JTAC/JFO Team Training Effectiveness in a Simulation-based Environment

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ABSTRACT

Joint Terminal Attack Controllers (JTACs) sometimes have to rely on trained Joint Fires Observers (JFOs) during combat to provide them with timely and accurate targeting information in support of close air support operations. Simulator-based training capabilities are available to most JTACs and JFOs but they do not often train together in such environments. Therefore, a key question is the extent to which simulation-based training (SBT) can enhance the operational effectiveness of JTAC/JFO teams. Our research addresses this question by developing a first-ever JTAC/JFO integration study to examine the effectiveness of integrated training via multiple objective and subjective measures. Because this was the first study of its kind, we conducted a preliminary evaluation as an initial step to explore the possibility of effectively training JTACs and JFOs together in a simulation-based environment. Sixteen Air Force JTACs and five Army JFO personnel participated in week-long team training research trials. Training was conducted via the Joint Terminal Attack Controller Training Rehearsal System simulator (JTAC-TRS) to provide simulated scenario training experiences. Objective measures of performance were collected throughout the training week via the Performance Evaluation Tracking System. Subjective measures of mission effectiveness were collected via observation and evaluation by researchers and JTAC instructors. JTAC/JFO teams rely heavily on verbal communication and coordination to accomplish mission objectives. Therefore, this study also tested innovative methods for measuring team effectiveness reflecting these unique communication and coordination activities. As expected, results from this study found that JTAC/JFO team performance improved significantly from pre- to post-training. More importantly, JTAC and JFO participants reported that this training was both valuable and necessary. This suggests that training in a simulation-based environment for JTAC and JFO personnel at the team level can significantly enhance training outcomes, including learning, performance, and overall mission effectiveness or transfer.

ABOUT THE AUTHORS

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INTRODUCTION

The Joint Terminal Attack Controller (JTAC) is the forward element of the theater air-ground systems and plays a vital role in close air support (CAS) military operations. According to the JP 3-09.3, *Close Air Support*, a JTAC "directs the action of combat aircraft engaged in CAS and other air operations…[and] provides the ground commander recommendations on the use of CAS and its integration with ground maneuver." However, since JTACs cannot be in a position to see every target on the battlefield, they often have to rely on trained Joint Fires Observers (JFOs) during combat to provide them with timely and accurate targeting information in support of CAS operations. A JFO is a JTAC's "line of sight" or "eyes-on." A JFO is "trained to request, control, and adjust surface-to-surface fires, provide timely and accurate targeting information in support of [CAS] to a [JTAC], forward air controller (airborne) [FAC(A)], or directly to aircraft when authorized by the controlling terminal attack controller (TAC), and perform autonomous terminal guidance operations (TGO)." In a CAS operation, the JTAC has terminal attack control authority and, with the JFO, "assist[s] maneuver commanders with the timely planning, synchronization, and responsive execution of all joint fires and effects" (JCAS AP MOA 2004-03, *Joint Fires Observer*). JTACs and JFOs are most effective when employed as a team in order to maximize the effectiveness of joint fires available to the supported ground commander. Ideally, JTACs and JFOs should build a working relationship prior to deploying for combat operations in order to refine team tactics, techniques, and procedures (TTPs) and gain each other's trust. However, this could prove difficult if there is a lack of training opportunities.

Feedback from JTACs and JFOs who have participated in Air Force Research Laboratory (AFRL) research over the past year suggests that there is a lack of teamwork training opportunities for JTAC/JFO teams, especially in the live environment. As the number of JTACs and JFOs increase within the Services, live training opportunities become more difficult to obtain due to competition for limited resources, and yet, training JTACs and JFOs together is necessary for effective performance of the JTAC/JFO team. Meta-analytic findings suggest team training interventions have a positive impact on teamwork and team performance (Salas, et al., 2008). Simulations or virtual environments are rich platforms for developing expertise in military teams (Grossman & Salas, 2013; Salas, Stagl, & Burke, 2004). Simulation-based training (SBT), in particular, can be used to cultivate effective team. Dynamic scenarios and tasks of varying complexity can address many essential team competencies, such as developing shared mental models or a shared understanding of the mission (Cannon-Bowers & Salas, 1997; Grossman & Salas, 2013). SBT provides the instructors with more control over scenario conditions and a safer, more cost-efficient method of instruction and practice compared to live training (Williges, Roscoe, & Williges, 2001). JTAC and JFO teams can leverage SBT as an effective means for refining TTPs, building trust, and maintaining proficiency. SBT capabilities are available to most JTACs and JFOs, but they do not often train together in such environments. This raises a key research question of interest to the JTAC and JFO communities of the extent to which SBT enhances the operational effectiveness of JTAC/JFO teams.

The AFRL's Warfighter Readiness Research Division utilizes SBT for individual, team, and team-of-teams training for several military audiences. SBT allows the lab to combine pedagogical theory and methods with high-fidelity, relevant, and lasting training experiences using state-of-the-art technology. We also use SBT to track trainee performance in real time and post scenario to assess training effectiveness.

Team performance, in particular, can be assessed at multiple levels using a variety of constructs, depending on the training technology, training interventions, and applicability of prior skill domains to the current team training context

(Dorsey, Russell, Keil, Campbell, Van Buskirk, & Schuck, 2009). We incorporated subjective measures of performance through the collection of self-reported survey data about perceptions of performance, competencies gained via training experiences, and remaining gaps in knowledge, skills, abilities, and other experiences to better understand the efficacy of SBT in enhancing team-level capabilities. We also collected objective measures of performance via the performance evaluation tracking system (PETS) that measures real-time performance in terms of specific actions taken, consequences, or results as reflected in the simulation [e.g., number of ground-launched artillery during this sortie, team's closest range to any threat of opposing force, number of friendly frats (Schreiber, Schroeder, & Bennett, 2011)]. These metrics can be used to assess JTAC/JFO performance, however they do not assess some of the key elements of team training effectiveness.

Effective teams can be identified by their ability to accomplish task work, but there are also several underlying characteristics and processes present in these teams that are critical to their success. For instance, effective teams (expert teams, especially) have shared cognitions and attitudes, communication, team orientation, team leadership, monitoring team performance, feedback, backup behavior, and coordination (Dickinson & McIntyre, 1997; Salas, Cannon-Bowers, & Johnston, 1997). Team communication and coordination, in particular, are especially important for JTAC/JFO teams. Communication, or exchanging information between team members to include tracking, updating, or verifying information, and acknowledging or repeating information to confirm understanding, is a primary task for JTAC/JFO teams. Similarly, coordination, or executing actions in a timely and integrated fashion such as passing information or assisting the other team member's performance, is also crucial for effective JTAC/JFO teamwork.

Prior research used subjective methods for assessing levels of team coordination on military training tasks (e.g., Bowers, Morgan, Salas, & Prince, 1993). An observational checklist is a method of collecting team coordination and communication by identifying critical incidents of teamwork occurrences from subject matter experts and defining teamwork measures that can be rated by an observer during a training event (Cannon-Bowers & Salas, 1997; Dickinson & McIntyre, 1997). As described in later sections, we used a similar observational checklist method for capturing subjective assessments of JTAC/JFO communication and coordination. These were used in combination with the subjective and objective measures of performance effectiveness typically used for SBT research at AFRL.

JTAC/JFO Team Training Using Simulation

The JTAC Training Rehearsal System (TRS) at AFRL provides high-fidelity SBT. This five-meter, 220° field-of-view simulator is accredited for Types I, II, and III daytime controls with laser target designator capability. Form fit replica devices provide operators with more realistic capabilities in the virtual environment, including the PLRF-25C Pocket Laser Range Finder capable of interfacing with a Defense Advanced GPS Receiver, a Special Operations Forces Laser Rangefinder Designator, and Tactical Remotely Operated Video Enhanced Receiver for video downlink capability. Scenarios are created using Modern Air Combat Environment (MACE), which generates threats and allows operators to use Call-for-Fire (CFF) and 9-line forms to task constructive entities (Battlespace Simulations, Inc., 2012). The JTAC-TRS and MACE are capable of presenting scenarios serving both JTAC and JFO roles, allowing teams to coordinate and execute standalone CAS missions together. Scenarios also extend to distributed CAS missions with constructive and virtual fighter aircraft over the Distributed Mission Operations Network.

EXPERIMENTAL OVERVIEW

JTAC/JFO Team Scenarios

From July to September of 2016, AFRL conducted a pilot study to investigate integrating a JFO team member into the historically JTAC-centric scenarios. Subject matter experts (SMEs) used JTAC and JFO feedback, which largely included desire for scenarios that encourage more JTAC/JFO coordination, to revise scenario mission materials and scripting. Improvements included formatting to match what operators receive in formal and operational settings and resource allocation designed to force the JTAC team member to both make room for and better utilize the JFO as an asset. Some of the JTAC's typical tools, such as the Remotely Operated Video Enhanced Receiver (ROVER) feed, were left out of scenarios to ensure the JTAC relied on the JFO for relevant observer-level information from the JFO. Target components added to encourage JTAC/JFO coordination included threats with different ranges and located at

various distances, thus requiring more planning and dialogue to effectively coordinate simultaneous artillery and CAS missions. One non-benchmark scenario removed the JTAC team member early on, forcing the JFO to conduct a CAS event as an "unqualified JTAC", ensuring the JFO team member had opportunities to practice TTPs specific to that situation. An equal number of defensive and offensive scenarios were created.

Method

We invited teams composed of a qualified JTAC and a JFO to participate in testbed evaluations for JTAC/JFO teamwork scenarios. Recently-developed tools and processes were implemented on each evaluation week for JTACs and JFOs to test and provide feedback.

Subjects. JTAC and JFO participants were from either the United States Air Force or United States Marine Corps and included 23 JTACs and 12 JFOs. JTAC-Instructors (JTAC-Is) (n = 11) acted as Instructor Observers. General demographics and qualified experience are presented in tables XX and XX below.

Table 1. General JTAC Demographic Information

Demographic	Number of Participants
Air Force	**15**
Gender	
Male	15
Age (average)	28
Current Status	
Active Duty	15
Current Qualification Status	
JTAC Trainee	1
JTAC	6
JTAC-Instructor	3
JTAC-Evaluator	5
JTAC Experience (average)	
Total Years of Service	8.86
Average number of years as Qualified JTAC	4.83
Total non-combat CAS events: Live	184.6
Total non-combat CAS events: In-Simulator	80.3
Total combat CAS events	138.3
Marines	**8**
Gender	
Male	8
Age (average)	30
Current Status	
Active Duty	6
National Guard	2
Current Qualification Status	
JTAC	4
JTAC-Instructor	1
JTAC-Evaluator	3
JTAC Experience (average)	
Total Years of Service	10.4
Average number of years as Qualified JTAC	3.41
Total non-combat CAS events: Live	80.3
Total non-combat CAS events: In-Simulator	99.8
Total combat CAS events	3.0

Table 2. General JFO Demographic Information

Demographic	Number of Participants
Army	**8**
Gender	
Male	8
Age (average)	27
Current Status	
Active Duty	6
National Guard	2
Current Qualification Status	
JFO	6
JFO-Evaluator	2
JFO Experience (average)	
Total Years of Service	6.7
Average number of years as Qualified JFO	3.8
Total non-combat CAS events: Live	14.8
Total non-combat CAS events: In-Simulator	1.0
Total combat CAS events	14.0
Marines	**4**
Gender	
Male	4
Age (average)	24
Current Status	
Active Duty	2
National Guard	2
Current Qualification Status	
JFO	4
JFO Experience (average)	
Total Years of Service	0.9
Average number of years as Qualified JFO	3.4
Total non-combat CAS events: Live	2.4
Total non-combat CAS events: In-Simulator	6.2
Total combat CAS events	0.0

Participants were also asked to estimate the number of training experiences they had with the opposite role. Participants listed types of JTACs or JFOs they had previously trained with (Table 3) and then answered two open-ended questions about their historical experience training with team members of the opposite role. The number of times participants have trained with the opposite role varies greatly (Tables 4 and 5). For three JTAC participants, this training at AFRL was the first or second time they had participated in team training. For three other participants, training opportunities numbered above 200; these participants tended to be at the Instructor level.

Marine JFOs reported training as part of a JTAC/JFO team more frequently than their Army JFO counterparts. One Air Force JTAC commented that their fellow JTACs will act as the forward observer during training, in place of a JFO, but the majority of Marine JTACs reported working with a JFO teammate. One Marine JFO commented, “Any time I do anything it’s with a JTAC.”

Table 3. Types/Roles the JTACs and JFOs Have Trained With Before

Type and Role	Air Force - JTACs	Army - JFOs	Marines - JTACs	Marines - JFOs
JFO – Army	12	-	2	-
JFO – Marines	10	-	7	-
JFO – Other: SOF, Coalition, Nation, Thailand, Korean Marines, Japanese JFOs, Philippines	12	-	9	-
JTAC – Air Force	-	8	-	3
JTAC – Marines	-	4	-	4
JTAC – Navy	-	0	-	0
JTAC – Army	-	6	-	2
JTAC – Other: Coalition, UK, Italy, Romania, Spain, Canada, New Zealand	-	4	-	6

Table 4. Opportunities to Train with Other Role – JTACs

Response	Frequency
Air Force	
Yes, I train with other role	**11**
Have opportunities but currently don't	1
No, not normally	1
Other JTACs act as our forward observers	1
Number of Times Training with Other Role	
A couple of times	5
Sparingly/Not very often	3
Fewer than 50 times	3
Only once before/This was the first time	3
More than 200 times/numerous times – I'm an instructor	2
Over 100 times	1
At least every month	1
1-2 times per quarter	1
Marines	
Yes, I train with other role	7
Number of Times Training with Other Role	
A couple of times/Sparingly	2
Fewer than 20 times	2
More than 200 times/numerous times – I'm an instructor	2

Table 5. Opportunities to Train with Other Role – JFOs

Response	Frequency
Army	
Yes, I train with other role	**8**
No	2
Number of Times Training with Other Role	
Fewer than 5 times	3
None/Only once before	2
A dozen times or so/10 times	2
Not often enough	1
A few times a month	1
1-2 times per quarter	1
Probably 2-4 times per year	1
Marines	
Yes, I train with other role	4
Number of Times Training with Other Role	
Any time I do anything it's with a JTAC	1
10 times since being a JFO, been a JFO for 2 weeks	1
30-40 times	1
105 times	1

Training Research Week (TRW) Protocol and Measures

Over the course of a TRW, teams completed eight Close Air Support (CAS) missions and eight mission planning and debrief sessions. TRWs followed a four-day schedule with pre- and post-benchmark missions on Tuesday and Friday, respectively; Mondays were reserved for the in-brief, familiarization with the JTAC-TRS, and for participants to fulfill currencies. The JFO was positioned in the dome in order to serve as the forward observer, with the ability to track target sets and pass that information to the JTAC. The JTAC participant was positioned in a mock Tactical Operations Center (TOC) set-up located outside the dome and could not directly observe target sets or activity. Neither team member could see the other and communicated only over radio. Arranging the team members as such is more routine and reflects real-world positioning and responsibilities for JTAC/JFO teams.

Teams completed a suite of pre- and post-benchmark surveys; these surveys were given to all participants who participated in research for the JTAC-TRS at AFRL. Surveys and forms included Informed Consent, Demographics, Initial Readiness and Follow-Up Readiness, Expectations and Experiences surveys, a Reactions survey, and a JTAC-TRS Capabilities survey.

Each team completed two benchmark scenarios on the second day (typically Tuesday) and the mirror benchmarks on Friday. Each benchmark scenario was preceded by a 45-minute mission planning session including 15 minutes in the dome to prepare and test the equipment and radios. For each scenario, JTAC/JFO teams received the Concept of Operations (CONOPS) and relevant map insets of the scenario area, an artillery targeting worksheet, and a target reference point (TRP) pre-planning worksheet. Teams also received laminated maps (scales 1:50k and/or 1:250k) for planning.

Following the first benchmark, teams were given the option to take a brief break before starting mission planning for the second mission. Once both benchmarks were completed, teams were given the option to debrief the scenarios using the Live Virtual Constructive Network Control Suite program. Researchers and JTAC Instructor Observers observed benchmarks; during missions, the researchers completed the defensive/offensive tracking forms and the JTAC Instructor Observers rated the JTAC and JFO team members on whether or not they successfully worked as a team. JTAC-Is also recorded any mission contracts established during mission planning and were in charge of debriefs.

During non-benchmark days, teams completed two scenarios with dedicated time to debrief after each mission. Like the benchmarks, each scenario was preceded by 45 minutes of mission planning including fifteen minutes of in-dome preparation. On Wednesday afternoons, the mission included Virtual and Constructive players from Distributed locations. The two scenarios on Thursdays were part of a two-phase mission; teams had one mission planning session prior to Phase I and did not debrief in between phases. On Thursday afternoons, Team 1 completed the post-training suite of surveys, which included the Reactions, Follow-up Readiness, Experiences, JTAC-TRS Training Capability surveys, and the JTAC/JFO Integration Questionnaire. Team 2 completed their post-training surveys on Friday morning before their benchmark missions. For this study, a Teamwork Integration Questionnaire was added to the normal battery of surveys to collect participant feedback on JTAC/JFO teaming in the JTAC-TRS. Additionally, the Instructor Observers and those SMEs roleplaying during mission scenarios filled out Teamwork Tracking & Ratings forms to evaluate teamwork performance.

RESULTS

Training teams to be more effective has been a common area of research in various military team contexts (Prince & Salas, 1993; Salas, Bowers, & Edens, 2001). JTAC/JFO teaming and teamwork effectiveness for JTAC/JFO teams, specifically, has been discussed in limited contexts. JTACs and JFOs have often been mentioned in training independently, or as part of a larger exercise (e.g., Reitz & Seavey, 2014, December; 2016, December; Salcedo & Serge, 2015, August). However, a team training effectiveness study applying specifically to JTACs and JFOs together has not been reported in prior research. The current study gathered data on current JTAC/JFO team training practices in operational and simulated environments using self-reported surveys. It also assessed the effectiveness of JTAC/JFO team training in a SBT environment using training scenarios tailored to those roles and interactions between team members.

Data collected during the evaluation weeks included measures relevant to teamwork between JTAC and JFO pairs (communication and coordination), evaluations of teamwork and individual performance, self-reported learning, reactions to training, and assessments of the JTAC-TRS capabilities. These contributed towards our understanding of effectiveness via the ability of the JTAC and JFO to communicate and coordinate to learn and perform effectively in simulated missions.

Team Integration Before and After Training

As described above, participant responses indicated that prior to participating in the current study, JTAC/JFO team training opportunities varied greatly. Anecdotally, previous participants of other JTAC studies at AFRL noted that although opportunities are available, such training is not prioritized over other training/duties. JTAC and JFO participants in the current study were asked if they felt there are enough opportunities for training. The responses were condensed across branches by role and is summarized in Table 6. The majority of responses from the JTAC participants (n = 10) indicated that there are not enough training opportunities. One participant commented that there are not enough Air Force JTACs to train with JFOs one-on-one. The majority of JFOs (n = 7) also did not believe there are enough opportunities for training, and many commented that the Army does not prioritize letting JFOs

integrate with Air Force JTACs. One JFO participant believed there are available opportunities for teamwork training in simulations, but not enough available for live controls.

Table 6. Do you feel you are given enough opportunities to work with other role? – JTACs/ JFOs

JTAC				**JFO**			
NO - 10		**YES - 7**		**NO - 7**		**YES - 3**	
No	4	Yes	5	No	4	Yes	1
Should do more training	1	I have opportunities but don't currently utilize/schedules don't work out	2	Not enough opportunities	1	Yes, considering I'm a reservist	1
This is my first time training with a JFO	1			Army doesn't give JFOs freedom to integrate with Air Force	1	In simulations, not as much for live controls	1
Higher organization does not prioritize this training	3						
Too many JFOs and not enough JTACs to train one on one	1						

More importantly, when participants were asked to name any overall training gaps with regard to JTAC/JFO teaming prior to participating in the TRW (Table 7), the most frequently mentioned training gap included lack of opportunities to integrate with the other role pre-deployment. JTACs and JFOs participants commented that building trust and working relationships are difficult to establish with current training requirement guidelines. Participants in both roles also cited the lack of standardization and collaborating on SOPs between branches as a training gap.

Table 7. Training Gaps in JTAC/JFO Teaming – JTACs

JTAC		**JFO**	
Lack of training with JFOs/Need more integration pre-deployment	12	Difficult to develop SOPs/Lack of JTAC/JFO standardization	3
Lack of TTP development/JTAC/JFO standardization	7	Lack of training opportunities	2
Hard to develop team work skills and working relationships/trust	4	Need more practice with non–co-located operations	2
Need more practice with non–co-located operations	2	Not enough live controls opportunities as a team	1
Gaps get worked out the longer teams train together	1	Teams get split up too much	1
Continuity of pairs is difficult to keep	1	Hard to build trust	1
		Lack of JFOs' training	1

The JTAC and JFO participants were asked to rate different components of their experience during the TRW and the success of training as a JTAC/JFO team while in the JTAC-TRS, on scales of 1–5, with 1 indicating less agreement and 5 indicating more agreement with each statement (see Table 8). For their experience during the TRW, Air Force and Marine JTACs rated their role as mentally demanding (M = 3.9, SD = 0.6 and M = 4.0, SD = 1.4, respectively) and scenarios were rated as relevant to JTAC/JFO operations (M = 4.5, SD = 0.8 and M = 4.8, SD = 0.5). When asked how ready they would feel to deploy with a team member of the other role after completing the training, JTAC participants from both branches reported that they felt ready (M = 4.1, SD = 1.0 and M = 4.3, SD = 1.0). Importantly, Air Force and Marines JTAC participants reported that the teamwork practice they experienced during the TRW was extremely valuable (M = 4.9, SD = 0.4 and M = 5.0, SD = 0.0).

The JFO participants reported similar attitudes toward their JTAC/JFO teamwork experience. Both Army and Marine JFOs rated the scenarios as relevant to JTAC/JFO operations (M = 4.4, SD = 0.7 and M = 4.3, SD = 1.0) and that they felt ready to deploy with a team member of the other role (M = 4.3, SD = 0.7 and M = 4.3, SD = 0.5). Army JFOs reported lower mental demand for their role during the week than their Marine JFO counterparts (M = 2.6 and M = 4.0, but note small sample sizes for each Service, Army n = 8, Marines n = 4). As with the JTAC participants, the JFO

participants reported that this teamwork practice during the TRW was extremely valuable (*M* = 5.0, SD = 0.0 and *M* = 5.0, SD = 0.0).

Table 8. JTAC/JFO Teamwork Integration Training Component Ratings – JTACs

JTAC					**JFO**				
Question	**Air Force**		**Marines**		**Question**	**Air Force**		**Marines**	
	M	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*
How mentally demanding was your role this week?	3.9	0.6	4.0	1.4	How mentally demanding was your role this week?	2.6	0.9	4.0	0.8
How relevant were the scenarios this week for team training of JTAC/JFO operations?	4.5	0.8	4.8	0.5	How relevant were the scenarios this week for team training of JTAC/JFO operations?	4.4	0.7	4.3	1.0
After this week's experience, if you were paired with the other role on deployment, how ready do you feel to work with the other role as a team?	4.1	1.0	4.3	1.0	After this week's experience, if you were paired with the other role on deployment, how ready do you feel to work with the other role as a team?	4.3	0.7	4.3	0.5
How valuable was this teamwork practice to you?	4.9	0.4	5.0	0.0	How valuable was this teamwork practice to you?	5.0	0.0	5.0	0.0

Participants were asked to elaborate on their value rating for the teamwork practice (Table 9). Both JTACs and JFOs responded that the TRW provided them with a rare opportunity to train with the other role and work on establishing a trusting working relationship. JFOs listed learning new TTPs and gaining experience as additional reasons they found the teamwork practice to be valuable. Additionally, JTACs mentioned that this training provided insight into the value of JFOs and allowed them to practice utilizing the JFO as an asset. One JTAC commented: "After never working with a JFO before, this exposure has built my confidence in using a third party to provide targeting data. I would not hesitate to deploy with a JFO who has gone through this training."

Table 9. Reasons Why Teamwork Integration is Valuable – JTACs/JFOs

JTAC		**JFO**	
Don't often train with JFOs	7	Don't often train with JTACs otherwise	4
Practice utilizing JFO as an asset	4	Working with JTAC heightened experience level/learned new TTPs	3
Effective team training	4	Sims helped JTACs and JFO establish trusting relationship	3
JTAC/JFO interaction/establishing cadence is extremely important	3	Can see how JTAC does things	1
Provided insight to JFO's value	3	Missions got smoother as week went on	1
Helped me get comfortable with my counterpart	2		
Allowed us to identify follow-on training	1		

Self-Report Measures

This JTAC/JFO integration study was an iteration of a larger research effort for AFRL focused on the JTAC domain. As such, participants in the current study were given the standard battery of surveys measuring self-reported pre to post learning and feedback for the TRW. The surveys focused on individual training experiences and the SBT program effectiveness. These surveys used a list of 81 Mission Essential Competencies ™ (MECs) associated with the JTAC domain, identified prior from the MEC process (see Alliger, Beard, Bennett, Colegrove, & Garrity, 2007). Participants

filled out these surveys before participating in the TRW and again at the end of the week, before they completed their post-benchmark scenario training. Results from these surveys, while not the focus of this paper, showed that JTAC and JFO participants can gain benefits in readiness while training in the JTAC-TRS and that the JTAC-TRS in general exceeds expectations; these results are consistent with previous research in the JTAC-TRS.

Post-Training Surveys: Reactions and JTAC-TRS Capabilities

Additional surveys in the post-mission survey battery included a Reactions survey, which evaluated participant responses to the overall TRW including training components, events, and experiences. A capabilities survey was administered to measure the capability of the simulator and equipment to provide a realistic training experience to JTACs and JFOs. Although part of the standard suite of surveys, both included teamwork-specific items.

Many participant perceptions reflected in the Teamwork Integration responses above were also reflected in the Reactions responses. Participants were asked to list training shortfalls they would like to see addressed and, although not targeting teamwork training specifically, Air Force JTACs listed current JTAC/JFO integration as a training shortfall. The Army JFOs also expressed a need for more training events with JTACs and more in-depth training. JTACs and JFOs from all branches strongly agreed that the JTAC/JFO integration training improved team coordination skills. Participants in all branches agreed with the following statements from the Reactions survey, providing additional support for the utility of JTAC/JFO team training.

- "The events I participated in provided a realistic training experience."
- "I have improved my tactical skills as a result of this experience."

Participants in all branches agreed that such training opportunities are not as accessible at their home units, as exemplified by their *disagreement* with the following statements:

- "I can routinely get the type of experience I had at AFRL at my home unit."
- "At my unit, I routinely get to practice air strikes against realistic threats."

Data from the JTAC-TRS Capabilities survey is typically used to prioritize upgrades to the JTAC-TRS dome and associated systems. Participants must rate how well the JTAC-TRS dome provides relevant training experiences including training benefits or shortcomings. These responses can access participant feedback on the capability of the JTAC-TRS to more specifically provide teamwork and role integration training opportunities. As summarized in Tables 10 and 11, several responses included both praise for JTAC/JFO integration as a training benefit and further expressions of participants' desire to train as an integrated pair.

Table 10. Teamwork Training Benefits of the JTAC-TRS - JTACs

Response	Frequency
Air Force	
Intensive integration with the JFO	2
Ability to work with other sims	1
Marines	
Good team-building tool for JTAC/JFO integration	1
Dislocated from JFO, having to paint a picture	1
Exposure and expansion of JTAC/JFO capabilities	1
Working with live pilots, gain their debrief points	1

Table 11. Teamwork Training Benefits of the JTAC-TRS - JFOs

Response	Frequency
Army	
JTAC and JFO integration/understand JTAC way of training	4
Increased confidence of JTAC and JFO relationship/Built trust	3
CAS training with actual pilots	1
Marines	
The integration of CFF and CAS	1

Participants regularly reported that no contradictory training took place. Some cited known limitations such as that the simulator could not handle more complex TTPs in addition to the simplified radio networks. Marine participants were already aware of branch-level procedural differences in command and control.

JTAC/JFO Teamwork and Benchmark Performance

Performance metrics were tracked and recorded by researchers during each benchmark mission. Tables 12 and 13 present a summary of relevant metrics. Based on paired-samples t-tests, for both offensive and defensive benchmarks, Air Force/Army teams planned significantly more attacks during Friday benchmarks. Marine teams neutralized significantly more enemy ground vehicles during post-benchmark missions than they neutralized on Tuesday. Final average vehicles neutralized on Friday were almost identical for both types of teams, but the Air Force/Army teams typically neutralized more during Tuesday missions than the Marines initially neutralized. Both types of teams had significantly faster completion times for all Friday benchmarks.

Table 12. Defensive Benchmark Performance

	Pre-Training		**Post-Training**				
Defensive Benchmark Variables	**M**	**SD**	**M**	**SD**	***t***	**df**	***p***
Air Force/Army Teams							
1. Number of Successful Attacks	6.8	1.3	11.3	2.8	-2.87	6	.03*
2. Number of Unsuccessful Attacks	0.0	0.0	0.0	0.0	-	-	-
3. Number of Enemy Ground Vehicles Neutralized	19.8	3.3	23.5	1.0	-2.17	6	.07
4. Phase Line 1: Enemy Vehicle Breach	12.0	1.41	13.0	0.0	-1.2	5	.29
5. Phase Line 2: Enemy Vehicle Breach	7.3	4.2	3.0	1.0	1.75	4	.16
6. Phase Line 3: Enemy Vehicle Breach	7.0	-	1.0	0.0	-	-	-
7. Time to Complete (*mm:ss*)	43:18	2:06	36:18	4:48	2.67	6	.04*
Marines Teams							
1. Number of Successful Attacks	4.0	3.6	9.8	0.9	-3.14	5	.03*
2. Number of Unsuccessful Attacks	3.0	0.6	0.0	0.0	-	-	-
3. Number of Enemy Ground Vehicles Neutralized	8.5	7.5	23.8	0.5	-4.01	6	.01*
4. Phase Line 1: Enemy Vehicle Breach	12.3	1.0	5.7	6.4	2.09	5	.09
5. Phase Line 2: Enemy Vehicle Breach	9.7	2.2	0.0	-	-	-	-
6. Phase Line 3: Enemy Vehicle Breach	10.0	-	0.0	-	-	-	-
7. Time to Complete (*mm:ss*)	45:00	0:00	37:27	3:29	4.61	6	.00*

Note. Higher numbers indicate better performance for items 1 & 3; lower numbers indicate better performance for items 2, 4, 5, & 6. *Indicates significance at $p < .05$.

Table 13. Offensive Benchmark Performance

	Pre-Training		Post-Training				
Offensive Benchmark Variables	***M***	***SD***	***M***	***SD***	***t***	***df***	***p***
Air Force/Army Teams							
1. Number of Successful Attacks	4.8	1.3	12.0	4.2	-3.28	6	.02*
2. Number of Unsuccessful Attacks	0.0	0.0	0.0	0.0	-	-	-
3. Number of Enemy Ground Vehicles Neutralized	16.0	5.4	23.0	4.0	-2.10	6	.08
4. Time to Complete (*mm:ss*)	43:30	3:00	36:50	3:11	3.04	6	.02*
Marines Teams							
1. Number of Successful Attacks	3.5	1.7	10.8	3.1	-4.09	6	.01
2. Number of Unsuccessful Attacks	0.8	1.50	0.0	0.0	1.00	6	2.4
3. Number of Enemy Ground Vehicles Neutralized	13.0	5.0	23.5	3.0	-3.6	6	.01*
4. Time to Complete (*mm:ss*)	45:00	0:00	39:08	4:08	2.83	6	.03*

**Note*. Higher numbers indicate better performance for items 1 & 3; lower numbers indicate better performance for items 2, & 4. .
*Indicates significance at $p < .05$.

JTAC/JFO Team Communication and Coordination

Instructor Observers completed teamwork ratings for all teams (four Army/Air Force teams and four Marine teams) for each of the eight benchmark scenarios. These evaluators were current JTAC-Is, with 20 average years of experience as operational JTACs and/or as JFO instructors, who observed teams perform each benchmark scenario. Teamwork forms included 16 JFO-focused training components and four JTAC-focused training components. Items were derived from current career field training requirements. An example item is: "JTAC passes the intended plan of action to the JFO". The raters estimated team member performance using a five point scale, with a rating of "-2" signifying poor performance, and a rating of "+2" indicating excellent performance.

Trends from completed teamwork rating forms mirrored those exhibited in benchmark performance metrics, with ratings for JTAC/JFO pairs improving from pre-training conditions to post-training conditions. The sixteen JFO items and four JTAC items per team scenario were analyzed using a Wilcoxon signed-rank test. These comparative analyses showed that rater evaluations for post-training benchmarks indicated improved teamwork performance compared to pre-training benchmarks. Tables 14 and 15 present results for defensive and offensive benchmarks.

Table 14. Overall Teamwork Ratings for Defensive Benchmarks

	Pre-Training		Post-Training			
Defensive Benchmark Team Ratings	***M***	***SD***	***M***	***SD***	***Z***	***p***
Air Force/Army Teams						
Average Team Ratings	0.97	1.20	1.68	0.59	-3.48	.001**
Marines Teams						
Average Team Ratings	-0.38	1.12	0.96	0.97	-5.50	.000**

*Note.**Indicates significance at $p < .05$, **indicates significance at $p < .01$, ***indicates significance at $p < .001$.

Table 15. Overall Teamwork Ratings for Offensive Benchmarks

	Pre-Training		Post-Training			
Offensive Benchmark Team Ratings	***M***	***SD***	***M***	***SD***	***Z***	***p***
Air Force/Army Teams						
Average Team Ratings	1.29	0.87	1.81	0.39	-4.09	.000**
Marines Teams						
Average Team Ratings	-0.03	1.13	0.94	0.99	-4.79	.000*

*Note.**Indicates significance at $p < .05$, **indicates significance at $p < .01$.

The overall teamwork rating incorporates the essential teaming elements for both team members, which comprise a majority of the JTAC/JFO activities during the TRW scenarios. The significant differences in benchmark performance and ratings of teamwork performance from pre- to post-training highlight improvements in JTAC/JFO team efficiency. The tailored scenarios created in the JTAC-TRS for this study provided participants with a unique opportunity for teamwork-focused training.

DISCUSSION

In recent years, the demand for more JTAC involvement in military operations has increased, resulting in a demand for more JFOs to support these missions (Markham, 2008). Subsequently, the need to train and develop strong teamwork among JTAC/JFO teams is essential for successful mission execution. As reported by the JTAC and JFO participants in this study, both roles felt a significant lack of training opportunities with the other, and consequently a major shortfall for these communities is JTAC/JFO integration. Using the JTAC-TRS at AFRL, JTAC/JFO teams were able to train together using team-based CAS scenarios addressing specific competencies and gaps identified and validated by the JTAC community. The response from JTAC and JFO participants was quite positive, with most reporting that the training was mentally demanding, scenarios were relevant to JTAC/JFO operations, the teamwork skills practiced were extremely valuable to them, and as a result, they felt ready to deploy with their counterparts at the end of the training week and that their overall readiness was improved as a result of this training. Overall, both JTACs and JFOs felt this training was valuable to them because they would not get this training with their counterparts otherwise, and specifically this training gave them the opportunities to develop trusting working relationships with their teammate, develop new TTPs, and JTACs were able to utilize the JFO as an asset. Evaluators reported significant improvements in team performance from pre to post-benchmark scenarios, and significantly better teamwork via communication and coordination. Therefore, the JTAC-TRS was a successful platform for conducting JTAC/JFO team training for CAS missions. Not only did results from more objective measures of effectiveness find significant improvements in teamwork throughout the week, but subjective measures of perceptions of the training effectiveness, training platform capabilities, and reflections on competencies before and after training sustained the notion that SBT for developing JTAC/JFO teams can have a multitude of positive training outcomes.

There were limitations to this research. Participant availability was limited to units contacted. There were a few training weeks that were excluded from the sample due to incomplete teams or travel schedules that did not permit teams to complete the full week's schedule of training. Conducting pre-post assessments of training efficacy can also be limiting, since practice effects may always account for a portion of significant improvements in performance over time. Lastly, further evaluation and research must be done on observer evaluations of effectiveness. JTAC/JFO activity during CAS missions is primarily communications-based. Although this allows for the assessment of communication and coordination activities, we were not able to thoroughly evaluate these teaming activities. Technology and methods currently exist that allow for more comprehensive measurement and assessment of these dynamic actions, which will be considered in future research. Nonetheless, self-reported perceptions of the training as JTAC/JFO teams have been valuable for understanding the current and future need for more team training opportunities among these communities.

Future research for JTAC/JFO teaming can be even more beneficial when implemented in other live, virtual, and constructive training platforms. Building communication and coordination skills are what are essential for these career fields. Although JTAC/JFO teams conducted their training in a co-located context, learning these skills in distributed settings can be achieved just as successfully, especially with the capability to conduct mission planning via video or conference calling. Furthermore, correlating teamwork skills developed with actual success in real-world operations

is ideal and the ultimate goal for this research. Understanding how other team dynamics such as trust and shared mental models play out in operations as a result of training such as this is also an eventual goal.

The implementation of team training in the JTAC-TRS using team-based scenarios with virtual and constructive elements, paired with the assessment of team effectiveness using an observer checklist, can be applied to other teaming contexts. There are several military crew contexts in which communication and coordination activities are crucial for mission success (e.g., Air Support Operations Crews or Processing, Exploitation and Dissemination Crews). Although these teaming capabilities are essential job characteristics, it can be difficult to train and assess the effectiveness of these crews' teaming abilities, especially when one of the only measures of team success is a binary "Mission Success" or "Failure" evaluation. Incorporating live, virtual, and constructive training design, expert evaluation using pre-determined metrics of teaming success, and trainee reports of expectations, experiences, and perceptions of training success can be a comprehensive first step and glance at the effectiveness of a successful simulation-based team training program.

ACKNOWLEDGEMENTS

We would like to acknowledge the AFRL ICOTT team, including Mr. Chris Griffin, Mr. Mike Keehan, and Mr. Keith Westheimer, for their support in the development and execution of this research effort.

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