarding the perceived capabilities and roles of manned aircraft and UAS in the execution of aviation SR missions (Stewart, Roberts & Bink, 2012). Because MUM-T skills are relatively new to both helicopter aircrews and UAS operators, it is crucial to understand (a) specific skills required for MUM-T task performance and (b) the most efficient ways to train UAS operators on MUM-T skills.

The concept of MUM-T implies that the interaction between manned aircraft and UAS capitalizes on the strengths of the two types of aircraft. For example, the tactics, techniques, and procedures (TTP) for MUM-T have emerged in part through the maturation of Task Force ODIN (Observe, Detect, Identify, Neutralize), which was a counter improvised explosive device program started in 2006 (U.S. Army UAS Center of Excellence, 2010). At the core of these TTP was the creation of linkages between sensors and shooters wherein UAS sensor operators acquire information to develop the enemy situation and the shooters (i.e., armed helicopters) are able to attack the target at safer-and more covert- standoff distances (sometimes without even having to see the target itself). In addition MUM-T TTPs have been developed from simulation-based experimentation (Air Maneuver Battle Lab, 1998, 1999a, 1999b, 2000; Howse & Cross, 1998). The evolution of MUM-T TTP has been further evidenced by the development of new organizational structures in which UAS will operate. Currently, UAS Platoons are incorporated as Brigade level assets in either light or heavy Brigade Combat Teams (BCT), which are ground units. However, the newly organized Full Spectrum Combat Aviation Brigade (FSCAB) will incorporate organic UAS, including an Air Cavalry Squadron in which an eight-aircraft RQ-7B

Troop will replace nine of the Squadron's OH-58D Kiowa Warrior armed SR helicopters. The FSCAB will also be capable of performing MUM-T operations with Division-level MQ-1C Gray Eagle heavy UAS.

Altogether, there are indications of what types of tactical skills should be involved in MUM-T, but the specifics of teaming skills are yet to be defined. There are particular team-level skills required of both manned and UAS aircrews in order to successfully execute MUM-T missions. For example, attacking an identified target could require that the UAS aircrew identify the target, call for fire support from an AH-64D, laser-designate the target and hand the target off to the AH-64D. How those specific MUM-T skills are defined and classified will impact future training for UAS operators. More importantly, performance measures of MUM-T skills are needed both to ensure the effectiveness of MUM-T training and to aid in further defining appropriate MUM-T skills (e.g., Cannon-Bowers & Salas, 1997).

## Technical Objectives

The goal of this research effort, undertaken by the United States (US) Army Research Institute for the Behavioral and Social Sciences (ARI) was to identify an empirically-derived set of MUM-T critical skills and to develop benchmark indicators of performance on those skills. Specifically, the research was designed to meet the following objectives:

1. Identify the MUM-T coordination skills required for UAS aircrews.
2. Define training-critical MUM-T aircrew skills.
3. Determine benchmark indicators of MUM-T training-critical skills that can be used to develop training metrics.

The research concentrated on the most numerous UAS currently in service with the Army, the RQ-7B Shadow. RQ-7B currently is a BCT asset and associated with a Product Improvement Program that should allow for its employment in tactical UAS operations through the end of 2015. However, the ongoing stand-up of FSCABs will likely increase the RQ-7B's operational longevity beyond that date.

## Overview of Technical Approach

The current research project began with a review of Army doctrinal material and regulations, other Army documents, and other published materials to identify (a) the missions in which UAS operators would need to coordinate with helicopter pilots, (b) the specific tasks required to perform these missions in which manned and unmanned systems would interact, and (c) the MUM-T skills involved in conducting these tasks. Following the initial review, three types of workshops were convened. In general, the 3-4 hour workshops elicited the knowledge of subject-matter experts (SME) regarding MUM-T skills required for successful completion of reconnaissance and attack missions. Workshop SMEs included including UAS operators, helicopter pilots, and doctrine developers. The current methodology has some similarities to the Air Force Research Laboratory's Mission Essential Competencies (MEC) approach (Colegrove & Bennett, 2006), but the current approach is not a derivative of the Air Force approach.

The first set of workshops reviewed and confirmed the tasks and skills that were identified in published documentation. A second set of workshops was then conducted to establish the training criticality of the identified skills. Training-critical skills were identified on the basis of two criteria: (a) inadequate performance of the skills would likely lead to mission failure or would present a serious risk to personnel or equipment, and (b) UAS operators recently graduated from Advanced Individual Training (AIT) do not possess these skills. Ratings of the skills by UAS operators and helicopter pilots were used to establish an ordering of the skills by training criticality. A third set of workshops was conducted to identify performance indicators (i.e., benchmarks) for the skills, to identify events and processes in which these performance indicators might be observed, and to identify locations where these events and processes might take place. All workshops were conducted at Fort Rucker, AL.

## Defining the UAS MUM-T Task and Skill Set

The initial activities in this project focused on (a) identifying the reconnaissance and attack missions in which UAS and manned aircraft operate as a team, (b) specifying the tasks required performing those missions that involve interactions between manned aircraft and UAS, and (c) deriving the MUM-T skills that are needed to perform these tasks. To perform these activities, Army doctrinal material and regulations, other Army documents such as the Army UAS Roadmap (U.S. Army UAS Center of Excellence, 2010), relevant published aviation training research, and other contemporary sources were reviewed. Based on this information, a preliminary list of missions, tasks, and skills was produced. A workshop, in which Army Aviation SMEs participated, was then conducted to review the skills list and to make any corrections, additions, and clarifications.

### Identify Missions

Candidate Army aviation missions were derived from the two principal manuals for attack helicopter and armed reconnaissance helicopter operations (i.e., Field Manual 3-04.111, Aviation Brigades, Department of the Army, 2007a; Field Manual 3-04.126, Attack Reconnaissance Helicopter Operations; Department of the Army, 2007b). Other manuals and regulations also contributed to the wide range of missions considered. The process used to identify specific missions involved review of field manuals, Army tactical doctrine in general, and literature concerning aviation tactics in the contemporary environment. The list of missions for consideration was based on an expectation that UAS operators and SR and attack helicopter pilots would be collaborating as intact SR teams in the performance of all mission tasks.

The candidate missions were categorized into groups representing reconnaissance, attack, and other missions. This grouping ensured that missions that used similar tasks for their execution were considered together, thus simplifying the activity of identifying tasks. The information from these manuals and regulations was analyzed to determine which of these missions were currently being conducted using manned-unmanned platform teaming. A review of contemporary literature on helicopter operations led to modification of the original missions list and helped anticipate which missions might be supported by manned-unmanned teams in the near-term future. A list of the missions identified in this assessment is presented in Appendix A.

## Identify Tasks

Following Army doctrine, MUM-T *tasks* were defined as actions needed to successfully execute the Aviation tactical missions. To identify the MUM-T tasks, a list of UAS tasks was first developed by analyzing current UAS doctrine and scenarios for each mission to determine the supporting tasks that UAS operators could be expected to perform. This identification was aided by review of contemporary sources describing UAS operations during recent deployments and on projections of future MUM-T activities. Contemporary sources examined in this process included aviation or other military news publications (e.g., *Aviation Week, Defense Daily*), reports by Army organizations charged with the development of aviation capabilities (e.g., Program Executive Office, Aviation), and reports published by large military contractors and contractor organizations (e.g., Boeing, National Defense Industrial Association).

MUM-T tasks were selected from the total set of tasks by considering scenarios for each Army aviation mission that the UAS could be expected to support and by analyzing the activities of the UAS. The focus of the analysis was on what tasks UAS operators were expected to know and perform. The analysis was aided by review of contemporary literature concerning UAS operations on recent deployments and by ongoing research projects. The initial MUM-T task list was grouped into the following seven categories that support the full range of missions defined by this review of Army publications: (a) Conduct aerial observation, (b) Identify threats, (c) Share targeting information, (d) Communicate requirements, (e) Provide battle damage assessments, (f) Call for and adjust indirect fires, and (g) Conduct cooperative engagements.

## Identify Skills

Identification of critical coordination skills that Army UAS operators need for MUM-T consisted of three phases. First, published materials were reviewed to create a preliminary list of UAS operator teaming skills. Second, iterative reviews and revisions to the skill list were made. Third, the skills within the seven task categories were categorized using a matrix of missions, tasks, and skills. The following section describes the activities associated with each phase that resulted in the identification of the UAS operator coordination skills.

MUM-T *skills* are the behavioral processes UAS operators need to successfully execute MUM-T missions and tasks. Identification of the skills involved a review of military and research documentation on UAS capabilities potentially relevant to MUM-T including Army field manuals, Programs of Instruction, training materials, journal articles, and other government documents. Table 2 lists the major references that proved most useful for identifying UAS coordination skills that could apply to MUM-T.

Project research personnel, who were SMEs in task analysis, reviewed the preliminary list of skills and determined that not all of the skills entailed MUM-T. Skills that were not deemed relevant by the SMEs were excluded. Further modifications of the skill list included revisions to wording, removing ill-defined skills, and suggesting additional skills for inclusion. Revisions and updates were made through several additional iterations to produce a matrix of skills and tasks to be reviewed by SMEs. The matrix linked MUM-T tasks with UAS operator skills. Skills were assigned to every relevant task category. Therefore some skills were listed

under more than one task category. Table 1 presents the major technical references that provided criteria for developing these skills categorizations.

Table 1
*Major Reference Sources for Manned-Unmanned Teaming Skills.*

| Technical References |
|---|
| FM *3-04.126.Attack Reconnaissance Helicopter Operations (Department of the Army, 2007b)* |
| FM *6-99.2. U.S. Army report and message formats.* (Department of the Army, 2007c) |
| FM *3-04.155. Army unmanned aircraft system operations.* (Department of the Army, 2009) |
| TC *1-600. Unmanned aircraft system commander's guide and aircrew training manual*.(Department of the Army, 2007d) |
| TC *34-212. Unmanned aerial vehicle aircrew training manual*. (U.S. Army Intelligence Center, 1997) |
| *Notes*: FM = Field Manual; TC = Training Circular. |

## Task and Skill Review Workshop

A Task and Skill Review Workshop was conducted to obtain feedback from UAS operators, pilots, and training and doctrine experts on the draft missions, tasks, and skills that were produced by the document review. A focus group of SMEs reviewed, revised, and edited the draft to ensure that the proposed skills were actually required for MUM-T. The focus group was also asked to identify any additional MUM-T skills not included in the list, to minimize overlap among skill descriptions, and to discuss prerequisite relationships and sequential dependencies among skills.

### Method

**Participants**. Of the eight participants in the Task and Skill Review Workshop, four were from the U.S. Army Aviation Center of Excellence Directorate of Training and Doctrine (DOTD), two were from the Training and Doctrine Command Capabilities Manager (TCM) for UAS, and the remaining two were from the U.S. Army Aviation Center of Excellence Noncommissioned Officer Academy. The participants included four noncommissioned officers, one chief warrant officer, one commissioned officer, and two U.S. Army civilians. All six military personnel had completed a tour in a combat zone in the previous 3 years. Five had been in Iraq, and one of these had also served in Afghanistan (one did not indicate an area of operations). Four of the military personnel were UAS operators qualified in medium UAS (e.g., RQ-7B, MQ-5B). The remaining two were OH-58D armed scout helicopter pilots. Five participants indicated that they had experience with reconnaissance/security missions. One pilot indicated additional experience with attack missions.

**Materials**. An interview protocol was drafted that included a set of twenty discussion questions about the MUM-T skills list constructed in the previous document review. The

discussion questions are listed in Appendix B. The Participant Background Form asked seven questions to gauge the expertise and experiences of the workshop participants in the MUM-T environment, and is shown in Appendix C. Several MUM-T scenarios were derived from Army field manuals for reconnaissance and attack missions. These scenarios were provided to participants during the workshop to facilitate discussion about the required skills for UAS operators in the MUM-T environment.

**Procedure**. The workshop began with an overview of the project and the specific goals for the workshop. Informed consent and Participant Background Forms were also distributed to participants in this and all subsequent workshops, in compliance with ARI ethical protocol concerning use of human participants. The topic of the discussion then turned to the list of missions, tasks, and skills for UAS operators identified prior to the workshop. In each case, the SMEs were asked whether items (i.e., missions, task, or skills) should be added or removed from the list and whether the items were valid in terms of actual practice in the field. The SMEs were also asked whether there were likely future missions, tasks, or skills that should be considered in this research. SMEs were asked whether some skills were prerequisites for others, and about the sequential performance dependencies between identified skills. SMEs made several additions and deletions to the list of skills. In addition, they reviewed and edited terminology used to describe the items.

**Results**

SMEs did not recommend any changes to the list of missions, but they did recommend several changes to the identified skills and some changes to the tasks. These varied from relatively minor rewording of a task or skill to major changes in which skills were added, deleted, or combined. The following list summarizes the types of changes that were made to skill and task statements presented in Table 2.

- Added skills. SMEs added skills that they believed were missing from the original list. For example, they added the skill, "deconflict munition trajectories from airframes," to the task, "call for and adjust indirect fires."

- Changes in scope of tasks or skills. SMEs enlarged or focused the scope of some tasks or skills. For example, the task, "identify threats to aerial maneuver" was changed to "identify threats to maneuver," because the SMEs judged that a UAS operator would be required to identify threats to ground maneuver as well as aerial maneuver.

- Combining redundant or similar skills. SMEs developed general skills to encompass several closely related skills in the original list. For example, they identified a general skill, "utilize standardized radio communication and signal operating procedures," to combine what had been represented in three communication skills in the draft list.

- Adding or removing associations between skills and tasks. For example, the skill, "call for indirect fires" was removed from cooperative engagement task, because it was judged to be inappropriate for that task.

- Clarifying terminology. SMEs refined or clarified terms used in task and skills, such as the distinction between high payoff targets and high value targets.

- Editorial changes. SMEs made several changes to standardize descriptions of skills and to incorporate appropriate military terms.

Table 2
*Task Categories and Associated Manned-Unmanned Teaming Skills*

| Task Category | MUM-T Skill |
|---|---|
| Communicate Requirements | Utilize standardized radio communication and signal operating procedures* |
| | Utilize standardized report formats |
| | Transmit imagery, sensor data, tactical situational maps, overlays, and reports (e.g., spot reports)* |
| | Develop and send common operating picture information to air-ground team |
| | Utilize joint, Army, and civilian personnel recovery terminology |
| Conduct Cooperative Engagements | Find/track targets (e.g., HPTs, HVTs)* |
| | Provide the direction of the target in degrees and range from the battle position* |
| | Transmit information about the method of attack (i.e., scheme of maneuver, fire distribution, and maneuver for the attack)* |
| | Transmit imagery, sensor data, tactical situational maps, overlays, and reports (e.g., spot reports)* |
| | Select the best weapon systems to engage the target (e.g., lethal/nonlethal, munitions effect, collateral damage assessment) |
| | Transmit information about the location of threat forces, terrain, and obstacles that influence operations* |
| | Provide confirmation of the target prior to engagement* |
| Identify Threats | Find/track targets (e.g., HPTs, HVTs)* |
| | Transmit information about the location of threat forces, terrain, and obstacles that influence operations* |
| | Transmit imagery, sensor data, tactical situational maps, overlays, and reports (e.g., spot reports)* |
| | Provide accurate description of target to support target selection |
| | Provide confirmation of the target prior to engagement* |
| | Prioritize the engagement of targets |

*Notes*: Asterisk (*) indicates skills that appear in multiple task categories; HPT = high-payoff target; HVT = high-value target.

Table 2 (continued)
*Task Categories and Associated Manned-Unmanned Teaming Skills*

| Task Category | MUM-T Skill |
|---|---|
| Conduct Aerial Observation | Gain and maintain enemy contact |
| | Provide early warnings, ambush detection, overwatch, threat identification |
| | Transmit information about the location of threat forces, terrain, and obstacles that influence operations* |
| | Transmit imagery, sensor data, tactical situational maps, overlays, and reports (e.g., spot reports)* |
| Share Targeting Information | Provide the target location (i.e., direction of target in degrees and range from battle position) |
| | Transmit information about the location of threat forces, terrain, and obstacles that influence operations* |
| | Provide target description information* |
| | Transmit information about the method attack (i.e., scheme of maneuver, fire distribution, and maneuver for the attack)* |
| | Utilize standardized execution commands to initiate attack |
| | Conduct target handover |
| Call for and Adjust Indirect Fires | Provide the direction of the target in degrees and range from the battle position* |
| | Provide target description information* |
| | Deconflict munition trajectories from airframes |
| | Conduct call for indirect fires |
| Provide Battle Damage Assessment | Utilize standardized radio communication and signal operating procedures* |
| | Transmit imagery, sensor data, tactical situational maps, overlays, and reports (e.g., spot reports)* |
| | Perform battle damage assessment |

*Notes*: Asterisk (*) indicates skills that appear in multiple task categories; HPT = high-payoff target; HVT = high-value target.

For the seven task categories presented in Table 2, a total of 25 coordination skills were identified as required by UAS operators for MUM-T. Table 2 lists the skills for each task in the sequence they would typically be performed based on the judgments expressed by the SMEs. For example, a target must be located before it can be engaged with direct or indirect fire. Not all skills would be required to be executed within a typical SR mission. These skills are shown along with the corresponding MUM-T task(s) with which each skill is associated. Appendix D provides a list of references within published U.S. Army directives and regulations defining each of the identified skills.

## Training-Critical MUM-T Skills Workshop

MUM-T skills will be critical to train when (a) UAS operators who have completed AIT do not possess the skills, (b) the skills are required for successful performance of multiple missions, and (c) insufficient skill levels can produce a serious increase in risk to personnel and equipment. Training criticality variables were assessed as a function of the current training system and the expected performance of UAS operators at the completion of AIT. Thus, criticality reflects the need for additional training beyond what is currently provided. If a skill is trained sufficiently well, so that UAS operators and pilots can effectively perform their reconnaissance and attack missions and avoid risk to personnel and equipment, then training criticality is low for that skill, regardless of the importance of the skill to the mission or the risks of poor performance. For skills that are not trained in AIT or are covered more superficially, importance to the mission and risks of poor performance have a greater impact on the overall training criticality score. The time required to acquire a skill also contributes to skill criticality when a limited training budget must be allocated to train a subset of the total complement of required skills. In that case, skills that can be quickly trained represent a more efficient use of the training budget with all other criteria being equal.

In this phase of the research, a group of experienced UAS operators and helicopter pilots individually rated each of the 25 MUM-T skills identified in the first workshop. The skills were rated on four dimensions related to training criticality (i.e., performance, importance as to mission [attack, reconnaissance], and to personnel and equipment.) as well as on the level of resources required for training each skill. The original intention had been to obtain ratings in group workshops, which would allow additional information to be obtained in support of the rationale for the ratings. However, scheduling groups of participants was infeasible, so the ratings were individually obtained. Ratings were obtained using spreadsheets with a guided user interface presented on laptop computers.

### Method

**Participants**. A total of 23 raters provided judgments, including 18 UAS operators and five helicopter pilots. All but two of the 23 raters had completed at least one tour in a combat zone within the last 3 years, and those tours were mostly in Iraq or Afghanistan. All raters were experienced with reconnaissance/security missions. Seventeen were experienced with communication/relay missions and 11 were experienced with attack missions. All 18 of the UAS operators were qualified to operate a medium UAS, such as the Shadow, while five were also qualified to operate a heavy UAS, such as the MQ-1C. The UAS operators were primarily senior noncommissioned officers; pilots were warrant officers. The 5 raters who were pilots were qualified to operate the OH-58D armed scout helicopter.

**Materials**. The assessment of training criticality was based primarily on the Task and Training Requirements Analysis Methodology (Swezey, Owens, Bergondy, & Salas, 1998) with some modifications as described in the following discussion. In addition, a measure of the resources required to train each skill was incorporated into the assessment. Training criticality was assessed using the following four dimensions: *Performance Level*, *Importance to attack and reconnaissance missions,* and *Consequences of lack of skill* (*to personnel and equipment*). A

fifth dimension, training resources, was an ancillary measure that did not comprise the main index of training criticality. These dimensions are their criteria are described below:

***Performance level***. Performance level was based on a rating scale developed by Campbell, et al. (1990). Raters were asked to reflect on the knowledge and skills typical of UAS operators who had just completed AIT, based on their own operational experiences and training. They were then asked to allocate a hypothetical, unspecified group of 10 typical AIT graduates into five proficiency categories for each of the 25 skills identified previously.

1. The number of Soldiers that **Virtually Never** perform the skill effectively;
2. The number of Soldiers that perform the skill effectively **Less Than Half the Time**;
3. The number of Soldiers that perform the skill effectively **About Half the Time**;
4. The number of Soldiers that perform the skill effectively **Most of the Time**;
5. The number of Soldiers that perform the skill effectively **All of the Time**.

The spreadsheet on which raters responded automatically checked to ensure that the total number of entries was 10 for each skill.

The mean category to which the Soldiers were assigned represented the average skill level. Skilled performance could occur either because Soldiers were well trained on this skill in AIT or because the skill was easy or already known by entering Soldiers. The standard deviation of the response allocation represents the performance variability of the skill. Performance variability has a maximum value of approximately 2.0 when five Soldiers are assigned to the lowest category (Virtually Never), while the remaining 5 Soldiers are assigned to the highest category (All of the Time). When all Soldiers are assigned to the same category, the performance variability reaches its minimum value of zero. A uniform distribution of Soldiers among the five categories produces a performance variability of 1.41.

***Importance to success of attack missions***. Raters were asked to indicate the extent to which the skills were important to the success of attack missions. Responses were made on a 5-point scale with anchors for the extreme and middle points. Thus, the following response scale was used:

1. **Low**. Lack of skill unlikely to have negative consequence on performance of attack mission. Skill is not critical to attack mission,
2. **Low-Moderate,**
3. **Moderate**. Lack of skill would have moderate consequences and might jeopardize attack mission success. Skill is somewhat important to attack mission,
4. **Moderate-High**,
5. **High**. Lack of skill would most likely have serious consequences and lead to attack mission failure. Skill is critical to attack mission.

***Importance to success of reconnaissance missions***. Raters were asked to indicate the extent to which the skills were important to the success of reconnaissance missions. The format of the question, response options and 5-point scale were the same as for attack missions.

***Consequences to personnel and equipment***. Raters were asked to rate the extent to which the skills were important to reduce risk to personnel and equipment. Responses were made on a 5-point scale with anchors for the extreme and middle points. The anchors varied both the likelihood and severity of consequences of lack of skill. The following response scale was used:

1. **Low**. Lack of skill unlikely to increase risk to personnel and equipment,
2. **Low-Moderate**,
3. **Moderate**. Lack of skill would produce a moderate increase in risk to personnel and equipment,
4. **Moderate-High,**
5. **High**. Lack of skill would most likely produce a serious increase in risk to personnel and equipment.

***Training resources***. Although not one of the four dimensions directly comprising the training criticality measure, raters were asked to indicate the level of resources required to train a UAS operator to mission proficiency on each of the 25 MUM-T skills. These ratings were included because resources are often limited and must be allocated to the most critical tasks. Having an estimate of the resources required would allow calculation of the ratio of training criticality to resources. The resource ratio could provide a useful guide for specifying how resources should be allocated to address the most critical tasks within a resource budget. The raters were asked to rate each of the skills according to the amount of training resources (time, personnel, and/or equipment) required to train it. Responses were made on a 5-point scale with anchors for the extreme and middle points, using the following response scale:

1. **Low**. Skill requires minimal training time and little or no use of personnel or equipment to achieve an effective performance level,
2. **Low-Moderate**,
3. **Moderate**. Skill requires moderate training time and some use of personnel and equipment to achieve an effective performance level,
4. **Moderate-High**,
5. **High**. Skill requires extensive training time, personnel, and equipment to achieve an effective performance level.

**Procedure**. The workshop began with the participants completing Informed Consent Forms and the Participant Background Forms (Appendix C). When these forms were completed, the participants then rated each of the 25 MUM-T skills. Ratings were conducted using a Microsoft Excel spreadsheet, which provided feedback to the rater to ensure that they properly rated all skills for each of the four dimensions. Raters rated all skills for one dimension and then proceeded to the next dimension until all skills dimensions were completed.

## Results

**Summary of ratings**. Average performance level estimates (expressed as percentages rounded to the nearest percentage point) are shown in Table 3. For each rater, the mean

performance level rating and performance variability for each MUM-T skill was calculated. The mean of these values over raters indicated that skills vary greatly in rated performance with mean ratings ranging from a minimum of 1.39 (indicating that most newly trained operators virtually never performed the skill correctly) to a maximum of 4.26 (indicating that most operators performed the skill correctly all or most of the time). A total of 8 of the 25 skills had mean performance ratings of less than 2.0, which indicated that the typical newly trained UAS operators were rated to perform these skills incorrectly most of the time. Average performance variability was low with a maximum value of 0.36 on a scale ranging from 0.0 to 2.0. This suggested that low performance variability implied that raters tended to place most of the 10 hypothetical Soldiers in the same or similar categories rather than spreading their ratings over the scale. The low performance variability may reflect the fact that the hypothetical Soldiers were expected to have received the same training at AIT and that no differences in on-the-job experience would distinguish them.

The mean importance ratings are shown in Table 4 and indicated that all the skills were judged to be at least moderately important to attack missions, to reconnaissance missions and to present moderate to serious risks to personnel and equipment if incorrectly performed. Mean importance of skills to attack missions varied from 2.96 to 4.74 (5-point scale). Similarly, mean importance to reconnaissance missions varied from 2.91 to 4.74. For each of these variables, 10 of the 25 skills had mean ratings greater than 4.0. Ratings of the severity of consequences of lack of skill for personnel and equipment ranged from 3.17 to 4.39 with 9 of 25 skills receiving mean ratings of greater than 4.0. Intercorrelations between mean ratings of all three importance dimensions were statistically significant $\alpha < .01$ ($r_{\text{attack/ reconnaissance}}(23) = .86$; $r_{\text{attack/ personnel \& equipment}}(23) = .96$; $r(23)_{\text{reconnaissance/personnel \& equipment}} = .88$). These high correlations suggested that the three dimensions are equivalent, likely redundant, and reinforced the rationale for weighting them equally. Finally, it is noteworthy that mean estimated performance levels significantly correlated with importance dimensions for attack, reconnaissance, and personnel and equipment at the $\alpha < .01$ level ($r(23) = [.57, .72, .56]$, respectively), which indicated higher perceived performance for those skills adjudged most important. The latter lower correlations seem reasonable, as estimated performance showed more variability than ratings of importance.

The mean rating for training resources was 3.38 (*SD*=.30). This value was slightly greater than the moderate option on the 5-point scale. Ratings ranged between 2.78 and 3.91. Despite this relatively restricted range, it was possible that the ratings for this variable could be used to identify critical skills that could be trained using a relatively modest amount of resources. For example, those skills that call for the use of proper communication procedures and formats, that do not require **e**xpensive training device support, could be trained at home station on PC-based media. However, training resources was regarded simply as an ancillary measure of potential utility to the training developer and did not contribute to the determination of criticality.

Table 3
*Estimated Performance Levels for 25 Manned-Unmanned Teaming Skills.*

| Skill | Estimated Percent per Each Level of Performance | | | | | Performance Rating | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Mean | *SD* |
| Gain and maintain enemy contact | 24 | 15 | 31 | 20 | 10 | 2.91 | 0.36 |
| Provide early warnings, ambush detection, overwatch, threat identification | 4 | 34 | 15 | 38 | 9 | 3.22 | 0.36 |
| Transmit information about location of threat | 13 | 34 | 7 | 18 | 28 | 3.13 | 0.29 |
| Transmit imagery, sensor data, etc | 21 | 5 | 12 | 22 | 40 | 3.57 | 0.32 |
| Find and track targets | 1 | 2 | 31 | 33 | 33 | 3.96 | 0.33 |
| Provide accurate description of target | 3 | 2 | 37 | 35 | 23 | 3.74 | 0.31 |
| Provide confirmation of target | 7 | 4 | 50 | 30 | 9 | 3.48 | 0.36 |
| Prioritize engagement of targets | 63 | 20 | 7 | 5 | 5 | 1.78 | 0.17 |
| Provide target location | 29 | 4 | 13 | 20 | 34 | 3.39 | 0.36 |
| Provide target description | 4 | 4 | 2 | 59 | 31 | 4.26 | 0.26 |
| Transmit information on method of attack | 69 | 6 | 19 | 6 | 0 | 1.65 | 0.14 |
| Utilize standard execution commands to initiate attack | 67 | 11 | 11 | 7 | 4 | 1.74 | 0.11 |
| Conduct target handover | 7 | 45 | 21 | 10 | 17 | 3.00 | 0.35 |
| Utilize standardized radio communication | 4 | 27 | 10 | 25 | 34 | 3.70 | 0.31 |
| Utilize standardized report formats | 4 | 12 | 10 | 39 | 35 | 3.96 | 0.25 |
| Develop/send common operating picture information | 67 | 11 | 10 | 8 | 4 | 1.78 | 0.12 |
| Utilize joint, Army, & civilian personnel recovery terminology | 70 | 12 | 5 | 5 | 8 | 1.65 | 0.17 |
| Perform battle damage assessment | 27 | 6 | 6 | 23 | 38 | 3.52 | 0.27 |
| Provide direction of target | 30 | 4 | 8 | 25 | 33 | 3.39 | 0.30 |
| Deconflict munition trajectories from airframe | 83 | 6 | 8 | 3 | 0 | 1.39 | 0.09 |
| Conduct call for indirect fires | 42 | 9 | 10 | 24 | 15 | 2.52 | 0.30 |
| Select best weapon system | 87 | 3 | 1 | 3 | 6 | 1.39 | 0 .08 |
| Transmit information about location of unit of action | 1 | 16 | 11 | 37 | 35 | 4.04 | 0.23 |
| Conduct call for direct fires | 66 | 5 | 9 | 15 | 5 | 1.91 | 0.25 |
| Switch roles of laser designator | 70 | 5 | 4 | 8 | 13 | 2.00 | 0.18 |

*Note*. Performance Levels: 1= Virtually Never; 2 = Less than Half the Time; 3 = About Half the Time; 4=Most of the Time; 5= All of the Time.

**Training Criticality Index**. A training criticality index (TCI) was created to combine the perceived performance level ratings (Table 3) with the dimensions of importance to missions (i.e., attack and reconnaissance), and importance to personnel and equipment (Table 4). First, the index included an additive combination of the ratings of the three dimensions of importance. Given the intercorrelations of these three dimensions, the three importance ratings were equally weighted in determining the index. Second, the index included a multiplicative combination of performance level with the aggregated importance dimensions. If all Soldiers judged to be able to adequately perform a skill (that is, the skill is rated to be in category 5 on the performance scale), then the training criticality is low because there is not a need for additional training. However, as average performance decreases, the importance of consequences of lack of skill increases correspondingly. A training criticality index that has the previous properties is given by the following equation:

$$TCI = (5 - PL) \times (C_A + C_R + C_{PE}),$$

where *TCI* is the training criticality index, *PL* is the *performance level* rating (on a scale from 1 to 5), $C_A$, $C_R$, and $C_{PE}$ are the *consequences* of lack of skill (i.e., importance) to the attack mission, the reconnaissance mission, and personnel and equipment, respectively (each also on a scale from 1 to 5). That is, the greater the potential *consequences*, the greater the importance of the skill is to the mission. The TCI function has a minimum value of zero when either of the two factors is zero, and has a maximum value of 60, when the performance level is at its minimum value and the consequence variables are all at their maximum levels. For a worked example, let us compute the TCI for the skill: *deconflict munition trajectories from airframe*. The mean estimated performance level was 1.39; mean importance ratings were CA = 3.87; CR = 3.17, and CPE = 3.74). TCI = (5-1.39) x (3.87+3.17+3.74) = 3.61 x 10.78 = 38.92. This skill was highest in training criticality of all 25 of skills identified.

The last column in Table 4 shows the skills ordered by their value on the TCI. Because the mean performance level varies more than the three importance measures, it is not surprising that the most training-critical skills are the ones in which perceived or expected performance or new AIT graduates was rated lowest. Examination of the most training-critical skills shows that nearly all of them focus on tactical activities required for reconnaissance and attack missions. Skills at the bottom of the list have a low training-criticality index despite their high importance because Soldiers graduating from AIT are seen as already knowing these skills well. Recall that the lowest ranking skill, *Provide target description information*, was rated as being performed correctly most or all of the time by 90% of newly trained UAS operators (Table 4). Because rated performance is already so high on this important skill, it is not critical to provide training on it beyond AIT. Review of the less training-critical skills (those with TCI scores < 20.0) shows that most of them are consistent with the traditional MI mission for UAS. Again, these are very important skills in terms of impact on mission success, but they are not training-critical as they are adequately trained during AIT.

Table 4

*Importance Ratings for 25 Manned-Unmanned Teaming Skills Rank-Ordered of by Training Criticality Index Score.*

| Rank | Skill | Importance | | | TCI |
|---|---|---|---|---|---|
| | | Attack | Recon | Personnel and Equipment | |
| 1 | Deconflict munition trajectories from airframe | 3.87 | 3.17 | 3.74 | 38.92 |
| 2 | Utilize standard execution commands to initiate attack | 3.65 | 3.39 | 3.61 | 34.74 |
| 3 | Transmit information on method of attack | 3.39 | 3.26 | 3.61 | 34.35 |
| 4 | Switch roles of laser designator | 4.04 | 3.52 | 3.70 | 33.78 |
| 5 | Conduct call for direct fires | 3.57 | 3.61 | 3.70 | 33.55 |
| 6 | Select best weapon system | 3.13 | 2.91 | 3.17 | 33.26 |
| 7 | Develop/send common operating picture information | 3.35 | 3.35 | 3.30 | 32.17 |
| 8 | Utilize joint, Army, & civilian personnel recovery terminology | 2.96 | 3.17 | 3.22 | 31.29 |
| 9 | Prioritize engagement of targets | 3.00 | 3.30 | 3.30 | 30.91 |
| 10 | Gain and maintain enemy contact | 4.74 | 4.52 | 4.39 | 28.49 |
| 11 | Conduct call for indirect fires | 3.91 | 3.57 | 3.83 | 28.02 |
| 12 | Transmit information about location of threat | 4.52 | 4.74 | 4.30 | 25.36 |
| 13 | Conduct target handover | 4.00 | 4.48 | 3.87 | 24.70 |
| 14 | Provide early warnings, ambush detection, overwatch, threat identification | 4.52 | 4.61 | 4.35 | 24.03 |
| 15 | Provide target location | 4.30 | 4.26 | 4.30 | 20.70 |
| 16 | Provide confirmation target | 4.43 | 4.39 | 4.17 | 19.78 |
| 17 | Provide direction of target | 4.26 | 3.96 | 3.96 | 19.58 |
| 18 | Transmit imagery, sensor data, etc | 3.96 | 4.43 | 4.04 | 17.84 |
| 19 | Provide accurate description of target | 4.43 | 4.43 | 4.17 | 16.45 |
| 20 | Utilize standardized radio communication | 3.91 | 3.87 | 3.83 | 15.14 |
| 21 | Perform battle damage assessment | 3.26 | 3.30 | 3.22 | 14.46 |
| 22 | Find and track targets | 4.48 | 4.48 | 4.39 | 13.93 |
| 23 | Transmit information about location of unit of action | 3.87 | 3.96 | 3.74 | 11.06 |
| 24 | Utilize standardized report formats | 3.39 | 3.74 | 3.30 | 10.89 |
| 25 | Provide target description information | 4.26 | 4.22 | 4.30 | 9.45 |
| | Grand Mean | 3.89 | 3.87 | 3.82 | 24.11 |
| | *SD* | 0.52 | 0.55 | 0.41 | 8.87 |

*Note*: TCI = Training Criticality Index

## Benchmark Indicators Workshop

A benchmark is a standard by which something can be measured or judged. It is not itself an assessment method but rather a descriptor or locator of a particular (usually desired) level of an attribute or behavior. In the case of a training system, benchmarks can be used to provide instructional feedback and diagnostics during training, inform the evaluation of a course or program, or assess instructor performance. Benchmarks can also be used as indices of levels of proficiency including minimal competence. A benchmark is usually a location on a continuum derived from an observational measure of performance. A benchmark assumes an observable continuum to be measured, a method for measuring it, and the establishment of a point on that continuum that corresponds to the level of the attribute that is of interest. For the current research effort, the prime emphasis for the purpose of benchmarks is in determining minimum competence, and the secondary emphasis is on instructional feedback. Therefore, benchmarks could be considered as both indicators of competent performance and indicators of non-competent performance.

The approach to developing benchmarks for previously identified MUM-T skills set was to elicit relevant skill descriptions from experienced individuals representing both the manned aviation and unmanned aviation communities. The descriptions included behavioral indicators of competency (or non-competency), conditions under which those indicators would be observable, and environments in which the observable behaviors would be likely to occur. This approach was implemented through two group-discussion workshops using brief written response forms and consensus oriented discussion. The reader should note that workshop participants were not expected to be experts in instructional design or behavioral sciences. Therefore, it was not expected for participants to be able to identify or formulate performance benchmarks within a training program. However, it was expected that participants would have technical expertise in UAS operations (possibly to include MUM-T) and could describe behavioral indices for competency in MUM-T, especially if participants had direct past experience in MUM-T.

### Method

**Participants**. Participants were recruited from staff positions and from senior non-commissioned officer training courses at the U.S. Army Aviation Center of Excellence. The recruiting effort called for personnel who had direct experience in missions relevant to MUM-T and preferably direct experience in MUM-T. Due to scheduling limitations and in order to keep group sizes to a manageable level, separate workshops were conducted with one workshop consisting of manned aircraft pilots and the second workshop consisting of UAS operators. There were 12 participants in the two workshops.

In the first workshop, five chief warrant officers took part. All were OH-58D qualified, and all had experience in combat zones in Iraq as well as other areas of operation. All had experience in reconnaissance/security missions. Two had experience in attack missions, and one had experience in communications missions. Most had some experience in MUM-T operations, which often occur when RQ-7Bs report targets to armed helicopters.

In the second workshop there were seven UAS instructor-operators, all senior non-commissioned officers. All were qualified on medium UAS (e.g. RQ-7B). One was also qualified on heavy UAS (e.g. MQ-1C). All had operated in combat zones (i.e., Iraq and other areas of operation) within the past 3 years. All had experience in reconnaissance/security missions, and three had experience in attack missions. Two had experience in communications missions. Most had some experience in MUM-T operations in theater.

**Materials and procedure**. At the outset of each workshop, participants completed an Informed Consent Form and then were given the Participant Background Survey (Appendix C) to complete while the workshop facilitator reviewed the project objectives and previous efforts and explained the process for the current activities. Each of the workshops was conducted in two phases. In the first phase, participants produced brief free-text written responses entered onto printed forms. The main purpose for the first phase was to focus participants' attention on the relevant issues and get them to organize their thoughts in order to promote constructive discussion. In the second phase the participants discussed their responses, made comparisons and contrasts, and adjusted their descriptions in order to attain a consensus regarding the response set.

The results of the previous efforts in the project were used to assemble a list of the 25 identified MUM-T skills in descending order of training criticality (see Table 4). Each skill was associated with one of the seven task categories identified in the Task and Skill Review Workshop previously described. Each skill also was linked to a set of subtasks and performance standards defined by Army doctrine (see Appendix E). Participants were presented with the skill list and an accompanying form listing the same skills with blank areas for indicators, conditions and sources. In the first phase of the workshop, participants were asked to review the list and then enter responses onto the blank forms provided. For the response forms, *indicators* were defined as observable behaviors associated with varying levels of proficiency in the target skill, *conditions* were defined as observable events and processes within a training event that signal the likelihood of the target skill being observed, and *sources* were defined as the locations (e.g. Portable Institutional Mission Simulator) where an observation might be made. As an example, the first skill listed was *Deconflic*t *munition trajectories from airframes*. This skill was rated first in criticality (see Table 4). The skill is associated with the task category *Call for and Adjust Indirect Fires* (Table 2).

When the SMEs had completed as much of the forms as needed to reach a threshold allowing for sufficient collection of indicators and sources, the second phase of the workshop was initiated. In this phase, the skills were addressed in descending order of training criticality (see Table 4), and the group used the skill information and their written responses as the basis for an exchange of ideas and opinions regarding the response set. A workshop facilitator moderated the session and took notes of responses.

## Results

The written responses from all participants, along with the facilitator's notes were consolidated in a spreadsheet. One participant entered nothing on the written form but contributed extensively during the discussion phase. The spreadsheet was reviewed by the

research team to eliminate responses for indicators that were deemed unlikely to be measurable (e.g., "lack of confidence") or vague (e.g., "uses good decision making ability"). For each skill duplicate responses and tangential content were removed. Responses entered for indicators were re-written as active voice action statements. Responses for conditions and sources that did not fall within their operational definitions were eliminated.

**Indicators.** Indicators are defined as observable behaviors associated with varying levels of proficiency in the target skill. Both groups of participants (i.e., helicopter and UAS) agreed that most behavioral indicators of the skills could be derived from the subtask statements in the provided list. Several of the skills were identified as redundant. The helicopter participants agreed that skills ranked 17 and 22 through 25 (See Table 4 for skill rankings) were all redundant with other skills. UAS participants identified skills ranked 17, 21 and 25 as redundant and identified skills ranked 22, 23 and 24 as unimportant with respect to teaming. As an example, skill 23, *Transmit information about the location of the Unit of Action* had only one indicator identified. *Know own position relative to the target.* This is a basic individual skill inasmuch as UAS and target coordinates are shown on the operator's displays. Skills ranked 19, 24 and 25 (all related to describing and reporting targets) were identified by helicopter participants as a "relics from ISR." These skills were considered to have been relevant when the emphasis for UAS operations was on ISR missions with an MI perspective but are much less so for SR missions in the Aviation branch. The UAS participants identified skill 19 as redundant with skill 9, *Prioritize the engagement of targets*. Skills ranked 17 and 22 through 25, found to be redundant and/or unimportant by both UAS and manned participants, were excluded from further analysis.

The helicopter pilot participants identified four skills ranked 1, 3, 7 and 10 (see Appendix E) as mostly or entirely composed of situational awareness (SA). Although assignment of such a label may appear to be a neatly packaged statement, the issues related to measurement of SA are many. Not the least of these is selection of an operational definition. The participants from both communities provided other more specific information for all of these skills.

**Conditions.** These are observable events and processes within a training event that signal the likelihood of the target skill being observed. Participants tended to confuse the conditions requested on the response form with conditions and standards statements relating to training tasks. This difference was clarified by the moderator. The conditions responses are not unique across skills. Given the fact that skills may be associated with multiple task categories and the fact that conditions are necessarily fairly broad (i.e., the scope of this project does not afford specific analysis of training environments and their measurement capabilities.), multiple representation of conditions across skills was expected.

**Sources.** A source is a location where an observation might be made. There are a small number of venues in which MUM-T skills (or rather the behavioral indicators for them) may be observed. Observations are most likely to occur in institutional and unit training situations at crew and team levels. By definition, MUM-T skills cannot be observed in individual training venues. The indicators may be observed in any of the usual instructional delivery environments such as classroom instruction, and in constructive, virtual and live simulations. Indicators are also observable in combat operations although the likelihood that observations would be

recorded for training applications is low. At the level of specificity possible within the scope of this project, the set of sources for benchmark observations in MUM-T is limited. Not surprisingly, the participants' responses reflected this limitation. The range of responses was small but appeared to cover the possibilities available in training. The sources, naturally, are represented in most of the skills.

**Summary.** The reduced set of 20 MUM-T skills yielded a total of 140 indicators, 41 conditions, and 80 sources. The indicators were not necessarily unique to a given skill, but each of the conditions and sources were. An example of a MUM-T skill and associated indicators, conditions, and sources is given in Table 5 for the skill ranked highest in training criticality. The full set of MUM-T skills and indicators, conditions and sources appears in Appendix F, which is arranged in descending rank order of TCI scores (i.e., training criticality). The number of indicators, conditions and sources declines with the rank order of each skill. This may be due in part to fatigue of the participants later in the workshop or decreased criticality of those skills which are well trained.

Table 5
*Benchmark Indicators, Conditions, and Sources for "Deconflict Munition Trajectories from Airframes" Manned-Unmanned Teaming Skill*

**Deconflict munition trajectories from airframes**

***Indicators***

- Call for fire is complete and accurate
- Operator is aware that deconfliction is taking place
- Coordinates with Air Traffic Control for deconfliction
- Identifies intersecting munition trajectories; recommends lateral, vertical, or sequential maneuver
- Operator is aware of positions of friendly aviation assets
- Responds to instructions to deconflict. Moves aircraft to safe area
- Confirms when clear
- All aircraft are in assigned locations
- Air Mission Commander has to redirect the UAS from munition trajectory or impact area
- Air Mission Commander has to call a cease fire due to UAS location
- Determines if rounds are accurately placed on target
- Appropriate graphics are displayed and current

***Conditions***

- Call for Fire missions; own or other unit
- Troop suppression
- Show of force
- Preplanned coordinated attack
- Target of opportunity with priority of fires assumed

***Sources***

- Virtual simulations; Aviation Combined Arms Tactical Trainer, Portable Institutional Modular Simulator
- Live simulations
- Gunnery training
- Combat

There were also some notable open-ended comments made by SMEs during this workshop session for five skills varying in training criticality. These comments are listed in Appendix G. In brief, the most numerous and important comments were those regarding the two skills ranked 1 and 3 on the TCI (i.e., *Deconflict munition trajectories from airframes* and *Transmit information about method of attack.***)**. Comments regarding these MUM-T skills reflected concern for a need for joint mission planning by UAS and manned elements, and the lack of adequate communication and coordination, as well as a need to train both UAS and manned aircrews in the deconfliction of two aircraft with very different operational envelopes. The proper routing of communications and the lack of shared Tactical Standard Operating Procedures appeared to be another major concern.

## Discussion and Recommendations

The need to more centrally integrate UAS into aviation operations has resulted in increased MUM-T during aviation SR missions. As a consequence, greater emphasis on MUM-T and SR mission skills will occur in UAS training, particularly for RQ-7B operators. However, MUM-T skills are relatively new to both helicopter aircrews and UAS operators, and the doctrine for MUM-T is still evolving. In order to develop effective MUM-T training, it is crucial to understand the specific skills required for MUM-T task performance and the most efficient ways to train UAS operators on MUM-T skills. Therefore, the goal of the research reported here was to specify an empirically-derived set of MUM-T critical skills and to develop benchmark indicators for performance on those skills.

In order to meet this goal, this research used a combination of doctrinal review and SME input to (a) identify candidate MUM-T skills, (b) determine the training-criticality of the MUM-T skills, (c) revise the set of desired skills, and (d) produce a set of benchmark indicators for each training-critical MUM-T skill. Altogether, 25 MUM-T skills were identified. Of those 25 skills, 20 MUM-T skills were determined to be training-critical skills. Examples of training-critical skills included *Deconflict munition trajectories from airframes*, *Utilize standard execution commands to initiate attack*, and *Conduct call for direct fires*.

The evolutionary state of MUM-T doctrine and tactics presented a challenge to the identification of MUM-T Skills. However, participants in the Task and Skill Review Workshop including several members of DOTD, including a doctrine writer from the Director's staff, saw the draft list of proposed MUM-T skills as adequate and within the ambit of current doctrine. Minor changes to the list were recommended as some skills were added and others combined. Thus, the objective of identifying and validating (as to doctrine) tasks for MUM-T and their underlying skills, was met. One important thing learned in conjunction with the Task and Skill Review Workshop is that, in current DOTD thinking, MUM operations will involve peer-to-peer using voice-only communications. Unlike previous UAS operations, communications in most cases will not use the Tactical Operations Center as an intermediary.

Another challenge to the identification of MUM-T skills was that many of the helicopter pilots and UAS operators participating in the SME workshops were not fully aware of the capabilities of their counterpart personnel and airframes. That is, for example, many scout-attack pilots did not know the extent or nature of training UAS operators receive. Each group of

participants (i.e., pilots and UAS operators) tended to defer to the other when issues of specific airframes arose. As a consequence, the input on some skills is biased toward one perspective instead of representing an integrated perspective. The fact that the two groups of participants were not fully aware of their counterparts' capabilities also indicated that, despite an expectation of burgeoning reliance on MUM-T in the near term, manned and unmanned communities are still insufficiently integrated. For a more complete discussion of these differential perspectives, the reader is referred to Stewart, et al. (2012).

The training criticality of MUM-T skills was based on perceived current proficiency and on the consequences of team performance. More specifically, MUM-T skills were defined as training-critical if (a) UAS operators who have completed AIT cannot perform them, (b) the skills are essential for successful completion of missions, and (c) the lack of proficiency at the skills can endanger personnel and equipment. These dimensions were captured and formalized in the TCI. The prioritization of skills on the composite TCI indicated that the most critical skills were related to tactical SR operations, whereas the least critical skills were traditional ISR skills. There was little variation across skills in ratings of importance to missions or ratings of importance to personnel and equipment. Indeed, some of the skills rated as most important were ISR skills that are also proficiently performed by newly-trained UAS operators. Consequently, it seems that the determinant of training criticality was the perceived ability of UAS operators graduating from AIT to effectively perform the identified skills. One must note that was one application of the TCI to a set of skills all of which were judged to be at least moderately important. Therefore variation due to importance was low relative to variation due to estimated performance. For this reason, it would be premature to state that estimated performance is the most essential dimension, and the three importance dimensions are redundant. Further applications of the TCI to other skill sets are needed to determine the relative weights of the dimensions comprising the TCI.

**Measuring Performance of MUM-T Skills**

In order to establish benchmarks to measure MUM-T skills, 140 indicators (i.e., observable behaviors associated with levels of proficiency for a given skill) were developed across the final set of 20 MUM-T skills. The benchmarks also required the determination of 41 unique conditions (i.e., events signaling the likelihood that a given skill can be observed) and 80 unique sources (i.e., locations where the observation can be made) for the MUM-T skill set. The indicators, conditions, and sources are prototypical in the sense that they are currently not systematically used to assess performance in MUM-T operations. It should be emphasized that extensive field testing and refinement are necessary before these prototype tools can become usable by trainers and evaluators. It is likely that many of the indicators could be used in structured training environments, but this will require detailed assessment of the data recording capabilities embedded in the simulations and system equipment as well as assessment of the capacity for accommodation of trained observers. Perhaps the most usable assessment tools in the near term would be behaviorally-anchored, observer-based measures.

In order to develop specific measures of MUM-T skill from the developed benchmarks, refinement of the indicators, conditions, and sources will be necessary. The available training delivery environments should be reviewed to determine more specifically the sources where

MUM-T performance indicators may be observable. This review should include classroom training as well as constructive, virtual, and live training at institutions and homes stations. Each of the training environments should be analyzed for content (e.g. scenarios) that contain the conditions under which the indicators may be observable. The analyses should be aimed at identification and functional description of data elements relevant to the Indicators. The analyses could be done through SME observation (e.g., McGilvary, Leibrecht, & Lockaby, 2008; Sticha, Weaver, Ford, & Campbell, 2011) or through automation in constructive or virtual simulations (Dorsey, et al., 2009). One example approach to these analyses is Targeted Acceptable Response to Generated Events or Tasks (TARGETs) (Dwyer, Fowlkes, Oser, Salas, & Lane, 1997). TARGETs is an event based training development and measurement method that identifies events within a scenario that trigger the production of indicator behaviors for observation. ARI is currently in the process of developing both observer-based and system-based (i.e., automated) performance measures for aviation collective training (Seibert, Diedrich, Stewart, Bink & Zeidman, 2011). Although these measures were developed prior to the stand-up of FSCAB units, it is likely that this measurement technology can be adapted to MUM-T training.

The development of behavioral measures from the indicators should take into account the intra- and interpersonal processes involved in team operations. There is a considerable literature on team processes and consideration of this body of knowledge will provide direction for the structure and development of MUM-T measures. For example, cross-training of system operator roles is universal within Army UAS operators and within helicopter pilots but is not practiced between MUM-T elements. Cross-training within MUM-T is likely to increase the extent and quality of a shared mental model for MUM-T. Army Aviation is aware of the need for this training, and is currently experimenting with various training events intended to make the scout-attack pilot more sensitive to the role of the UAS operator.

**Training MUM-T Skills**

As indicated by the training criticality assessments, incorporation of UAS into SR missions has added the requirements for new skills that are not currently trained as part of UAS AIT. These new skills require a more active role for the UAS operator in various aspects of the missions. The general term: *developing the situation* is often employed to represent many of the target identification, attribution of target intent, communicating and reporting behaviors delineated in the extensive list of indicators (see Appendix F). Developing the situation will require extensive new learning of cognitive and procedural skills on an individual level in order for the UAS crew to become more effective in MUM-T missions. The MUM-T skills and corresponding benchmarks obtained in the present research effort, though prototypes, may prove beneficial as guides to determining and prioritizing those cognitive and procedural skills that must be trained. UAS crews must learn procedures and techniques currently not taught at AIT such as laser designation of targets for armed helicopters as well as the exclusion zones and other characteristics of laser guided munitions. The challenge for Army Aviation is to determine where and how these new skills are to be trained.

Those skills most in need of training were SR skills, the same as those performed by crews of manned scout helicopters, and for which the majority of UAS operators were perceived by SMEs as lacking sufficient background and experience. Obviously, if they are to become

effective MUM team members, UAS operators must master these skills. There are many questions as yet unanswered, as to how much training time will be required for mastery, by Soldiers who differ on many background dimensions from aviators (e.g., rank, method of selection, flight aptitude). Thus another, related challenge is *if* these skills can be acquired and sustained to the same level of proficiency as for the crews of manned aircraft.

Thus, the training aspect of MUM-T is crucial, not only for UAS operators, but also for pilots who may not fully understand the capabilities and limitations of the RQ-7B. For example, RQ-7B usually operates at an altitude of 6,000-8,000 ft, whereas scout and attack helicopters typically do not operate above 1,000 ft. Consequently, the operational environments of the two aircraft types are very different and must be mutually understood by both team members. In addition, because the RQ-7B has substantially greater endurance than a manned helicopter such as the AH-64D, the UAS crew will often be required to take initiative in identifying and reporting a target to an AH-64D that is joining the UAS to operate as a part of a MUM-T operation.

Live training is available to UAS units at home station but is limited in the amount of participation by other assets. Formation of MUM-T in home station live training will generally require that helicopter elements be filled by role players. Live training in large federations, such as Combat Training Centers, are only rarely available and provide a greatly curtailed maneuver box for aviation assets and limited ability to incorporate UAS into SR missions (Stewart, Barker, & Bink, 2010). Likewise, inclusion of UAS in large-scale virtual training exercises such as the Aviation Training Exercise (ATX) has been minimal to date. Typically, UAS crew positions during ATX have been filled by role-players (e.g., aviation warrant officers on casual duty). However, inclusion of UAS personnel in ATX is expected to be more frequent as more FSCABs are organized and come to participate in ATX staring in the summer of 2012. As a result, ATX will become a primary training environment for MUM-T.

**Conclusions**

The TCI composite index, similar in many ways to the Air Force's MEC methodology, was successfully exercised in the current research effort to identify and prioritize training-critical MUM-T skills. Both of these methodologies promise to be useful tools for pinpointing specifically what skills require priority attention for training when new systems, and/or new doctrines and tactics, are under development. This report presents a snapshot of MUM-T skills and benchmark performance indicators based on the current UAS capabilities and the capabilities envisioned for the near future. However, there are numerous changes taking place in the Army's UAS assets and their employment. These changes are taking place in organization, in missions, in airframes, in mission equipment, and in tactics, techniques and procedures. The organizational changes are driving the shift in emphasis from ISR toward SR at a greater than planned rate. This shift is driving an expansion in the breadth of missions in which they are employed. This, then, drives the development of new TTP. At the same time, changes to the airframes and their mission equipment packages are adding capabilities which feed further expansion of missions and TTP. A major organizational change, beyond the transfer from MI to Aviation, is the development of FSCABs (Stewart et al., 2012). Employment of UAS in attack and Signal Intelligence missions is increasing.

At the current stage of MUM-T doctrine and training development, several key challenges exist to the successful implementation of efficient and effective instructional strategies. These have been addressed at length in the current paper, but should be summarized briefly here. First, it is evident that UAS operators must acquire and master many of the SR skills that until recently were performed solely by aircrews of armed scout and attack helicopters. ARI research (Stewart, et al., 2011; Stewart, et al., 2012) has indicated that training in AIT still emphasizes on ISR as opposed to SR operations. Secondly, the onus of training critical MUM-T skills rests with the operational units, since AIT does not provide this training. A challenge is the lack of opportunity to acquire and maintain MUM-T skills at home station in live training, thus necessitating the use of virtual training environments, including purpose-built simulators and portable training devices at home station, and participation in ATX exercises. Third, performance measurement technology lags behind the state of the art for simulation for unmanned as it also does for manned aviation, and this technology is crucial for efficient and effective unit level training. Such measures will be required for MUM-T.

Finally, but nonetheless important, is the need to integrate training for UAS and manned aircrews, starting at the Combat Skills Phase of Initial Entry Rotary Wing training, This would involve mission planning exercises for OH-58D and AH-64D aircrews, in which RQ-7B crew participated directly in the planning and rehearsal of simulated SR missions. The result would be assimilation of the UAS aircrews into the mainstream of Army Aviation training. MUM-T must not focus entirely on the training needs of the UAS operators; pilots of helicopters such as the OH-58D must be familiarized with the capabilities and especially limitations of UAS. The same requirement should apply to BCT leadership, which may not be familiar with means of employing RQ-7B as a tactical asset. So not only is training of aircrews important, but education of leaders as well.

As doctrine specific to the Scout/Attack and UAS communities becomes more closely coordinated, differences between the communities in perspective and practice will be reduced. This coordination will simplify MUM-T training. Communication is one of the principal factors in MUM-T operations and is an area in which consistent doctrine will have a large impact. Mission planning is another area in which the development of doctrine consistent with MUM-T will be beneficial. Because of the disparity in endurance a UAS crew may team with three or four rotary wing missions in a single flight. This tempo could place the UAS flight inside the mission planning cycle of the helicopter team elements. Therefore, the UAS crew could be placed in the position of planning missions while operating their system. New procedures may be necessary to ensure that the UAS element's planning is done completely without adversely affecting their workload. Mission planning and team training are also affected by geographical separation of the helicopter and UAS elements.

Finally, it should be noted that many of the critical skills identified and prioritized in the present research can be considered platform-independent. Indeed, SR operations are based upon time-honored Cavalry scouting doctrine and tactics that were in use prior to the invention of the aircraft. Also, reconnaissance and scout activities have long been a part of naval operations. Thus, many of these skills would be applicable to a new generation of ground-based and even marine unmanned reconnaissance systems that perform the role previously performed by the venerable Army scout and pathfinder teams.

Preliminary findings from the present research effort, along with recommendations, have been disseminated to the UAS and Scout-Attack communities, through joint briefings to TCM-Reconnaissance-Attack and TCM-UAS.

## References


Air Maneuver Battle Lab. (1998). *Final Report: manned and unmanned aerial platform operations on the digitized battlefield concept experimentation program* (Final Report No. TRADOC Report Project No 97-CEP-0101). Fort Rucker, AL: United States Army Aviation Center.

Air Maneuver Battle Lab. (1999a). *Final Report: Concept experimentation program (CEP) manned and unmanned aerial platform operations on the digitized battlefield* (Final Report No. TRADOC Report 98-CEP-0104). Fort Rucker, AL: United States Army Aviation Center.

Air Maneuver Battle Lab. (1999b). *Manned and unmanned aerial platform operations on the digitized battlefield: Final Report to the Air Maneuver Battle Lab* (Final Report No. TRADOC Report 98-CEP-0104). Fort Rucker, AL: United States Army Aviation Center.

Air Maneuver Battle Lab. (2000). *Manned and unmanned aerial platform operations on the digitized battlefield* (Final Report No. TRADOC Project 99-CEP-0101). Fort Rucker, AL: United States Army Aviation Center.

Campbell, C.H., Ford, P., Rumsey. M.G., Pulakos, E. D., Borman, W. C., Felker, D. B., et al. (1990). Development of multiple job performance measures in a representative sample of jobs. *Personnel Psychology, 43*(2), 277-300.

Cannon-Bowers, J. A., & Salas, E. (1997). A framework for developing team performance measures in training. In M.T. Brannick, E. Salas, & C. Prince (Eds.), *Team performance assessment and measurement: Theory, methods, and applications* (pp. 45 – 62). Mahwah, NJ: Lawrence Erlbaum.

Colegrove, C. M., & Bennett, W. (2006). *Competency-based training: adapting to warfighter needs*. (AFRL-HE-AZ-TR-2006-14). Air Force Research Laboratory: 711th Human Performance Wing.

Department of the Army. (2007a). Field Manual 3-04.111. *Aviation brigades*. Washington, DC: Author.

Department of the Army. (2007b). Field Manual 3-04.126. *Attack reconnaissance helicopter operations*. Washington, DC: Author.

Department of the Army. (2007c). Field Manual 6-99.2. *U.S. Army report and message formats*. Washington, DC: Author.

Department of the Army. (2007d). Training Circular 1-600. *Unmanned aircraft system commander's guide and aircrew training manual*. Washington, DC: Author.

Department of the Army. (2009). Field Manual 3-04.155. *Army unmanned aircraft system operations.* Washington, DC: Author.

Dorsey, D., Russell, S., Keil, C., Campbell, G., Van Buskirk, W., & Schuck, P. (2009). Measuring teams in action: automated performance measurement and feedback in simulation-based training. In E. Salas, G. F. Goodwin & C. S. Burke (Eds.), *Team effectiveness in complex organizations: cross disciplinary perspectives and approaches* (pp. 351-382). New York: Routledge.

Dwyer, D. J., Fowlkes, J. E., Oser, R. L., Salas, E., & Lane, N. E. (1997). Team performance measurement in distributed environments: the TARGETs methodology. In M. Brannick, E. Salas & C. Prince (Eds.), *Team performance assessment and measurement: theory, methods and applications* (pp. 137-154). Mahwah, NJ: Lawrence Erlbaum.

Howse, W. R., & Cross, K. D. (1998). *The manned and unmanned aerial reconnaissance team: tactics, techniques and procedures for zone reconnaissance: Report to the Air Maneuver Battle Lab* (Interim Report). Fort Rucker, AL.

McGilvray, D. H., Leibrecht, B. C., & Lockaby, K. J. (2008). *Measuring learning and performance in collective training exercises* (Contractor Report 2008-02). Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA480052)

Seibert, M. K., Diedrich, F. J., Stewart, J. E., Bink, M. L., & Zeidman, T. (2011). *Developing performance measures for Army aviation collective training* (Research Report 1943). Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADA544425)

Stewart, J. E., Barker, W. C., & Bink, M. L. (2010). *Army RQ-&B unit training issues*. Paper presented at 63rd meeting of Department of Defense Human Factors Engineering Technical Advisory Group, Tempe, AZ.

Stewart, J. E., Bink, M. L., Barker, W. C., Tremlett, M. L., & Price, D. (2011). *Training needs for RQ-7B unmanned aircraft system operators in the scout-reconnaissance role* (Research Report 1940). Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. ADB367652)

Stewart, J.E., Roberts, K.R., & Bink, M.L. (2012). *Unmanned aircraft systems in the scout-reconnaissance role: perceptions of the U.S. Army manned and unmanned aircraft communities* (Research Report 1956). Fort Belvoir, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Sticha, P. J., Weaver, E. A., Ford, L. A., & Campbell, R. C. (2011). *Assessing Learning and Performance in Collective Training Exercises* (FR 11-55). Alexandria, VA: Human Resources Research Organization.

Swezey, R. W., Owens, J. M., Bergondy, M. L., & Salas, E. (1998). Task and training requirements analysis methodology (TTRAM): An analytic methodology for identifying potential training uses of simulator networks in teamwork-intensive task environments. *Ergonomics, 41*, 1678-1697.

U.S. Army Intelligence Center. (1997). Training Circular 34-212. *Unmanned Aerial Vehicle Aircrew Training Manual*. Fort Huachuca, AZ: Author.

U.S. Army UAS Center of Excellence. (2010). *"Eyes of the Army": U.S. Army Roadmap for Unmanned Aircraft Systems 2010-2035*. Fort Rucker, AL: Author.

## Acronyms

| | |
|---|---|
| AIT | Advanced Individual Training |
| ARI | U.S. Army Research Institute for the Behavioral Sciences |
| ATX | Aviation Training Exercise |
| BCT | Brigade Combat Team |
| DOTD | Directorate of Training and Doctrine |
| FSCAB | Full Spectrum Combat Aviation Brigade |
| ISR | Intelligence, Surveillance, and Reconnaissance |
| MEC | Mission Essential Competencies |
| MI | Military Intelligence |
| MUM-T | Manned-Unmanned Teaming |
| SA | Situational Awareness |
| SME | Subject-Matter Expert |
| SR | Scout-Reconnaissance |
| TARGETs | Targeted Acceptable Response to Generated Events or Tasks |
| TCI | Training Criticality Index |
| TCM-UAS | Training and Doctrine Command Capabilities Manager |
| TTP | Tactics, Techniques, and Procedures |
| UAS | Unmanned Aircraft System |

# APPENDIX A

# ARMY AVIATION MISSIONS INVOLVING MANNED-UNMANNED TEAMING AND PRIMARY REFERENCE SOURCE

*Army Aviation Missions Involving Manned-Unmanned Teaming and Primary Technical Reference*

| **Army Aviation Mission** | **Primary Reference Source** |
|---|---|
| Conduct Raids | FM 3-90, Tactics |
| Provide Aerial Escort and Suppressive Fires | FM 3-04.111, Aviation Brigades |
| Provide Mobile Firepower | FM 3-04.111, Aviation Brigades |
| Destroy Enemy Formations | FM 3-04.111, Aviation Brigades |
| Conduct Limited Joint Suppression of Enemy Air Defenses Operations | FM 3-04.111, Aviation Brigades |
| Coordinate and Adjust Indirect Fires | FM 3-04.111, Aviation Brigades |
| Conduct Joint Air Attack Team with Close Air Support and Field Artillery | FM 3-04.111, Aviation Brigades |
| Conduct Air Assaults | FM 3-04.111, Aviation Brigades |
| Support Maneuver Forces Through Close Combat Attack | FM 3-04.111, Aviation Brigades |
| Conduct Area Reconnaissance | FM 3-04.126, ARH Operations |
| Conduct Zone Reconnaissance | FM 3-04.126, ARH Operations |
| Conduct Route Reconnaissance | FM 3-04.126, ARH Operations |
| Conduct Area Security Operations | FM 3-04.126, ARH Operations |
| Conduct Screening Operations | FM 3-04.126, ARH Operations |
| Conduct Guard and Covering Force Operations | FM 3-04.126, ARH Operations |
| Conduct Chemical, Biological, Radiological, and Nuclear Reconnaissance | FM 3-04.111, Aviation Brigades |
| Conduct Aeromedical Evacuation | FM 3-04.111, Aviation Brigades |
| Conduct Downed Aircraft Recovery Team Operations | FM 3-04.513, Aircraft Recovery Operations |
| Participate in Personnel Recovery Operations | FM 3-50.1, Army Personnel Recovery |
| Conduct Command and Control Operations | FM 3-04.111, Aviation Brigades |
| Conduct Aerial Sustainment Operations | FM 3-04.111, Aviation Brigades |

*Notes*: ARH = Attack Reconnaissance Helicopter; FM = Field Manual.

# APPENDIX B

# TASK AND SKILL REVIEW WORKSHOP PROTOCOL

# Task and Skill Review Workshop Protocol

*The objective of the review workshop is to present the draft list of the Aviation unit missions, Aircrew coordination tasks, and UAS coordination skills to determine whether the information accurately represents the interactive role of UAS operators in aircrew teaming scenarios. The meeting participants will discuss the questions provided below to develop of a final list of manned and unmanned missions, tasks, and skills.*

***Missions***

1. Are there aviation unit missions that are missing from this list (e.g., missions not covered in Army doctrine)?
2. Are there aviation unit missions that should be removed from this list (e.g., mission is no longer performed in the field)?
3. Are there aviation unit missions that overlap or are the missions independent of each other? If they overlap can the statements be combined into a single mission?
4. Are the aviation unit missions listed valid in terms of actual practice in the field?
5. What future aviation unit missions are required for manned and unmanned teaming?

***Tasks***

6. What aircrew coordination tasks are required for the attack and reconnaissance missions?
7. Are we missing any tasks from this list (e.g., tasks not covered in Army doctrine)?
8. Are there tasks that should be removed from the list (e.g., task does not involve aircrew coordination)?
9. Do the task statements overlap or are they independent of each other? If they overlap can the statements be combined into a single task?
10. Are the task statements listed valid in terms of actual practice in the field?
11. What future tasks will UAS operators need to perform in aircrew coordination teaming?

***Skills***

12. What coordination skills do UAS operators need to perform the tasks?
13. Are we missing any skills from this list (e.g., skills not covered in Army doctrine)?
14. Are there skills that should be removed from the list (e.g., the skill does not aircrew coordination)?
15. Are there skills that should be moved under another task statement?
16. Do the skills overlap or are they independent of each other? If they overlap can the statements be combined into a single skill?
17. What prerequisites are needed prior to training the skills listed?
18. What type of training is currently provided for the skills listed?
19. Are the skills listed valid in terms of actual practice in the field?
20. What are the sequential performance dependencies between the skills?

# APPENDIX C

# PARTICIPANT BACKGROUND FORM

## Manned-Unmanned Teaming Skill Review Workshop
### Participant Background Form

1. **What is your rank**?

   _____

2. **What is your branch assignment**?
   - ☐ Military Intelligence
   - ☐ Aviation
   - ☐ Other_____

3. **When was your last tour operating in a combat zone**?
   - ☐ Within the past three years
   - ☐ Four or more years ago
   - ☐ I have not operated in a combat zone

4. **What type of aircraft did you primarily operate during your last tour**?
   - ☐ Attack Helicopter
   - ☐ Observation Helicopter
   - ☐ Other Helicopter
   - ☐ Heavy UAS (e.g., Predator, Sky Warrior)
   - ☐ Medium UAS (e.g. Shadow, Hunter)
   - ☐ Other UAS
   - ☐ None of the above (specify the system) _____

5. **Mark the system(s) you are currently qualified to operate:**
   - ☐ OH-58D
   - ☐ AH-64D
   - ☐ Other Helicopter Systems
   - ☐ Heavy UAS (e.g., Predator, Sky Warrior)
   - ☐ Medium UAS (e.g. Shadow, Hunter)
   - ☐ Other UAS system_____
   - ☐ None of the above (specify the system) _____

6. **Mark the aviation unit missions you have experience with:**
   - ☐ Attack
   - ☐ Reconnaissance/Security
   - ☐ Communications Relay
   - ☐ Other (please specify) _____

7. **Indicate the area(s) of operations you have experience with:**

_____

# APPENDIX D

# MANNED-UMANNED TEAMING SKILLS REFERENCE INFORMATION

| *Manned-Unmanned Teaming Skills Reference Information* | | | | | |
|---|---|---|---|---|---|
| **Skill** | **Reference and Page Number** | | | | |
| | FM 3-04.155 | FM 34-212. | TC 1-600. | FM 3-04.126 | FM 6-99.2 |
| Conduct call for direct fires | 3-17 | | | | |
| Conduct call for indirect fires | | | A-62 | | |
| Conduct target handover | 3-36 | | | | |
| Deconflict munition trajectories from airframes | B-11 | | | | |
| Develop and send COP information to air-ground team | 3-14 | | | | |
| Find/track targets | 3-28 | | | | |
| Gain and Maintain Enemy Contact | 3-2 | | | | |
| Perform BDA | 3-40 | | | | |
| Prioritize the engagement of targets | 3-27 | | | | |
| Provide accurate description of the target to support selection | 3-36 | | | | |
| Provide confirmation of the target prior to engagement | 3-36 | | | | |
| Provide early warnings, ambush detection, overwatch, threat identification | 3-4 | | | | |
| Provide target description information | 3-36 | | | | |
| Provide the direction of the target in degrees and range from the battle position | 3-36 | | | | |
| Provide the target location | 3-36 | | | | |
| Select the best weapon systems to engage the target | 3-27 | | | | |
| Switch roles of laser designator and missile launch platforms | 3-37 | | | | |
| Transmit imagery, sensor data, tactical situational maps, overlays, and automated reports | 3-3 | | | | |
| Transmit information about the location and direction of the UA as it relates to the target | 3-37 | | | | |
| Transmit information about the location of threat forces, terrain, and obstacles that influence operations | 3-3 | | | | |
| Transmit information about the method attack | 3-36 | | | | |
| Utilize joint, Army, and civilian personnel recovery terminology | | | | 3-89 | |
| Utilize radio communication and signal operating procedures | | | 4-6 | | |
| Utilize standardized execution commands to initiate attack | 3-36 | | | | |
| Utilize standardized report formats | | | | | 39 |

# APPENDIX E

# MANNED-UNMANNED TEAMING SKILL EXECUTION SUB-TASKS AND STANDARDS

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| 1 | **Deconflict munition trajectories from airframes** | **Call for and Adjust Indirect Fires** | • Determine doctrinal, regulatory, or TACSOP requirements for munitions clearance vice aircraft locations.<br>• Visualize where friendly fires will be coming from in relation to their expected targets and friendly aircraft locations.<br>• Confine the aircraft to a specific region.<br>• Utilize the common grid reference system<br>• Notify appropriate contact when potential, or actual, conflicts are detected. | • Aircraft are outside the minimum safety zones for friendly direct and indirect fire trajectories and their impact area when the fire occurs, according to the type of weapons and munitions being fired. |
| 2 | **Utilize standardized execution commands to initiate attack** | **Share Targeting Information** | • Determine the execution commands required for the type of attack.<br>• Issue command IAW TACSOP and appropriate doctrine.<br>• Ensure information complies with Army information standards. | • Shared tactical information with manned aircraft on the method of attack using army aviation concepts, terms and graphics, containing all the required elements of the FRAGO or attack order. |
| 3 | **Transmit information about the method attack (i.e., scheme of maneuver, fire distribution, and maneuver for the attack)** | **Share Targeting Information** | • Determine elements required to share concerning the method of attacking the target.<br>• Prepare an appropriate communications to share the information (FRAGO, call for fire, fire command).<br>• Transmit information.<br>• Ensure information complies with Army information standards. | • Shared tactical information with manned aircraft on the method of attack using army aviation concepts, terms and graphics, containing all the required elements of the FRAGO or attack order. |
| 4 | **Switch roles of laser designator and missile launch platforms** | **Conduct Cooperative Engagements** | • Determine other party to transfer of roles.<br>• Contact party to verify procedures to be used.<br>• Assess the target location, laser designator position, and UA location.<br>• Effect the transfer.<br>• Test the transfer. | • UAS transferred duties of designator or missile launch enabling a timely and effective delivery of munitions. |

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| 5 | **Conduct call for direct fires** | **Conduct Cooperative Engagements** | • Collect information required to call for direct fire.<br>• Determine requirements for a clearance of this type of fire.<br>• Determine who may be available to provide fire.<br>• Deliver a fire request or fire command.<br>• Prepare to support the execution of the fire mission (e.g., spotting, covering movement into position, watching flanks during execution).<br>• Provide informal BDA to firing unit. | • Request for direct fire was tactically sound and rapidly understood, and was IAW TACSOP and current rules of engagement. |
| 6 | **Select the best weapon systems to engage the target (e.g., lethal/nonlethal, munitions effect, collateral damage assessment)** | **Conduct Cooperative Engagements** | • Determine target effects requirements.<br>• Determine risk for collateral damage.<br>• Determine current rules of engagement for this situation.<br>• Recommend weapons system and/or munitions type based on mission and risk assessment.<br>• Prepare information to inform clearance of fires authority.<br>• Respond to requests for more information. | • Weapons selection ensured the required target effect with minimal collateral damage, and IAW current rules of engagement. |
| 7 | **Develop and send common operating picture information to air-ground team** | **Communicate Requirements** | • Determine proper method to post COP-related information.<br>• Maintain fresh COP information.<br>• Follow the TACSOP for COP information procedures and standards.<br>• Verify with other parties that COP information is being shared properly.<br>• Ensure information complies with Army information standards. | • COP-related information sharing was in accordance with tactical communications SOP<br>• Information was complete, accurate, reliable, precise, usable, and timely. |

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| 8 | **Utilize joint, Army, and civilian personnel recovery terminology** | **Communicate Requirements** | • Maintain personnel recovery operations references.<br>• Utilize the PR terminology from FM 3-04.126.<br>• Execute PR battle drill in accordance with doctrine and TACSOP. | • Communication was in accordance with personnel recovery operations TACSOP and JP 3-50. |
| 9 | **Prioritize the engagement of targets** | **Identify Threats** | • Compare identified target to target priority list.<br>• Recognize targets that pose an immediate danger that are not necessarily on the list.<br>• Recognize targets that may have difficulty being engaged by organic weapons systems.<br>• Prioritize actions IAW preceding considerations.<br>• Report target priority and recommendations.<br>• Ensure information complies with Army information standards. | Prioritized identified enemy targets based on:<br>• Target list<br>• Target threat<br>• Ability to engage target with available weapons |
| 10 | **Gain and Maintain Enemy Contact** | **Conduct Aerial Observation** | • Identify enemy.<br>• Maintain visual contact with moving enemy even when changing location.<br>• Provide imagery as required. | • Acquired the intended enemy target(s).<br>• Once acquired, did not lose contact with moving enemy target(s). |
| 11 | **Conduct call for indirect fires** | **Call for and Adjust Indirect Fires** | • Collect information required for a call for indirect fire.<br>• Determine requirements for a clearance of this type of fire.<br>• Complete a fire request.<br>• Determine contact for requesting indirect fires.<br>• Transmit fire request and respond to requests for more information.<br>• Prepare to support the execution of the fire mission.<br>• Acknowledge fire mission receipt. | • Call for indirect fire was IAW TACSOP and FM 3-09.30, enabling a successful fire mission. |

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| **12** | **Transmit information about the location of threat forces, terrain, and obstacles that influence operations** | **Conduct Aerial Observation** | • Recognize threats to mission from enemy, terrain, weather, or other obstacles.<br>• Report threats.<br>• Maintain contact with threat until handover or told to move on.<br>• Ensure information complies with Army information standards. | • Information was provided in the correct format and was complete, clear, accurate, reliable, precise, usable, and timely. |
| **13** | **Conduct target handover** | **Share Targeting Information** | • Provide alert of target handover and description<br>• Establish time and location of handover.<br>• Ensure no gap in target coverage occurs during handover.<br>• Handover target responsibility and information about target (including recent target behavior).<br>• After handover, maintain contact with other party until coverage is firmly established.<br>• Verify that party losing contact is free to depart. | • Target was not lost during the handover of tracking responsibility.<br>• Target was acquired by the receiving party in a timely manner. |
| **14** | **Provide early warnings, ambush detection, overwatch, threat identification** | **Conduct Aerial Observation** | • Reconnoiter the route and terrain.<br>• Find all threats and obstacles that influence movement.<br>• Maintain enemy contact.<br>• Report route and threat information.<br>• Prepare to support friendly reaction to threats. | • Detected and reported enemy anti-air forces before they are able to attack friendly elements. |

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| **15** | **Provide the target location (i.e., direction of target in degrees and range from battle position)** | **Share Targeting Information** | • Determine target location as accurately as possible.<br>• Develop description of target locations if lasing is not reliable due to weather conditions, other obscurations, or range.<br>• Transmit target location relative to UA location.<br>• Ensure information complies with Army information standards. | • Information was provided in the correct format and was complete, clear, accurate, reliable, precise, usable, and timely. |
| **16** | **Provide confirmation of the target prior to engagement** | **Identify Threats** | • Acquire the best target identification picture feasible.<br>• Identify target as actionable, or not.<br>• Relate confidence level of target identification to authorizer of fire.<br>• Respond to requests for more information. | • Identified target as enemy prior to release of munitions. |
| **17** | **Provide the direction of the target in degrees and range from the battle position** | **Call for and Adjust Indirect Fires** | • Determine target location as accurately as possible.<br>• Develop description of target locations if lasing is not reliable due to weather conditions, other obscurations, or range.<br>• Transmit target location relative to UA location.<br>• Ensure information complies with Army information standards. | • Information was provided in the correct format and was complete, clear, accurate, reliable, precise, usable, and timely. |
| **18** | **Transmit imagery, sensor data, tactical situational maps, overlays, and reports (e.g., spot reports)** | **Conduct Aerial Observation** | • Receive and understand requirement to transmit information.<br>• Prepare information in proper formats.<br>• Disseminate/transfer information over proper communications channels.<br>• Ensure information complies with Army information standards. | • Information was provided in the correct format and was complete, clear, accurate, reliable, precise, usable, and timely. |

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| **19** | **Provide accurate description of target to support target selection** | **Identify Threats** | • Gain all information required for target selection standard.<br>• Prepare target report.<br>• Transmit target report.<br>• Respond to requests for more information.<br>• Prepare to support friendly reaction to target report. | Target information contained all the elements required to support target selection:<br>• Type<br>• Identification<br>• Activity<br>• Number<br>• Location |
| **20** | **Utilize standardized radio communication and signal operating procedures** | **Communicate Requirements** | • Utilize radio terminology from DoD Flight Information Publication.<br>• Utilize equipment terminology from operator's manual.<br>• Restrict official transmissions to established communications procedures and terminology.<br>• Police the net when variances are detected. | • Communication was IAW tactical communications SOP and Army aviation doctrine.<br>• Communication did not degrade or delay unit operations |
| **21** | **Perform battle damage assessment** | **Provide BDA** | • Collect required information for BDA reporting.<br>• Complete BDA report.<br>• Send BDA report, and respond to requests for more information.<br>• Ensure information complies with Army information standards. | • BDA report IAW TACSOP and FM 101-5-2, and was clear, accurate, reliable, precise, usable, and timely. |
| **22** | **Find/track targets** | **Identify Threats** | • Recognize target as a high priority target.<br>• Report HPT IAW TACSOP.<br>• Maintain contact with threat until handover or told to move on.<br>• Prepare to support friendly reaction to HPT report. | • Prioritized targets were identified and reported, and UAS did not lose contact with target before handover or mission completion. |

| Criticality Rank | Skill | Task Category | Sub-Tasks | Standard |
|---|---|---|---|---|
| **23** | **Transmit information about the unit of action** | **Conduct Cooperative Engagements** | • Determine UA location relative to target location as accurately as possible.<br>• Develop description of UA relative to the target, with more detail if the UA is not showing on the aviation unit COP.<br>• Transmit UA location relative to target location.<br>• Verify aviation understanding of UA location.<br>• Ensure information complies with Army information standards. | • Aviation unit aircraft were able to determine UA location even if not shown on their COP.<br>• Information was provided in the correct format and was complete, clear, accurate, reliable, precise, usable, and timely. |
| **24** | **Utilize standardized report formats** | **Communicate Requirements** | • Maintain current references for reports from doctrine or TACSOP.<br>• Select appropriate report format for the type of information to be delivered.<br>• Determine proper communications method to transfer reports. | • Communication was in accordance with tactical communications SOP and Army aviation doctrine. |
| **25** | **Provide target description information** | **Share Targeting Information** | • Collect all required information on target.<br>• Complete spot report with information required for target type, specific information requirements, purpose of report, etc.<br>• Transmit report IAW TACSOP.<br>• Ensure information complies with Army information standards. | • Target description contained all required elements for direct or indirect attack, to include for the type of munitions to be fired. |

*Notes:* TACSOP = tactical standard operating procedure; IAW = in accodance with; FRAGO = framentary order; AO = area of operation; COP = common operating picture; SOP = standard operating procedure; BDA = battle damage assessment; HPT = high priority target; UA = unit of action.

# APPENDIX F

# BENCHMARK INDICATORS, CONDITIONS, AND SOURCES FOR MANNED-UNMANNED TEAMING SKILLS

Indicators, Conditions, and Sources for MUM-T Skills Benchmarks
(Presented in training-criticality order)

| | |
|---|---|
| **1. Deconflict munition trajectories from airframes** | |
| ***Indicators*** | Call for fire is complete and accurate |
| | Operator is aware that deconfliction is taking place |
| | Coordinates with ATC for deconfliction |
| | Identifies intersecting munition trajectories and recommends lateral, vertical, or sequential maneuver |
| | Operator is aware of positions of friendly aviation assets |
| | Responds to instructions to deconflict. Moves aircraft to safe area |
| | Confirms when clear |
| | All aircraft are in assigned locations |
| | Air Mission Commander has to redirect the UAS from munition trajectory or impact area |
| | Air Mission Commander has to call a cease fire due to UAS location |
| | Determines if rounds are accurately placed on target |
| | Appropriate graphics are displayed and current |
| ***Conditions*** | Call for Fire missions; own or other unit |
| | Troop suppression |
| | Show of force |
| | Preplanned coordinated attack |
| | Target of opportunity with priority of fires assumed |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Gunnery training |
| | Combat |
| **2. Utilize standardized execution commands to initiate attack** | |
| ***Indicators*** | SPOT reports are complete, accurate, and in correct format |
| | Determines target location and relays appropriately |
| | Uses proper radio procedures IAW TACSOP |
| | Terminology and sequence are IAW current JFIRE publications |
| | Understands commands, expected responses and order of steps |
| | Uses internal Position feedback communication |
| | Gets positive feedback (i.e. closed loop communication) |
| | Fails to identify danger close condition |
| | Fails to assess fratricide or collateral damage |
| | Fails to positively identify the target |
| | Fails to ensure clearance of fires |
| ***Conditions*** | Call for Fire missions; own or other unit |
| | Unit in contact teaming with attack platforms, mortar or FA teams |
| | On identification of a target for engagement |

| | |
|---|---|
| | On receipt of a request for targeting information |

| | |
|---|---|
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Gunnery training |
| | Combat |
| | Table talk discussion |
| | Garrison training |
| | Operation within an ATC command airspace |
| **3. Transmit information about the method of attack** | |
| ***Indicators*** | Transmits appropriate information |
| | Uses secure net properly |
| | Uses JFIRE manual |
| | Updates locations of friendlies and enemy targets |
| | Chooses appropriate scheme of maneuver |
| | Understands formations for mounted/unmounted maneuver (e.g. wedge, bounding overwatch) |
| | Identifies defensive postures and positions |
| | Identifies fire support elements and likely locations |
| | Understands distribution of fires |
| | Follows the appropriate checklist for the munition selected |
| | Provides verbal feedback & acknowledgments |
| ***Conditions*** | Call for Fire missions; own or other unit |
| | Unit in a defensive position and under attack |
| | Offensive operations |
| | MOUT operations |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | MOUT sites |
| | National Training Center |
| | Combat |
| | Table talk discussion |
| **4. Switch roles of laser designator and missile launch platforms** | |
| ***Indicators*** | Understands both designator and shooter roles |
| | Knows weapons limitations and effects |
| | Communicates transfer of responsibilities and confirms |
| | Transmits target location, description, laser code, laser target line |
| | Uses standard execution commands |
| | Clears area of fire, UA and friendly ground forces |
| | Repositions airframe correctly |
| | Confirms LASER code is same as munitions code |
| | Understands LASER designator operation |

| | |
|---|---|
| | Follows launch procedures |
| | Receipt of transfer request |
| | Attack mission |
| | FA teaming if possible beyond Line of Sight firing |
| | Quick reaction to convoy attack |
| | Periodic currency requirements training |
| ***Conditions*** | |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | CAB training event |
| | Convoy operations |
| | Table talk discussion |
| | Combat |
| | Gunnery training |
| **5. Conduct call for direct fires** | |
| ***Indicators*** | Employs correct communication channels |
| | Executes standard Call for Fire commands and makes correct responses |
| | Follows TACSOP |
| | Complies with ROE |
| | Understands both designator and shooter roles |
| | Knows scheme of maneuver |
| | Confirms locations of friendlies |
| | Uses checklists |
| | Meets Safety and employment guidelines |
| | Knows correct clearance of fire authority |
| | Uses risk mitigation procedures |
| | Knows the munitions effects (expected trajectories, burst radius, etc) and safe clearances |
| | Clears area of fire, UA and friendly ground forces |
| | Observes target effects |
| ***Conditions*** | On request for direct fires |
| | FA teaming (live fire) |
| | Infantry mortar platoons teaming |
| ***Sources*** | |
| | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Combat |
| | Classroom |
| | Discussion with manned element (briefing area) |
| | Gunnery training |
| | Counter Insurgency training |

| |
|---|
| During Sergeant's Time training |

| | |
|---|---|
| **6. Select the best weapon systems to engage the target** | |
| ***Indicators*** | Identifies target, enemy locations and friendly locations |
| | Interprets commander's intent |
| | Understands ROE |
| | Understands scheme of maneuver |
| | Understands weapons characteristics limitations |
| | Understands munitions and effects |
| | Correctly matches platforms with weapon systems |
| | Correctly discriminates hardened sites and soft targets |
| | Performs BDA |
| | Evidence of undesired effect on target |
| | Excessive collateral damage |
| | Anticipates re-engagement |
| ***Conditions*** | During engagement scenarios |
| | Tank or FA live fire |
| | Mortar live fire |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Combat |
| | Table |
| | Combat |
| | Gunnery training |
| **7. Develop and send COP information to air-ground team** | |
| ***Indicators*** | Exhibits loss of situational awareness |
| | Determines if new information coincides with or diverges from Air Mission Brief |
| | Relays information to all parties involved |
| | Understands preceding COP |
| | Understands commander's intent |
| | Updates situation frequently |
| | Transmits information IAW TACSOP and checklists |
| ***Conditions*** | Change in scenario or situation |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Combat |
| | Field Training Exercise |
| | National Training Center |
| **8. Utilize joint, Army, and civilian personnel recovery terminology** | |
| ***Indicators*** | Understands COP in relation to PR assets in play |
| | Provides accurate SPOT reports |

| | |
|---|---|
| | Reporting is IAW FM 3-04, 126 |
| ***Conditions*** | Has information about PR for transmission |
| | Receives information about PR |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Combat |
| | Field Training Exercise |
| **9. Prioritize the engagement of targets** | |
| ***Indicators*** | Understands target priority list |
| | Understands commander's intent |
| | Prioritization is IAW commander's intent |
| | Understands friendly scheme of maneuver |
| | Knows threat systems and capabilities |
| | Knows reasons for prioritization of targets (e.g. wind/smoke obscuration) |
| | Understands ROE |
| ***Conditions*** | Encounter with threat |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Combat |
| | Field Training Exercise |
| **10. Gain and Maintain Enemy Contact** | |
| ***Indicators*** | Updates COP promptly |
| | Provides early and accurate threat warning |
| | Communicates contact information |
| | Informs when contact is lost |
| | Demonstrates Area of Operations and Plan of Operations expertise |
| | Uses positive target identification procedure |
| | Able to identify the target, observe what target is doing |
| | Anticipates cover, concealment and terrain masking |
| | Assesses terrain for most likely route of target |
| ***Conditions*** | Reconnaissance missions |
| | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Combat |
| | Field Training Exercise |
| ***Sources*** | |
| **11. Conduct call for indirect fires** | |
| ***Indicators*** | Acknowledges fire mission receipt |
| | Employs closed loop radio procedure |
| | Uses terminology and sequence IAW JFIRE and FM 6-30, IAW TC 1-248 |
| | Coordinates with supporting Fire Support Element |

| | |
|---|---|
| | Knows clearance authority |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Gunnery |
| | Field Training Exercise |
| **12. Transmit information about the location of threat forces, terrain, and obstacles that influence operations** | |
| ***Indicators*** | Transmits SPOT reports in SALT-W format IAW TC 1-248 |
| | Identifies imminent threats to the manned element |
| | Identifies obstacles to maneuver |
| | Knows current Priority Intelligence Requirement |
| | Knows terrain effects on helicopter maneuvering |
| ***Conditions*** | On redirection of helicopter element |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| | Gunnery |
| | Field Training Exercise |
| **13. Conduct target handover** | |
| ***Indicators*** | Proceeds IAW TC 1-248 |
| | Uses 8-line message to redirect, then hand over to helicopter |
| | Correctly reads grid locations |
| | Identifies out of the ordinary behavior or placement of vehicles |
| | Maintains awareness of relative positions and obstacles |
| | Ensures target designator energy is not blocked from helicopter element by terrain or obstacles |
| | Stays on target until handover is complete |
| ***Conditions*** | Target handover or relief on station |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |
| **14. Provide early warnings, ambush detection, overwatch, threat identification** | |
| ***Indicators*** | Identifies out of the ordinary behavior or placement of vehicles |
| | Transmits information sent to the appropriate recipient IAW Air Mission Brief |
| | Interprets Air Mission Brief for the UAS role |
| | Knows what a threat (e.g. ambush) looks like |
| ***Conditions*** | Mission analysis |
| | Encounter with threat, ambush situation |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |

**15. Provide the target location**

| | |
|---|---|
| ***Indicators*** | Positively identifies and locates targets |
| | Sends grid and target identification are sent to the manned system |
| | Provides direction relative to receiver's position |
| | Knows manned asset location |
| | Solicits manned asset location |
| ***Conditions*** | Target detection |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |

**16. Provide confirmation of the target prior to engagement**

| | |
|---|---|
| ***Indicators*** | Uses appropriate method (Spot tracker, LASER, talk-on) to get manned system onto target |
| | Understands ROE |
| | Understands differences among Detect, Recognize, and Identify a target |
| | Uses positive target identification and local SOP |
| | Knows commander's intent |
| ***Conditions*** | Target detection |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |

**18. Transmit imagery, sensor data, tactical situational maps, overlays, and reports**

| | |
|---|---|
| ***Indicators*** | Indicators are covered in the subtasks |
| | Understands the drivers of the requirements |
| | Uses local SOP |
| | Knows current network configuration |
| ***Conditions*** | SR mission |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |

**19. Provide accurate description of target to support target selection**

| | |
|---|---|
| ***Indicators*** | Complies with priority of fires |
| | Uses positive target identificaiton and local SOP |
| | Recognizes combat vehicle systems |
| ***Conditions*** | Target detection |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |

**20. Utilize standardized radio communication and signal operating procedures**

| | |
|---|---|
| ***Indicators*** | Knows application of plain v cipher text |
| | Follows SOP |
| ***Conditions*** | SR mission |
| ***Sources*** | Virtual simulations; AVCATT, PIMS |
| | Live simulations |

*Notes*: ATC = air traffic control; AVCATT = Aviation Combined Arms Tactical Trainer; BDA = battle damage assessment; CAB = combat aviation brigade; COP = common operating picture; FA = field artillery; FM = Field Mannual; IAW = in accordance with; JFIRE = joint application of firepower; MOUT = military operations in urban terrain; PIMS = Portable Institutional Mission Simulator; PR = personnel recovery; SALT-W= size, activity, location, time, and what you wil do; SR = scout-reconnaissance; TC = Training Circular; UA = unit of action.

# APPENDIX G

# COMMENTS BY SUBJECT MATTER EXPERTS ON FIVE MANNED-UNMANNED TEAMING SKILLS

| Manned-Unmanned Teaming Skills Rank Ordered on Training Criticality Index |
|---|
| **1. Deconflict munition trajectories from airframes** |
| Past experience has been that all communications were relayed from the GCS to the manned element unit tactical operations center and then to manned element operators. |
| Mission planning by the team is not currently practiced. It may be written in the TACSOP. There are essentially no preplanned MUM-T missions |
| The disparity in mission endurance between manned (~2 hrs) and unmanned (6-8 hrs) systems requires accommodation in mission planning and execution. The UAS may team with three different helicopter missions in one flight. |
| Manned and unmanned components presently have different TACSOPs. |
| **3.Transmit information about method of attack** |
| Failure to properly position the UAS may prevent the manned platform from engaging a target. |
| All units participating will require common standard operating procedure/policies for proper coordination. |
| Checklists for munitions should be present in hard-copy. It would be better to put on system displays. |
| Fragmentary Orders arrive in the GCS by chat, e-mail, or voice. |
| **7. Develop and send Common Operating Picture information to air-ground team.** |
| Introduction of enhancements to the UAS mission package (e.g. Synthetic Aperture Radar) will have a large impact on this. |
| **18. Transmit imagery, sensor data, tactical situational maps, overlays, and reports** |
| The MUM-T team needs complete digital communications |
| The MUM-T team elements need Command, Control, Communications, Computers, and Intelligence in order to properly use Force XXI Battle Command Brigade and Below, Blue Force Tracker, Advanced Field Artillery Tactical Data System, and other tools. |
| **19. Provide accurate description of target to support target selection** |
| Recognition of Combat Vehicles course should be an annual requirement. |

*Notes*: GCS = Ground Control Station; MUM-T = manned-unmanned teaming; TACSOP = tactical standard operating procedure.