Developing a Tactical Communications Training Environment

Kevin Sullivan, Susan R. Flaherty, Michael Knapp
Aptima
Woburn, MA
ksullivan@aptima.com, sflaherty@aptima.com, mknapp@aptima.com

Kevin Elfenbein
Advanced Simulation Technology Inc.
Herndon, VA
kevin.elfenbein@asti-usa.com

Troy Zeidman
Imprimis, Inc.
Huntsville, AL
troy.zeidman@imprimis-inc.com

Scott Graham
U.S. Army Research Institute
Fort Benning, GA
scott.e.graham.civ@mail.mil

ABSTRACT

U.S. Army Aviation organically teams rotary wing aircraft with Unmanned Aircraft Systems (UAS) as a force multiplier in combat operations. Clear and effective communications between the teamed airborne helicopter pilot and the UAS operator in the ground control station are critical for mission success. Current Army flight training for pilots vs. UAS operators reveals differences in the time spent on reconnaissance, surveillance, and target acquisition (RSTA) skills, contributing to variance in tactical communication proficiencies. Previous studies have recommended additional training in tactical communications for the UAS sensor operator in order to support communications accuracy, protocol adherence, and measured timeliness in teaming engagements.

This paper describes the architecture, development challenges, and usability assessment for a single player, browser-based game designed for UAS sensor operators to practice manned-unmanned team (MUM-T) communications skills. Speech recognition features utilizing natural language processing and communications performance measurement were developed. Real-time audio feedback was provided to soldiers during communications with virtual game entities. Access to remediation and cumulative performance scoring was available via after action reviews (AARs).

The training system is comprised of the following key elements: a UAS simulation platform, commercial speech recognition, natural language parsing system, human performance measurement system, communications performance measures, and UAS mission scenarios. Challenges addressed in this project include: management of the dialog state vs. scenario context between the trainee and synthetic entities during speech recognition; design and implementation of communications measures based on pattern and vocabulary matching synchronized to simulation events; and the development of context sensitive feedback to guide the trainee based on measurement results.

An initial user assessment was conducted at Ft. Huachuca AZ with eight Advanced Individual Training soldiers and qualified UAS course instructors. Subjective ratings related to usability and game applicability were collected. Preliminary results suggest perceived benefit from gameplay supplementing current methods of instruction.

ABOUT THE AUTHORS

Kevin Sullivan is Vice President of Engineering at Aptima. Mr. Sullivan has developed numerous software products contributing to the fields of computer-aided design, artificial intelligence, training, and simulation. Mr. Sullivan holds a M.S. in Computer Science from Boston University and a B.S. from the Massachusetts Institute of Technology.

Susan R. Flaherty is an Aptima Research Psychologist serving as liaison for Army Research Institute on all UAS training research. She holds an M.A. in Experimental Psychology and B.A. in Psychology from San Jose State University and UC Berkeley, respectively. Her current research is focused on training Army tactical communications and UAS gunnery skills.

Kevin Elfenbein is the Lead Construct Developer and Application Engineer at ASTi. He specializes in signal processing, artificial intelligence, and develops software to provide automated voice-enabled entities in a simulation environment. Mr. Elfenbein holds a M.S. in Electrical and Computer Engineering from Carnegie Mellon University.

Michael Knapp is a Principal Software Engineer at Aptima. He specializes in architecting and implementing distributed computing systems. Mr. Knapp received a M.S. in Electrical & Computer Engineering from the University of Florida.

Troy Zeidman is a Senior Program Manager at Imprimis, Inc. and former combat aviator. He has spent the last three years developing collective training performance measures for manned-unmanned teaming concepts. Mr. Zeidman is a graduate of the United States Military Academy and is pursuing his M.B.A. from Vanderbilt University.

Scott Graham is Chief of the U.S. Army Research Institute Fort Benning Research Unit. He leads a research program that is developing talent assessment and feedback techniques and enhanced methods for training complex cognitive skills. He holds a PhD in Cognitive Psychology from the University of Maryland.

Developing a Tactical Communications Training Environment

Kevin Sullivan, Susan R. Flaherty, Michael Knapp
Aptima
Woburn, MA
ksullivan@aptima.com, sflaherty@aptima.com, mknapp@aptima.com

Kevin Elfenbein
Advanced Simulation Technology Inc.
Herndon, VA
kevin.elfenbein@asti-usa.com

Troy Zeidman
Imprimis, Inc.
Huntsville, AL
troy.zeidman@imprimis-inc.com

Scott Graham
U.S. Army Research Institute
Fort Benning, GA
scott.e.graham.civ@mail.mil

TACTICAL COMMUNICATIONS IN MANNED-UNMANNED TEAMING OPERATIONS

U.S. Army Aviation employs teamed rotary wing aircraft with Unmanned Aircraft Systems (UAS) as a successful force multiplier in combat operations. Manned-Unmanned Teaming (MUM-T) utilizes each airborne asset's unique capabilities, endurance, and payloads for strategic superiority. In following the Army Aviation Restructuring Initiative (US Army Aviation Center of Excellence, 2008), MUM-T operations were formalized in Attack Reconnaissance Battalions. Subsequently, organic manned-unmanned units were assembled, where the UAS operator functioned in the role of mission scout. Due to the UAS platform's longer endurance and higher altitude than the helicopter, the UAS scout functions as a persistent aviation capability within the MUM-T dynamics. In this way, the UAS operator's ability to detect, identify, and report a threat in prescribed tactical communications protocol has become increasingly critical for successful operations (Stewart, Bink, Barker, Tremlett, & Price, 2011).

In earlier research, U.S. Army Research Institute (ARI) highlighted clear and effective communications between the helicopter pilot and the UAS operator in the Ground Control Station (GCS) as a critical skill required for MUM-T missions (Stewart et al, 2011; Sticha, P. J., Howse, W. R., Stewart. J. E., Conzelman, C E., & Thibodeaux, C., 2012). By comparison, flight training for Army pilots vs. UAS operators revealed differences in emphases on Reconnaissance, Surveillance, and Target Acquisition (RSTA) skills. In the case of UAS operator training, perceived differences include variance on tactical communication skills necessary to support teamed RSTA missions. Previous studies (Stewart, J. E., Bink, M. L., Dean, C.R., & Zeidman, T., 2015; Flaherty & Bink, 2015) have recommended additional training in tactical communications for the UAS payload operator in order to support communications accuracy, protocol adherence, and measured timeliness in teaming engagements. In following, there is a need for a flexible training aid for UAS operators to learn required tactical communications supporting efficient teaming with manned aviators.

Following principles outlined in *The U.S. Army Training Concept 2012-2020* (Dept. of the Army, 2011), a skills-adaptive, game-based desktop solution was developed to train tactical communications skills for the UAS payload operator. The game is intended for U.S. Army 15W Advanced Individual Training Soldiers (AIT) who have completed a minimum of Phase 1 Common Core Aviation ground school. In collaboration with ARI and U.S. Army Night Vision and Electronic Sensors Directorate (NVESD), the Night Vision Tactical Trainer - Shadow (NVTT-Shadow), a tactical communications training game, was developed. NVTT-Shadow provides nominal MUM-T mission scenarios (see United States Army Aviation Center of Excellence, 2014) to learn and practice MUM-T tactical communications skills in a single player domain. A summary of the game architecture, performance measures development, and initial usability assessment follows.

Concept of Operations

The NVTT-Shadow game progresses the Soldier through a series of UAS scout mission scenarios involving various assets (e.g., manned, unmanned, aerial, and ground-based). The Soldier, while seated at laptop GCS, interacts with virtual team entities via ad hoc communication over a simulated radio to accomplish increasingly complex missions. NVTT-Shadow is a web-based system integrating natural language processing components (i.e., speech recognition, speech-to-text, text-to-speech, and language recognition), performance measurement and feedback components into a One Semi-Automated Forces (OneSAF) flight simulator platform.

Training Purpose and Content

NVTT-Shadow is designed to augment the current U.S. Army Program of Instruction (POI) by focusing on MUM-T related critical tasks with specific focus on accurate and timely tactical communications. Figure 1 shows the NVTT-Shadow user interface with (clockwise from upper left) a voice client, terrain view, sensor and laser control panels, chat, and mission map windows.

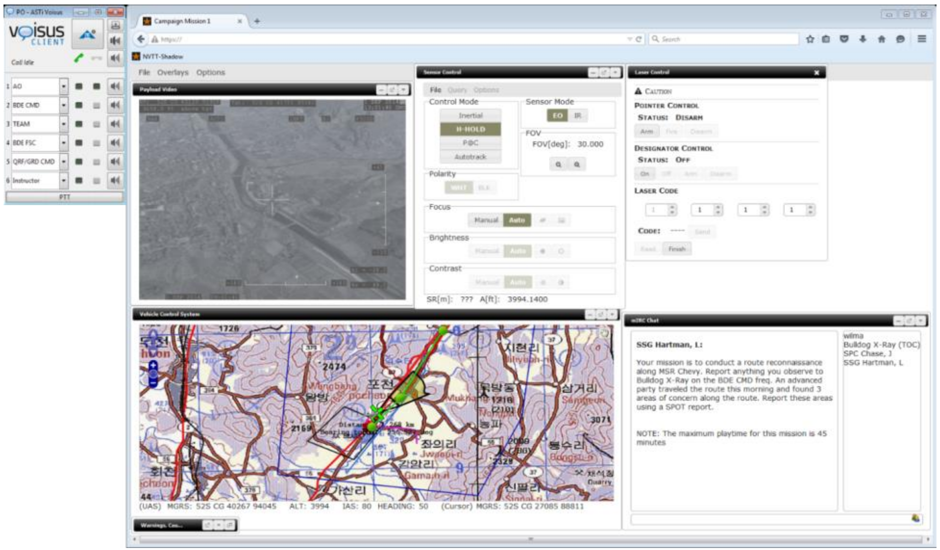

Figure 1. NVTT-Shadow User Interface

Gameplay is intended to supplement and reinforce instruction in existing POI modules. Specifically, gameplay may enhance Soldier knowledge retention when delays have been experienced prior to practical flight line skill exercise. The game is aimed at developing the tactical communication skills proficiency of the payload operator through accomplishing outlined mission objectives in routine UAS missions (e.g., Route Reconnaissance, Convoy Security). Coordination with external agencies and manned aircraft scout/attack teams are emphasized. Game content encompasses MUM-T related critical tasks outlined in the UAS Commander's Guide and Aircrew Training Manual (TC 3-04.61) (Table 1). More complex mission tasks involving UAS gunnery and fire training are based on skills outlined in Combat Aviation Gunnery (January 2014) (Table 2).

Table 1. RQ-7 Shadow Aircrew Training Program Requirements

Task #	Title
1110	Track a Static Target
1115	Track a Moving Target
1120	Perform Aerial Reconnaissance
1125	Call for and Adjust Indirect Fire
2054	Perform Target Hand Over to an Attack Helicopter
2092	Transmit a Tactical Report
2474	Designate for a Laser Guided Missile

Table 2. MUM-T Tasks Outlined in Combat Aviation Gunnery Represented in Game Missions

UAS Common Tasks
Target Handover Using the Laser Target Marker and Laser Designator
Request and Adjust Indirect Fire
Request Close Combat Attack (AH-64 cannon & rockets)
Request and Designate Remote Hellfire Missile
Request Close Air Support (Bomb on Coordinate)

NVTT-SHADOW GAME ARCHITECTURE

Game Components

NVTT-Shadow operates as a distributed, web-based game supporting multiple, simultaneous players executing unique missions. The minimum (i.e., single player) hardware configuration is composed of two rack-mounted software servers displaying on a 22-in 1920x1080dpi monitor with keyboard and joystick. A laptop can be used by a game procter/instructor as a duplicate of the soldier's game display. The ability to monitor correct transcription of speech-to-text is also accessible via the voice client panel. Game software is comprised of the following five integrated simulation services that function across a Distributed Interactive Simulation (DIS) to generate the mission training environment: 1) One Semi-Automated Forces (OneSAF), 2) AVSim Flight Model, 3) Night Vision Image Generator (NVIG), 4) Voice recognition server (ASTi Voisus), and 5) Aptima's Performance Measurement suite. Additional details on system architecture and synchronization across game components can be found in Berglie & Gallogly (2016). For the purpose of this paper, a general overview of the game software, natural language processing, and performance calculation follows.

Game Imagery

NVTT-Shadow utilizes a geographically diverse terrain database depicting terrain features including steep mountains, rivers, valleys, and coastal regions. Correlated satellite imagery overlays the wireframe terrain world, such that cultural features (e.g., bridges, roads) are represented. The presence of simulated ground vehicles and dismounted soldiers is defined within OneSAF and subsequently overlaid onto the terrain database. A single terrain database is utilized for all game missions.

Game Missions

Game scenarios are divided into Training missions and Campaign missions. Training missions exercise progressively more difficult skills in increasingly complex situations and are unscored. These missions serve as a tutorial for understanding command and control of the aircraft and payload sensors, as well as providing training on all tactical communications required for successful Campaign mission execution. Soldier interaction is prompted and guided by a virtual instructor toward achieving the learning objective. Training missions are indexed by the primary learning objective/tactical report contained within. By contrast, Campaign missions are designed for soldiers to exercise free play without guidance from a virtual instructor. Campaign missions are scored for timing and communications accuracy. Each Campaign mission begins with a briefing outlining the high level mission objective (e.g., Area Reconnaissance) and critical actions required for success (e.g., "locate hostile threats and conduct target handover to Apache 11 using laser target marker"). Feedback and measurement on mission objectives as well as tactical communications is displayed upon mission completion.

Speech Data Processing

The Soldier uses a virtual multi-channel radio panel to communicate with game entities to affect aircraft maneuvers, weapon fires, support calls, and reconnaissance reports. Entities respond with real-time feedback based on Soldier speech and context. The game allows the Soldier to select which channels to transmit and receive on, ensuring that h/she remain aware of which automated entity they are communicating with. The system utilizes automatic speech recognition (ASR) tuned with application specific data followed by a natural language processing (NLP) stage that extracts relevant meaning from the text. Multiple potential utterances can be collapsed into a single 'extracted' meaning. For example, a trainee utterance of "Fly east" will have the same extracted meaning, as "Fly heading 090". The extracted meaning, based on both the content of the trainee transmission and the current game context within the mission, is used for real-time feedback as well as later performance scoring. A text to speech (TTS) library generates realistic transmissions for real-time vocal responses to the Soldier via a variety of doctrine and phraseology for SPOT and BDA reports, remote hellfire, and other radio interactions

Soldier communications extracted by the NLP is passed to the game controller software to be validated and trigger in-game actions. The current context of the mission and state of the simulation are tracked in the form of a state machine. The game controller also maintains a state machine for each synthetic entity, and both state machines reside in a centralized context. Both voice system and the game controller can update the context, via voice commands or in-game events, respectively. For example, upon the Soldier transmitting to the virtual Apache pilot, "Remote hellfire", the voice system updates the virtual Apache pilot's state to reflect that the trainee is requesting remote hellfire air support. The game controller confirms that the Apache is able to perform the requested actions and updates its context, triggering the voice system to respond affirmatively using TTS.

Context-based error checking is employed so that a game entity can provide real-time feedback. For example, if a Soldier calls for a remote hellfire engagement from the Apache pilot and provides an invalid grid location, the Apache pilot will respond, "Say again grid." This tailored feedback takes into account the specific type of information expected based on the current game context and provides feedback which helps the Soldier improve his communications.

A transactional model for context state machine synchronization is employed to manage the critical synchronization of the interdependent voice and game contexts. Thus, any state change made by one system is confirmed by the second system prior to the second system changing. This mechanism allows Soldiers to issue commands, transmit information, receive relevant and constructive real-time vocal feedback, and visually confirm events occur in the game using only voice commands.

Using language processing techniques key information from trainee transmissions is organized into utterances for performance assessment. Speech events and audio are shared on the network to support the communications performance measurement system.

Communications Measures

A critical component of the training game is the measurement of accurate and timely tactical communications. Players are measured and scored on the transmission and content of their radio transmissions across four primary dimensions:

1. **Accuracy**: Did the trainee accurately describe and report the event in the scenario? Trainee utterances must match one of a set of predefined possible lexical formulations for the event adhering to Army scout reconnaissance protocol (USAACE, August 2014). Moreover, specificity counts: for example, "red truck" is always preferred to simply "truck". Distinctions such as these are reflected in the accuracy score.
2. **Completeness**: Did the trainee report all the required information for the event? Utterances are parsed into fields of required information with respect to communication type. For example, for a Spot report, fields include number, description, activity, location, time, and "what I'm doing". Completeness is computed as the percentage of slots filled by the trainee.
3. **Order**: Did the order in which a trainee reported the event match protocol? Most communication types must follow a structured format where the order of slots of information is prescribed. Order is computed as the distance in terms of "edits" (re-arrangement of a pair of slots) from the prescribed order.
4. **Timeliness**: Did the trainee report the event in a timely manner according to protocol? Timeliness is defined as the speed that a communication is formulated and transmitted relative to event observation in the scenario.

Measurement of these dimensions takes into account the content and form of Soldier utterances, as well as contextual information from the game environment to create a context-aware measurement system. For example, accuracy of a description in a SPOT report is relative to a known event in the scenario, and timeliness is measured with respect to the event onset in simulation runtime.

Context aware (i.e. game situation aware) performance measurement affords a semantic level of measurement of situations where virtual entities are participants. For example, the trainee may view a group of persons firing weapons at a building. The natural language parsing engine aligns the game situation with a dictionary of utterances to supplement adherence scoring. Thus, beyond just providing a description of, “persons firing weapons” in the SPOT report, the trainee may also provide a description of “terrorist attack” and still receive a partial grade for still conveying the battlefield threat to their commander. The extension to context awareness allows for domain specific speech to be scored more favorably than common jargon.

Assessment along the measurement dimensions is applied to the raw values to bin the Soldier’s score as “expert,” “average,” or “poor” performance. Performance assessment thresholds were established from input by Army Aviation Subject Matter Experts (SMEs). Measurement flexibility is supported by performance thresholds that can be tuned by an instructor to meet alternate goals.

Game Scorecard

A player’s primary pre and post mission interaction with the game is through the game’s scorecard (Figure 2). The scorecard contains the following elements: Campaign Mission Map, Training Mission Overview, Mission After Action Review (AAR), and Mission Selection.

The Campaign Mission Map was designed to orient the student to their overall progression through the game. The overarching campaign is composed of missions with a unifying objective. At a glance, the student is able to ascertain their campaign progress as well as individual mission accomplishment. Prior to mission play, a student may select a mission to receive either a mission briefing or their After Action Review (AAR) if previously played.

Figure 2. NVTT-Shadow Mission Map and Scorecard

In further detail, the game interface is divided into three sections of information:

1. The banner area displays basic user information including their name, game rank, total score, as well as number of missions played.
2. The Mission Map displays all of the missions in the game. Hovering and clicking reveal greater mission detail.
3. The UAS Dashboard displays selected mission details including training objectives, previous play, and averaged scores.

The Training Mission Overview provides the mission essential information. Players are given a list of training missions along with the corresponding Training Objectives. A Soldier may either follow the guided order of training or choose to focus on selected training by need.

The Mission AAR was designed based on the recommendations for formative feedback by Shute, V.J. (2008). The guiding philosophy outlines focusing on the task, limiting the feedback to only specific areas with cues for student improvement. The feedback is both situation and context-specific. Once a Soldier selects a specific communications report, he was provided four types of feedback: 1) an assessment of the communications dimension, 2) context-specific narrative feedback 3) access to his voice recording, and 4) an exemplar recording from an expert. By providing different levels of feedback, the student is able to receive the associated cue for the task being assessed. For example, the student may listen to the audio samples to hear the difference in cadences between himself and the expert. Additionally, he is able to view accomplishment (solid green), or deficiency (red) of the mission objective by viewing the overlay.

Figure 3. NVTT-Shadow Scorecard Detail and Performance Feedback

Detailed Soldier performance vs. game objectives and communications measures is presented in four sections (Figure 3):

1. Training Objectives are shown with both the number of attempts at that objective as well as their assessment.
2. Situations described in the trainee's reports are shown for each.
3. The assessments for each of the communications dimensions is shown along with narrative feedback
4. The trainee may either listen to their speech for the report or that of an expert giving the report.

Instructor Dashboard

In addition to the Player Dashboard, an Instructor Dashboard was developed to view the aggregate performance of selected players. Design features include the ability to sort data by Campaign Mission, Training Objective(s), or Student(s). Sorted data is presented in graphical format to support any remediation deemed necessary by the instructor.

USABILITY ASSESSMENT

Participant Demographics

Four 15W UAS AIT soldiers and four UAS instructors participated in the evaluation. AIT soldiers included two Shadow operators and two Gray Eagle operators enrolled in their 15th and 32nd week of instruction, respectively. Two of the four participating instructors were dual-qualified on Shadow and Gray Eagle UAS platforms, with the remaining two qualified on Shadow UAS, exclusively. In collected demographic surveys, soldiers reported spending 3.6 days per week playing video games for an average of 1.7 hrs. per day. Five of the eight participants reported engaging in predominantly First Person Shooter (FPS) video games over other types of game genre. Participants were scheduled by the UAS Training Battalion and subject to availability.

Gaming Session

An initial usability assessment was conducted at 2-13th AV Regt, Ft. Huachuca, AZ in December 2015 (Figure 4). Two participants were scheduled at a time for a 2-hr. session of self-paced gameplay, including approximately 30 minutes of tutorial training missions for game familiarization. Minimal proctor intervention was required.

Training Missions

Soldiers were introduced to joystick payload functions and method of gameplay through a series of short training missions prior to actual scored gameplay. Appropriate communications protocols for specified mission context were outlined in simple mission instances via interaction with an instructor avatar. Emphasis on appropriate selection of radio channel and sequence of information elements within a tactical communications report was given to advance the student through each learning objective. Feedback on correct transmission or need for improvement was audibly given by the instructor avatar in real-time. Training missions differed from Campaign missions in that they were ungraded and advancement was predicated on successful completion. Training missions required 5-15 minutes of gameplay depending on player's skill level.

Campaign Missions

The two Campaign Missions evaluated incorporated multiple reconnaissance skills and followed typical Combat Aviation Brigade operations. Mission success was predicated on accomplishing mission objectives in a timely and accurate manner with the appropriate tactical communications. For the purpose of this assessment, tactical communications included a Spot Report, Call for Indirect Fire, and Battle Damage Assessment. Campaign Mission duration was approximately 30 minutes depending on player skill level.

Data Collection

Prior to the gaming session, participants were asked to complete demographic and knowledge assessment surveys. Specifically, surveys required participants to rate their knowledge of nominal MUM-T tactical communications reporting (e.g., 9-line report, 5-line report, Spot report). After concluding the game session, participants again rated their knowledge related to tactical communications reporting. A user feedback questionnaire was administered to collect subjective ratings on: 1) Game Effectiveness and 2) Perceived Value of Game Practice to Specified Communication Reports. Lastly, Soldier comments related to game preferences (i.e., likes, dislikes) were documented.

Results

Due to reduced sample size (*n* = 8) and limited gameplay time, statistical analyses of variance did not yield significant differences in pre/post game exposure knowledge ratings. Likewise, a separation of means in 1) Game Effectiveness ratings and 2) Perceived Value to Specified Communication Report was not revealed. However, aggregated ratings show data trends that support the benefit of gameplay and warrant further study with a larger sample size and longer test session. A presentation of the data follows.

Knowledge Ratings

Soldiers rated their knowledge of nominal tactical communications reports required in MUM-T operations before and after exposure to TCTE gameplay. Ratings were collected on a 4-point scale (1 = No Knowledge; 4 = Very Knowledgeable). Although no statistical significance was found in a comparison of pre vs. post gameplay means, it is hypothesized that increased gameplay and a larger sample size would lead to higher ratings collected post gaming session.

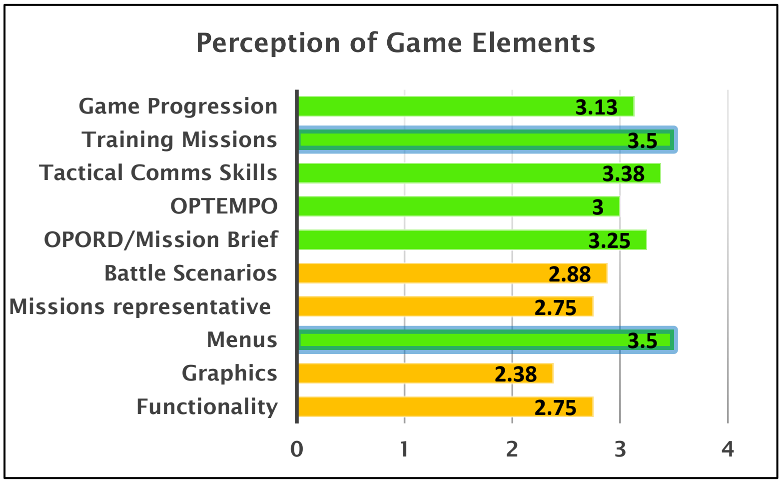

Figure 4. Subjective Ratings of Game Elements (n = 8)

Game Effectiveness

Soldiers rated game elements contributing to an overall profile of game effectiveness. Ratings were collected on a 4-point scale (1 = Major Deficiencies (Undesirable or Ineffective); 4 = Exceptional (Highly Desirable or Very Effective). A summary of mean ratings is presented below (Figure 5). It should be noted that ratings were closely distributed, such that the standard deviation of all ratings was < 1. Of the ten elements rated, six elements received an average rating of 3 or greater. Ratings of $\geq$ 3 were deemed without deficiency and desirable to highly desirable. Game graphics received the lowest average rating, which was further explained in soldier comments related to window obscuration and absence of hotkey mapping.

Value of Gameplay

Soldiers rank ordered the top 3 communications reports that could have benefited from more game practice (Figure 6). A total of 10 communication reports were available for selection. From the list presented, *Call for Indirect Fire/Remote Hellfire Engagement* was ranked highest in applicability and perceived benefit of gameplay. Four of the 8 soldiers tested gave a top 3 rank order to *Call for Indirect Fire* tactical communications. In both *9-line* and *Communications with the Apache pilot*, no ratings were received. Implications of no ratings should be caveated with the knowledge that the 9-line was not tested in the time allotted and Apache pilot communications were implicit tasks within other ranked reports.

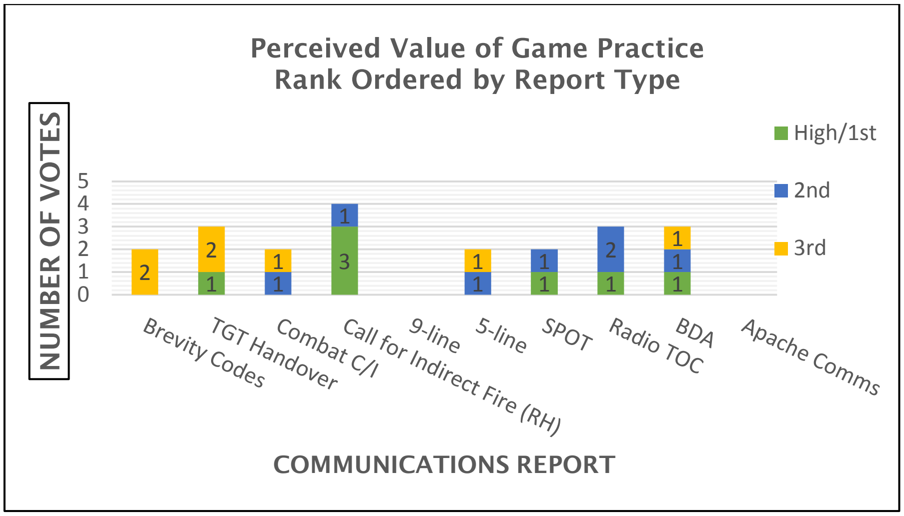

Figure 5. Rank Ordering Top 3 Tactical Communications Reports (*n* = 8).

Soldier Comments

Written responses related to areas for game improvement, desired additional features, and user opinions are summarized in the following paragraphs.

Game Issues Requiring Improvement

Joystick controllability was frequently cited as needing improvement. Difficulties in controllability of the payload due to unexpected or variant behaviors were the underlying reason given. Voice recognition performance was also identified as an area for improvement. As previously stated, one of the purposes of the usability testing was to collect additional voice data for further natural language processing refinement. Lastly, software failures to generate scorecards during some missions were documented.

Desired Features

Several soldiers stated that payload autotrack performance should be enhanced to match the current aircraft capabilities. Also, the labelling of hotkeys and access to joystick mapping during the game was specified. On display technology, soldiers stated that better contrast of map overlays would enhance ability to see borders and boundaries. Lastly, the possibility for a demonstration mode was mentioned in order for users to understand what is acceptable within gameplay.

Game Acceptance

Overall acceptance, relevance and perceived benefit of the game received excellent marks from course instructors qualified in both Shadow and Gray Eagle platforms. Game instructions were found to be “clear and to the point.” Due the missions presented, slight favor was shown for inserting gameplay into the simulation phase of Gray Eagle versus Shadow instruction. One instructor stated that he foresaw “astronomical benefit” to the solider trainee from playing the game over the current methods of voice communications training. An AIT soldier affirmed, “It’s more interactive than what we are currently doing.” Gameplay was favored for overcoming the current challenge of the required 1:1 student/instructor contact when refresher or remediation training is needed in tactical communications skill training. Additional comments showed that AIT soldiers believed the game was “very useful” and the “correct technology.” All eight soldiers described the positive learning potential for MUM-T tactical communications practiced in a game setting.

CONCLUSION

Usability testing conducted with the 15W instructors and 15W AIT soldiers demonstrated the feasibility of interactive gaming applied to MUM-T tactical communications. Acceptance from both populations validated mission context, game content, and game relevance. Limitations of the study included sample size and duration of gameplay. Positive data trends support further validation of the game in follow-on study. The authors recommend a target training population of novices vs. UAS instructors. Recommendations for extended gameplay (4-6 hrs.) and larger sample size are advised. Expansion of the mission library to include repetition of current tactical reports is recommended for the next development phase. Refinements of performance thresholds aligned with novice, intermediate, and expert performance is advisable is future development efforts. Additional performance criteria including proper use of brevity codes would enhance game relevance. At present, the game is recommended for both Gray Eagle and Shadow Operator classes.

ACKNOWLEDGEMENTS

The authors extend their great appreciation to those who helped conduct the research and development described here: Dr. Martin Bink (ARI), Dr. Fredrich Deidrich, and all our contributing partners at Imprimis Inc., ASTi Inc, Aptima Inc., Kinex Inc., and Trideum Inc. The authors also thank our colleagues at Night Vision and Electronic Sensors Directorate, Modeling and Simulation Division, Ms. Susan Harkrider and Mr. Chris May. Finally, the authors thank U.S. Army 2-13th AV Regiment, Ft. Huachuca, AZ for their participation and support toward the advancement of this research.

REFERENCES

Berglie, S. T. & Gallogly, J. J. (2016). Collaboration between human and nonhuman players in night vision tactical trainer-shadow. *Proceedings of SPIE 9848, Modeling and Simulation for Defense Systems and Applications XI, 984803,* Orlando, FL.

Department of the Army. (2009). Army Unmanned Aircraft System Operations. (FM 3-04.155). Fort Monroe, VA.

Department of the Army. (7 January 2011). The U.S. Army Training Concept 2012-2020. (TRADOC PAM 525-8-3). Fort Monroe, VA.

Department of the Army. (2014). Combat Aviation Gunnery. (TC 3-04.45). Fort Rucker, AL.

Flaherty, S. R. & Bink, M. L. (2015). Training manned-unmanned teaming skills in Army Aviation. *Proceedings of International Symposium on Aviation Psychology*, Dayton, OH: Wright State University.

Shute, V. J. (2008). Focus on Formative Feedback. *Review of Educational Research*, 78(1), 153 -189.

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. (ADB 367652).

Stewart, J. E., Bink, M. L., Dean, C.R., & Zeidman, T. (2015). *Developing Performance Measures for Manned-Unmanned Teaming Skills* (Draft ARI Research Report). Author.

Sticha, P. J., Howse, W. R., Stewart. J. E., Conzelman, C E., & Thibodeaux, C. (2012). *Identifying critical manned-unmanned teaming skills for unmanned aircraft system operators*. (ARI Research Report 1962). Fort Belvoir, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA565510).

United States Army Aviation Center of Excellence (USAACE). (2008). Aviation Restructuring Initiative Combat Aviation Brigade Unmanned Aircraft System Integration Doctrine and Training Supplement. Fort Rucker, AL.

United States Army Aviation Center of Excellence (USAACE). (August 2014). MUM-T Handbook: Leveraging Aviation Manned Unmanned Teaming (Draft). Fort Rucker, AL.