What are the Most Critical Skills for Manned-Unmanned Teaming?

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ABSTRACT

With the transfer of U.S. Army unmanned aircraft systems (UAS) from Military Intelligence to the Aviation Branch in 2003, the role of UAS changed from intelligence gathering to scout-reconnaissance (SR). SR requires close coordination between UAS and manned aircraft, necessitating that UAS operators acquire new communication and coordination skills. The objective of this research was to (a) identify manned-unmanned teaming (MUM-T) skills required for UAS operators, (b) define/prioritize training-critical MUM-T skills, and (c) determine benchmarks for assessing MUM-T performance for RQ-7B Shadow and other Army UAS. We first reviewed Army doctrinal material and regulations to identify (a) missions in which UAS operators must coordinate with helicopter pilots, (b) tasks required to perform these missions, and (c) UAS operator skills required to execute these tasks. Results of the review and analyses were confirmed by subject matter experts (SME), comprising senior Army UAS operators, SR helicopter pilots, and doctrine developers. SMEs identified training-critical SR skills for which (a) inadequate performance would jeopardize the mission, and (b) UAS operators graduating advanced individual training (AIT) performed poorly. Skills were rated for performance and training criticality, for attack and SR missions. Ratings were rank ordered for 25 skills critical to SR mission success. Perceived current performance levels varied greatly, indicating that many skills were not addressed in AIT, while others were adequately trained. Next, SMEs from manned and UAS communities proposed performance indicators for 20 of these skills deemed most relevant to MUM-T. For these skills a total of 140 prototype indicators were identified. Future research will refine these indicators into valid, reliable, and usable benchmark performance measures to assess proficiencies of UAS operators on MUM-T skills. These findings were briefed to project sponsors for UAS and Reconnaissance-Attack, for use in pinpointing the most critical MUM-T skills to train UAS operators.

ABOUT THE AUTHORS

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INTRODUCTION

In 2002, the Army, Air Force, Navy, and Marine Corps operated a total of 167 unmanned aircraft systems (UAS) of all types. Today, the Army alone has over 4,000 UAS and has amassed more than one million operational flight hours (U.S. Army UAS Center of Excellence, 2010). In 2003, the mission of developing and employing UAS passed from the U.S. Army Military Intelligence (MI) branch to the Aviation branch. The focus changed from strategic intelligence, surveillance, and reconnaissance (ISR) to tactical scout-reconnaissance (SR). This transition sought to integrate UAS more centrally into Army aviation operations. To accomplish this objective, the concept of manned-unmanned teaming (MUM-T) has emerged, in which manned and unmanned aircraft must coordinate to execute tactical missions. The challenge of MUM-T is to train UAS operators, whose Advanced Individual Training (AIT) was primarily MI, to execute those aviation SR mission tasks previously performed by aircrews of OH-58D and AH-64D helicopters (Department of the Army, 2007). This challenge is formidable when one notes that the respective roles of the manned and unmanned team players are as yet not well defined.

The tactics, techniques, and procedures for MUM-T can be traced to Task Force ODIN (observe, detect, identify, neutralize). ODIN was initiated in 2006 as a counter-improvised explosive device program, using modified MQ-1 Predator UAS and AH-64D Apache helicopters. At its core was the creation of linkages between sensors (UAS) and shooters (armed helicopters). UAS operators, because of higher operating altitude and longer endurance, can acquire target information and report the tactical situation to the shooter. This allows the shooter to stand off at a more covert location, and attack the target undetected; in some cases the shooter can attack the target without seeing it.

As MUM-T coordination becomes more critical to the missions conducted by UAS, it should substantially impact UAS operator training. Recent research by Stewart, Bink, Barker, Tremlett, & Price (2011) investigated the extent to which RQ-7B Shadow operators were trained to execute tactical SR missions. The RQ-7B is currently the Army's most numerous UAS. (MUM-T is not restricted to one platform, and applies also to the MQ-5B and especially the MQ-1C multi role UAS). Stewart, et al. found that RQ-7B AIT at the schoolhouse at Ft. Huachuca, AZ, focused primarily on ISR rather than SR functions. Tactical training for RQ-7B operators was minimal and mostly classroom-based. Furthermore, for a number of reasons, including airspace restrictions and resource limitations, unit level SR training was severely limited. The UAS operators had to wait until deployed in theater, and then acquire these skills on the job. Although some opportunities for tactical SR training were possible at the Combat Training Centers, (CTC) structured interviews with training personnel at the Joint Readiness Training Center (Stewart, Barker, & Bink, 2010) revealed that (a) the focus of the mission was ISR, and (b), SR mission-relevant performance benchmarks were not used for UAS.

Tactical SR mission performance by UAS crews is the cornerstone for successful MUM-T operations. For example, the UAS aircrew must actively search for, locate and identify the target, report target information to an armed helicopter, laser-designate and/or hand off the target to the helicopter. How these specific MUM-T skills are identified and classified will impact future training of UAS operators. By contrast, ISR operations typically entail being dispatched to a pre-determined area, where the UAS loiters, observing and reporting potential threats in that area. Particular skills are required by both team members to execute MUM-T tasks successfully. However, because MUM-T is relatively new, little is known about what these specific skills are, or the most effective and efficient ways to train them.

Technical Objectives

The UAS transition from MI to Aviation presents human performance and training challenges for UAS operators at both institutional and unit levels. The objective of this research effort is to: (a) identify MUM-T coordination skills required for UAS operators, (b) define and prioritize those skills that are the most critical to mission performance, (c) develop prototype performance indicators for these MUM-T skills in order to develop metrics and criteria for training.

METHOD

This research, under direction of the US Army Research Institute for the Behavioral and Social Sciences (ARI) began with a review of Army doctrinal material and regulations, other Army documents, and other doctrinal sources, to identify (a) SR and attack missions in which UAS operators would need to coordinate/communicate with helicopter pilots, (b) specific tasks required to perform these missions in which UAS and helicopters must interact, and (c) skills involved in executing these tasks. The current methodology has some similarities to the Air Force Research Laboratory's Mission Essential Competencies (MEC) approach (Colegrove & Bennett, 2006), though it is not a derivative of MEC.

Following the initial review, we convened and facilitated three workshops (i.e., focus groups). Each 3-4 hr workshop elicited knowledge of subject matter experts (SME) including UAS operators, pilots, and doctrine developers, regarding MUM-T skills required for successful performance of SR and attack missions.
Workshop 1 reviewed and confirmed the tasks and skills we had identified in the written documentation. Workshop 2 examined these skills to determine their training criticality, which was defined by two attributes: (a) inadequate performance would likely lead to mission failure or risk to personnel and equipment, and (b) UAS operators recently graduated from AIT did not possess these skills. Ratings on these dimensions by SMEs were used to prioritize the skills by training criticality. Workshop 3 identified performance indicators for these skills, processes and events underlying their performance, situations where these indicators could be observed, and locations where the processes and events may take place.

WORKSHOP 1: TASK AND SKILL REVIEW

Overview

Workshop 1 was conducted to obtain feedback from UAS operators, helicopter pilots, and training and doctrine experts on the draft missions, tasks and skills that were produced by our document review. A focus group of eight SMEs reviewed, revised and edited the draft skills list to ensure that the skills proposed were actually required. The focus group was also asked to identify any additional MUM-T skills, to minimize overlap between skills descriptions, and to discuss sequential dependencies among skills.

Participants

Eight SMEs, six of whom were active duty military personnel, were recruited from various staff positions at the U.S. Army Aviation Center of Excellence (USAACE), Fort Rucker, AL. Four were doctrine developers, two were UAS training developers, and two were senior UAS instructor-operators. All six military personnel had completed a tour in a combat zone (including Iraq) in the previous three years. Four were UAS operators qualified in medium UAS (MQ-5B Hunter, RQ-7B Shadow). The remaining two were pilots rated in the OH-58D Kiowa Warrior armed scout helicopter. Five reported experience with reconnaissance and security missions; one pilot had additional experience with attack helicopter operations. For all three workshops, participants completed Consent and Participant Background Forms, as required by ARI Institutional Review Board protocol.

Procedure

Workshop 1 began with an overview of the project. After the purpose of the workshop was described, discussion turned to items on the list of missions, tasks, and skills. SMEs were asked whether any of the items should be added or removed from the list, and whether the obtained skills were valid as to actual practice in the field. SMEs were also asked whether any future missions, tasks, or skills should be considered in this research, whether any of the skills were prerequisites for others, and about sequential dependencies between them. Participants made additions and deletions to the list of skills. They reviewed and edited terminology used by the authors and provided all other requested information.

Results

SMEs did not recommend any changes to the list of missions but did recommend several changes to the skills and some minor changes to the tasks. Changes varied from relatively minor changes in wording of a task or skill statement to major changes in which skills were added, deleted or combined. The most important of the added skills was *deconflict munition trajectories from airframes* to the task: *call for and adjust indirect fires*. The scope of the task: *identify threats to aerial maneuver* was changed to *identify threats to maneuver* since the UAS operator would be required to identify threats to ground maneuver as well. The skill: *call for indirect fires* was removed from the *cooperative* *engagement* task because it was judged inappropriate to that task. SMEs also refined and clarified terms in task and skill statements. A total of 25 coordination skills were identified as required by UAS operators for MUM-T.

WORKSHOP 2: SKILL CRITICALITY

Overview

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 increase risk to personnel and equipment. Training criticality variables were assessed as a function of the current training system and expected performance at completion of AIT. Criticality reflects the need for additional training beyond what is currently provided. If the skill is trained sufficiently well, so that UAS operators and pilots can execute the mission successfully, then training criticality for that skill is low, regardless of its importance to mission success or potential consequences of poor performance. For those skills not trained at AIT or covered superficially, importance of the skill to the mission and risks of poor performance have greater impact on the overall determination of criticality. In this phase of the research, a group of experienced UAS operators and scout-attack helicopter pilots individually rated each of the skills on four variables related to training criticality, as well as resources required to train each skill. Though the original intent had been to employ the same focus group format as Workshop 1, scheduling and logistical difficulties necessitated obtaining the ratings individually.

Participants

A total of 23 SMEs, including 18 UAS operators and five pilots of scout and attack helicopters, provided ratings of criticality for the 25 skills. All but two raters had completed at least one combat tour within the past three years, mostly in Iraq and Afghanistan. All raters had executed reconnaissance/security missions; 17 had performed communications/relay missions; 11, attack missions. All 18 UAS operators were qualified in medium UAS (MQ-5B, RQ-7B). Five were also qualified in heavy UAS (MQ-1C Gray Eagle). All five pilots were rated in the OH-58D armed scout helicopter.

Procedure

Assessment of training criticality was based on the Task and Training Requirements Analysis methodology (Swezey, Owens, Bergondy, & Salas, 1998), with some modifications. Namely, an assessment of the resources required to train each skill was added to the overall set of rating criteria. Training criticality was assessed using the following four rating criteria:

Performance level. The rationale for performance level was based on a rating system developed by Campbell, et al. (1990). Raters are asked to consider 10 typical UAS operators who have just completed AIT. For each of the 25 skills, raters were asked to allocate the UAS operators among five proficiency categories ranging from a low of 1 (**virtually never** perform the skill effectively) to 5 (perform the skill effectively **all of the time**). The mean (*M)* category to which Soldiers are assigned represents the average skill level for any given task. Standard deviation (*SD*) of the allocated responses represents the performance variability of the skills. Maximum variability is 2.0 when five Soldiers are assigned to the lowest category and the remaining five to the highest; lowest is 0 when all are assigned to the same category.

Consequences of lack of skill to attack missions (C_A). Raters indicated the extent to which lack of each skill was important to the success of attack missions. Responses were on a 5-point scale ranging from 1 (low importance) to 5 (high importance).

Consequences of lack of skill to scout-reconnaissance missions (C_R). Using the same approach, raters were asked to indicate the importance of poor performance on each skill to scout-reconnaissance missions.

Consequences of lack of skill to personnel and equipment (C_{PE}). Raters were asked to indicate the extent to which poor performance on each skill would significantly impact risks to personnel and equipment. Like the previous examples, a 5-point scale was used, ranging from 1: Low (lack of skill unlikely to increase risks to personnel and equipment) to 2: High (lack of skill would most likely produce a serious increase in risks to personnel and equipment).

Training resources. Although not directly part of the training criticality measure, raters were asked to indicate the level of resources required to train a UAS operator to perform each skill effectively. This rating variable was included because resources for training are often limited and must be allocated to the most critical tasks. Having an estimate of resources required would allow calculation of the ratio of training criticality to resources, which could provide a useful guide for specifying how resources should be allocated to address the most critical tasks within a constrained budget. Each skill was rated in terms of amount of time, personnel, and/or equipment required for training it. A 5-point scale ranging from 1: Low (skill requires minimal training time and little or no use of personnel or equipment to achieve an effective performance level) to 5: High (Skill requires extensive training time, personnel, and equipment to achieve an effective performance level).

Training Criticality Index

The aggregate ratings were combined into the Training Criticality Index (TCI). First, the TCI included an additive combination of the ratings on the three consequences of each skill (to attack and scout-reconnaissance missions, and to personnel and equipment). Because of a lack of empirical data on the relative weights of these variables as to training criticality, the three were equally weighted. Second, the TCI included a multiplicative combination of performance level x aggregated consequences. The rationale for this is if all Soldiers perform a skill adequately, then criticality is low, because no additional training is required. As performance decreases, the importance of consequences of lack of skill increases correspondently. A TCI having the above properties is given in the following equation:

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

Where PL is performance level (5-pt scale), $C_{A,}$ $C_{R,}$ and C_{PE} are consequences of lack of skill for the two missions, and for personnel and equipment (scale = 1 to 5). This function has a minimum value of 0 when either of the two factors is 0, and a maximum value of 60 when performance is minimal and consequences are maximal. Simply stated, the two multiplicative terms represent performance, and the potential impact of poor performance on missions, personnel, and equipment.

Participants rated each of the 25 skills on all of these criteria. Ratings were conducted using a Microsoft Excel spreadsheet, which provided feedback to the rater to ensure that they properly rated each skill on each variable. Participants rated all skills for one variable, and then proceeded to the next until all assessments were completed for all 25 mission skills.

Results

Training Criticality Measures

Table 1 shows the skills ordered by their value on the TCI. Because the mean performance level varies more than the three criticality measures (C_A, C_R, C_{PE}) it is not surprising that the most training-critical skills are the ones in which performance is the lowest. Examination of the most training-critical skills shows that nearly all of them focus on tactical activities required for SR and attack missions. Skills at the bottom of the list (e.g., *provide target description information*) had low training-criticality ratings despite their high importance. These are ISR skills which UAS operators graduating from AIT already know well. For example, participants indicated that 90% of new UAS operators should be able to provide target description information.

For the 25 skills, the lowest mean performance rating was for *deconflict munition trajectories from airframe* (M = 1.91, SD = .09), indicating that new UAS operators virtually never performed the skill correctly, and highest for *provide target description information* (M = 4.26, SD = .26), indicating that most new operators could perform the skill all or most of the time. Because rated performance is already so high for this important skill, it follows that it is not critical to provide additional training on it. Eight of the 25 skills had performance ratings less than 2.0, indicating that most UAS operators graduating AIT performed these skills incorrectly all or most of the time. The average of these values over raters indicated that skills varied greatly in rated performance. Within each individual skill, variability in rated performance was low, indicating that raters tended to place most of the 10 hypothetical UAS operators in the same or adjacent categories. This low variability within skill may indicate also that most UAS operators receive the same level of training at AIT, and that there were few differences in on-the-job performance that would distinguish them.

Overall, criticality ratings (5 pt. scale) indicated that all 25 skills were judged to be at least moderately important to attack (M = 3.89, SD = .52), and SR (M = 3.87, SD = .55) missions, and to present moderate to serious risks to personnel and equipment if performed

Table 1. Training Criticality Index (TCI) Ratings of 25 MUM-T Skills (Ranked)

TCI	Skill Description
38.9	1. Deconflict munition trajectories from airframe
34.7	2. Utilize standard execution commands to initiate attack
34.4	3. Transmit information about method of attack (scheme of maneuver, fire distribution, maneuver for attack)
33.8	4. Switch roles of laser designator and missile launch platforms
33.6	5. Conduct call for direct fires
33.3	6. Select best weapon system to engage target
32.2	7. Develop, send common operating picture information to air-ground team
31.3	8. Utilize joint, Army, civilian personnel recovery terminology
30.9	9. Prioritize engagement of targets
28.5	10. Gain/maintain enemy contact
28.0	11. Conduct call for indirect fires
25.4	12. Transmit information about location of threat forces, terrain, and obstacles that influence operations
24.7	13. Conduct target handover
24.0	14. Provide early warning, ambush detection, overwatch, threat identification
20.7	15. Provide target location (direction of target in degrees and range from battle position)
19.8	16. Provide confirmation of target prior to engagement
19.6	17. Provide direction of target in degrees and range from battle position
17.8	18. Transmit imagery, sensor data, tactical situation maps, overlays, reports (e.g., spot reports)
16.5	19. Provide accurate description of target to support target selection
15.1	20. Utilize standardized radio communication and signal operating procedures
14.5	21. Perform battle damage assessment (BDA)
13.9	22. Find, track targets
11.0	23. Transmit direction and location of unit of action in relation to target.
10.9	24. Utilize standardized report formats
9.5	25. Provide target description information

incorrectly (M = 3.82, SD = .41). Mean rating for training resource requirements was 3.38 (SD = .30). Despite the low variability of this measure relative to the other measures of criticality, it is possible that this variable could be used to identify those skills with mean resource requirements less than 3.0 that could be trained using a relatively modest amount of resources (in the present example, *perform battle damage assessment* M = 2.78).

WORKSHOP 3: BENCHMARK INDICATORS

Overview

A benchmark is 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, prime emphasis on benchmarks is for determining minimum competence, and secondarily, for instructional feedback. Therefore benchmarks can be indicators of competent and non-competent performance, as well as instructional tools.

Participants

Participants were recruited from Army Aviation staff positions and from senior NCO training courses at USAACE. 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 session, five pilots, all OH-58D qualified, took part. All had operated in combat zones (primarily Iraq) in the past three years. All had experience in reconnaissance/security missions. Two had experience in attack missions, one in communications/relay missions. Most had some MUM-T experience. In the second workshop seven UAS operators participated. All were qualified on medium UAS; one on heavy UAS. All had operated in combat zones, including Iraq, in the past three years. All had experience in reconnaissance-security missions, three in attack missions, and two in communications/relay missions. Most had some experience in MUM-T operations.

Procedure

Each workshop was conducted in two phases. In the first phase, participants produced brief written responses on printed forms, in order to focus their attention on the relevant issues and to organize their thoughts, so as to promote constructive discussion. In the second phase they discussed, as a group, their responses, made comparisons and contrasts, and adjusted their descriptions to attain consensus.

The list of 25 prioritized skills (Table 1) was presented to the participants. Each skill statement was also associated with a task category, a set of subtasks and performance standards, identified in Workshop 1 (see Table 2). Participants were also presented with a list of the skills with blank areas for indicators, conditions, and sources. *Indicators* are observable behaviors associated with varying levels of proficiency for a given skill; *conditions* are observable events and processes within a training event signaling the likelihood that a particular skill is being observed; *sources* are the locations (e.g., simulator, field exercise) where the observation can be made. In Phase I, participants were asked to review the skills list and enter responses in the blank areas provided. When participants had completed as many of the forms as they thought reasonable, Phase II was initiated. They used the 25 skills and their written responses as a basis to exchange ideas and opinions regarding the indicators, conditions, and sources, for each skill. This phase was moderated by a workshop facilitator who took notes of the group input.

Results

Written responses from all participants, along with facilitator's notes, were consolidated into a spreadsheet. One participant entered nothing on the written form but contributed extensively to the group discussions. The spreadsheet was reviewed to eliminate responses for performance indicators deemed unlikely to be measurable (e.g., *lack of confidence*) or vague (*uses good decision making ability*). For each skill statement duplicate responses and tangential content were removed. Responses for indicators were rewritten as active voice action statements (e.g., for *deconflict munition trajectories from airframe*: *confirms when clear*); responses for conditions and sources that did not fall within the operational definitions were eliminated.

Both groups of participants agreed that most behavioral indicators of the 25 skills could be derived from the subtask statements in the provided list. Pilots agreed that skills 17 and 22-25 from the prioritized skills list (Table 1) were redundant with other skills. Similarly, UAS respondents agreed that skills 17, 21, and 25 were redundant and 22, 23, and 24 unimportant with respect to MUM-T. For example, skill 23, (*transmit location and direction of unit of action as it relates to target*) had only one indicator identified: *know own position relative to target.* This is an individual skill, as all relevant data are available to the UAS operators from sensor displays and maps in the UAS ground control station. Skills 19, 24, and 25 were identified by pilots as holdovers from UAS ISR surveillance missions but not relevant to the contemporary SR role. On the basis of independent consensus of participant SMEs from both manned and UAS communities, skills 17 and 22-25 were excluded from further analysis.

Summary of Workshop 3

Workshop 3 resulted in the reduction of the skills list from 25 to 20, after skills determined to be redundant with other skills were eliminated. A final set of 140 prototypes for behavioral indicators for MUM-T were generated by the focus groups. These indicators are not necessarily unique to a single skill statement; there are 41 unique responses for conditions (events observed) and 80 unique responses for sources (location where the Indicators can be observed, such as simulator or live exercise). It should also be emphasized that these are *prototype* measures which must undergo refinement through field research before they can be used routinely in training environments. For example, the cognitive indicator (e.g., *is aware*) is inferred from more overt behaviors relevant to a particular task.

Table 2 simplifies the conceptual relationships among task, skill, subtasks, and the behavioral and knowledge-based attributes that enable a particular task to be performed correctly. The example used was one of the 25 skills deemed critical by SMEs who participated in this research effort. There was some tendency on the part of participants to confuse the use of the term conditions in the context of performance indicators with the term used in Army doctrine in relation to tasks and performance standards.

Table 2 shows that the overarching task category is *identify threats*, and that the focus is on one specific underlying skill, *prioritize engagement of targets*. In order to perform this skill, five subtasks must be executed successfully, to the standard listed in the last column. The second row shows how behavioral indicators of successful performance of the skill are observed (e g., in live and virtual simulations), and the cognitive and behavioral foundations for the indicators themselves (e.g., prioritizes targets, demonstrates knowledge of threat, understands rules of engagement). It is evident in this example, that the performance criteria are largely cognitive and procedural, suggesting that these could probably be trained using low-cost simulators and other training devices such as PC -based hand held tablet devices and part-task trainers.

Table 2. Relationships between Task, Skill, Subtasks, and Performance Indicators

Task Category	Skill	Condition	Subtasks	Standard
Identify Threats	Prioritize engagement of targets	Given a UAS teamed with an attack or armed recon helicopter platoon, and area of operations containing enemy targets.	Compare identified target to target priority list; Recognize targets that pose immediate danger that are not necessarily on list; Recognize targets that may be difficult to engage; Prioritize targets, based on above Considerations; Report target priority & recommendations.	Prioritized identified enemy targets based on: Target list; Target threat; Ability to engage target with weapon.
Performance Indicators				
Sources		**Indicators**		
Virtual simulations, live simulations, combat, field exercises.		Understands target priority list, Understands commander's intent, Prioritizes targets based on commander's intent, understands friendly scheme of maneuver, demonstrates knowledge of threat systems and capabilities, demonstrates basis for prioritization of targets (e.g., wind, smoke, and obscuration); understands rules of engagement.		

DISCUSSION

Findings

MUM-T doctrine and tactics are evolving, presenting a challenge to the identification of appropriate skills for these complex team operations. Given the concern that the latest MUM-T doctrine may not be completely documented, it was noteworthy that the SMEs who participated in Workshop 1 saw the list of 25 critical skills as adequate and within the ambit of current doctrine. Thus, the objective of identifying skills for MUM-T was met. One important lesson learned from this research effort was that in current Army doctrinal thinking, MUM-T operations will be aircraft-to-aircraft, voice-only instead of involving a Tactical Operations Center as an intermediary.

Workshop 2 successfully met the second research objective of deriving a list of MUM-T skills prioritized as to training criticality. Criticality of skills for training (importance as to team proficiency and consequences of substandard performance) was determined by a set of internally-consistent ratings derived for the same list of skills identified in Workshop 1. In Workshop 2, it became apparent that many SR and attack pilots did not know the extent of training that UAS operators received at the schoolhouse. This corroborates other ARI research that indicates that (a) UAS operators are not well-prepared for SR operations on completion of AIT, and (b) despite the imminence of MUM-T in the near future manned and unmanned aviation communities are not sufficiently integrated.

Workshop 3 generated an extensive list of prototype indicators for MUM-T. These are prototypical in the sense that they are not as yet used systematically to assess performance in MUM-T operations, and will require refinement and pretesting before a set of usable measures can be fielded. It is likely that eventually many of these indicators could be used in structured virtual and live training environments, but this would require detailed investigation of the data and recording capabilities of simulators and other training devices as well as the development of usable assessment materials for trained observers to use during live training exercises.

Implications

As indicated by the training criticality assessments, incorporation of UAS into SR missions has added new skills that are not currently trained as part of AIT. These new skills require a more active role for the UAS operator than in past ISR missions, which consisted more of surveillance than scouting. The term: *developing the situation* is often employed to represent many of the communicating and coordinating behaviors identified in Workshop 3, including target identification and attribution of target intent. This will require extensive new learning of cognitive and procedural skills on an individual level in order for the UAS crew to become a player in MUM-T, as opposed to a passive facilitator who provides overhead sensor feed to a ground-based operations center. The skills list and corresponding indicators obtained in the present research effort, though prototypes, will prove beneficial guides to determining and prioritizing those cognitive and procedural skills that must be trained in order for UAS operators to acquire the necessary skills to perform as team members alongside manned helicopters. 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 and other UAS. The 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. In addition, since the RQ-7B has substantially greater endurance than a manned helicopter such as the OH-58D and AH-64D, the UAS crew will often be required to take initiative in identifying and reporting a target, to an armed helicopter that is joining the UAS in a MUM-T operation.

UAS operators must learn procedures and techniques that were previously executed by manned SR and attack helicopter crews, such as laser designation of targets for precision-guided munitions. They must also learn the laser exclusion zones in which the munitions (e.g., Hellfire missile) cannot effectively lock on to the target. These skills are not taught at the schoolhouse, and must typically be acquired on the job in theater.

MUM-T skills are communication-dependent, and require mastery of a standard aviation nomenclature for target location, reporting and designation by UAS crews. As doctrine specific to reconnaissance-attack and UAS communities becomes more closely coordinated, the differences in perspective identified by Stewart, Roberts, and Bink (2012) will be reduced. This transition to MUM-T will be easier for those RQ-7B crews assigned to the new Full-Spectrum Combat Aviation Brigades, (FSCAB) which will have an Air Cavalry Squadron combining OH-58Ds and RQ-7Bs, than to those assigned to ground Brigade Combat Teams, where there is minimal face-to-face contact between helicopter and UAS crews. By contrast, the FSCAB MUM-T members will be able to participate fully in the mission planning process so critical to successful MUM-T operations.

Finally, it should be noted that the critical skills that were identified and prioritized in the present research effort are to a large degree platform-independent. SR operations are based upon time-honored U.S. Army Cavalry scouting doctrine and tactics that were in use prior to the invention of the aircraft. Thus, many of these skills would be applicable to the new generation of ground-based unmanned reconnaissance systems that perform the role previously performed by the Army ground scout or pathfinder.

This research effort has implications beyond UAS and military aviation, including many situations that involve merging and/or restructuring complex work organizations to meet changing technological, economic, or environmental demands. One challenge is the assimilation of individuals from different organizations or departments who have learned different habits and internalized different values of how things are to be done. In short, not only must jobs be redesigned and new and different skills acquired, but two different groups, who have had little contact with one another must accommodate to a new organizational climate and culture. Training new skills is only one facet of the complicated picture of organizational socialization. Stewart, et al. (2012), in a survey of 65 members of the manned and UAS Army aviation communities, found the perspectives of both groups to be quite different with regard to the perceived capabilities of UAS to perform SR missions, as well as what specific missions were appropriate for UAS. These differences in perspective were attributed largely to the historical separation of manned and unmanned aviation communities, as well as to the different organizational cultures of Army MI and Aviation. Even though both UAS and manned communities agreed overall that MUM-T operations would soon dominate aviation tactical operations, consensus was lower on the relative status and importance of UAS as a partner in MUM-T. These results reinforce the notion that organizational culture changes slowly, and that direct contact and joint training are necessary for building and integrating teams.

Recommendations

This research effort has provided some insights into the skills underlying MUM-T as well as preliminary notions on how performance on these skills can be measured. It has also provided actionable guidance that will impact the training and performance of MUM-T skills. The research pinpointed critical weaknesses in current UAS operator training that pose potential obstacles to effective integration of UAS crews into MUM-T. The research also identified those skills that are already well trained and do not require additional training time or resources. It produced a set of prototype indicators which will later provide a rationale for the development of usable performance measures for MUM-T for trainers and unit commanders in virtual exercises. Examples would be the Brigade-level Aviation Training Exercises (ATX), conducted at Ft. Rucker, AL, in which units train in realistic, shared virtual environments prior to deployment, and live training exercises conducted at home station and at the CTCs. The importance of performance measure development is paramount; without objective, reliable and valid metrics, it is impossible to assess the effectiveness of any training system, let alone training outcomes for a particular set of tasks and skills. Consequently the next step is to refine pretest and validate performance measures derived from the indicators. Once usable performance measures are developed, it will be necessary to determine where and how the identified critical skills will be trained. Much of this training will have to take place in virtual, networked training environments. As the Army stands up more FSCABs, MUM-T should become more integral to ATX than it is at present. This is important because previously, UAS aircrews have not participated in ATX. Valuable opportunities to learn the aviation SR roles, and the organizational culture of Army aviation, were missed. Also crucial is the need for UAS and manned aircrews to "live in the same world" of tactical aviation. This should include joint training of UAS and manned aircrews beginning at the Combat Skills phase of Initial Entry Rotary-Wing training at Ft. Rucker, where UAS and manned students could acquire and practice the mission-planning skills so vital to successful execution of MUM-T missions. The results of this research were briefed to the Training and Doctrine Command Capability Managers (TCM) for UAS and Reconnaissance-Attack, on February 10, 2012.

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