

ASOC Training Research: Joint Theater Air Ground Simulation System

Leah J. Rowe & Sharon L. Conwell
Air Force Research Laboratory
Wright-Patterson AFB, OH
Leah.Rowe.1@us.af.mil, Sharon.Conwell@us.af.mil

ABSTRACT

Across the armed forces, warfighters are required to perform in complex, dynamic, networked environments. Adequate preparation requires training in robust simulations that replicate these situations. Designing a training environment for Air Support Operation Center (ASOC) personnel comes with a unique set of challenges. The ASOC warfighters are required to work within their team of nine as well as, with an undefined number of personnel external to their location. The problem in creating a simulated training environment for local training at the operational unit is that it has been proven to be difficult to access, on a regular basis, thirty role-playing warfighters across different locations in order to staff an exercise. The purpose of this paper is to introduce an ongoing effort to create a robust ASOC training environment – the Joint Theater Air Ground Simulation System (JTAGSS) – which overcomes this limitation. JTAGSS incorporates the nine personnel who work within the ASOC, as well as, reflex agents playing the role of team members external to the ASOC (e.g., Joint Terminal Attack Controllers, F16, Joint Fires, etc.). Reflex agents are software-generated role players which are smart, synthetic, team members. Using Mission Essential CompetenciesSM (MEC) the research team identified the primary competencies, supporting competencies, knowledge, skills, and developmental experiences that an ASOC warfighter requires for successful mission completion. The MECs were then leveraged to design and create JTAGSS to provide a training platform to address current ASOC training gaps. This paper presents the successes and lessons learned through creating this unique training environment.

ABOUT THE AUTHORS

Ms. Leah J. Rowe is a Senior Research Psychologist in the Warfighter Readiness Research Division with the Air Force Research Laboratory Human Effectiveness Directorate in Dayton Ohio. She is the Technical Advisor in the Continuous Learning and Performance Assessment Branch where she leads researchers, engineers, and subject matter experts in training effectiveness research. Ms. Rowe and her team are involved in research related to performance evaluation, personnel assessment, training requirements identification, and quantifying the impact of organizational interventions - such as interactive, high fidelity immersive simulation environments and job redesign/restructuring and training systems impacts on individual, team, and organizational learning and effectiveness. Ms. Rowe received her MS in Applied Psychology at Arizona State University and is presently pursuing a PhD in Industrial and Organizational Psychology.

Dr. Sharon L. Conwell is a Senior Research Psychologist at the Air Force Research Laboratory, 711th Human Performance Wing, Human Effectiveness Directorate, Warfighter Readiness Research Division in the Continuous Learning and Performance Assessment Branch. She is a member of the Integrated Combat Operations Training-Research Testbed where she conducts research to improve training environments for Close Air Support, Remotely Piloted Aircraft, and the Air Support Operation Center. In previous positions, Dr. Conwell has served as the Corporate Development Officer for the 711th Human Performance Wing, as the Duty Director Strategic Planning & Market Research at GSA, Chief, Joint Advertising, Marketing Research and Recruiting, DMDC Liaison to Accession Policy for the ASVAB Testing Program, Human Factors Engineer for the U.S. Navy, and positions at AT&T. Her research interests include psychometrics, the operation of bureaucracies, power structures and political economies in bureaucratic organizations, and market research.

ASOC Training Research: Joint Theater Air Ground Simulation System

Leah Rowe & Sharon L. Conwell
Air Force Research Laboratory
Wright-Patterson AFB, OH
Leah.Rowe.1@us.af.mil, Sharon.Conwell@us.af.mil

INTRODUCTION

In the military there is a strong demand signal for the transformation of training (Foster & Fletcher, 2013). Through the last decade with the birth of Distributed Mission Operations (DMO) it has been demonstrated that in training one size does not fit all. DMO provides a mission training and rehearsal environment by linking teams and teams of teams into a common battlespace (Chapman & Colegrove, 2013). Additionally DMO allows for constructive entities (i.e., computer generated) and virtual trainers (i.e., simulators) to be used congruently for training. The introduction of constructive entities in training has allowed for the realization that a complex training environment can be generated with a smaller white force or role player footprint. These constructive entities provide great potential to create more effective and efficient training for personnel who require information rich environments where coordination and communication are critical. In this paper we use the Air Support Operations Center (ASOC) as an example for how to address, leverage and push the current advances in transforming training techniques.

The Air Support Operations Center (ASOC) is the primary control agency of the Theater Air Control System (TACS) for execution of air power in direct support of land operations. Its primary mission is to control air operations short of the fire support coordination line or in its assigned area. Normally collocated with the senior Army fires element, the ASOC coordinates and directs support for land forces. The ASOC is directly subordinate to the AOC, and is responsible for the coordination and control of air component missions in its assigned area (Chairman of Joint Chiefs of Staff, 2014, p. II-9).

Personnel in the ASOC have limited training opportunities receiving training in part-task trainers, infrequent large-scale exercises, and on-the-job-training. The Air Force Research Laboratory's Warfighter Readiness Research Division in the Human Effectiveness Directorate has an ongoing ASOC training research effort underway where the Joint Theater Air Ground Simulation System (JTAGSS) is being developed. Ultimately, JTAGSS will enable ASOC personnel to train one or many warfighters in a stand-alone environment with limited resources as well as in live, virtual and constructive training exercises. In JTAGSS constructive entities are being developed and will be role players, for the purposes of JTAGSS these entities are reflex agents.

The ASOC has nine positions that can be filled during operational deployment and at least three positions that are always occupied. Seven of the nine jobs in the ASOC are unique creating a heterogeneous teaming environment. For the most part the personnel in the ASOC come mostly from different career tracks and therefore have different knowledge and skill sets. The nine positions are as follow: 1) Senior Air Director, 2) Senior Air Technician, 3) Air Space Manager, 4) Intel Duty Technician, 5) Air Tasking Order Manager, 6) Joint Air Request Network Operator, 7) Interface Control Technician, 8) Procedural Controller 1, and 9) Procedural Controller 2. The personnel within an ASOC are required to work with an array of joint and coalition assets at any given time. Some examples of the personnel that the ASOC supports are Army Fires Cell personnel, Aircraft pilots, Joint Terminal Attack Controllers (JTAC), and Air Battle Managers (ABM).

Today in order for ASOC personnel to receive effective training, they require a highly skilled white force (i.e., role-players) to adequately replicate the ASOC and battle space environments. These additional role players significantly increase not only the personnel requirements to conduct training events, but also the cost to conduct them. To address this problem of needing many to training a few we are pursuing the creation of advanced reflex agents to fill the roles of the various positions in the ASOC. As conceptualized, these agents would interact both

verbally and digitally through written text with the nine personnel in the ASOC. These verbal and digital interactions utilize the standard ASOC interfaces such as radio communication and chat rooms. At full operational capability the trainee would not be able to detect whether his/her team members were humans or reflex agents. Creating these agents has proven to be an incredible undertaking, and is pushing the boundaries of speech recognition and modeling for complex interaction. In this paper we discuss defining requirements, overarching engineering concepts and the processes by which agents are being developed in JTAGSS.

DEFINING TRAINING GAPS

In order to address training gaps, the JTAGSS development team used the Mission Essential CompetencySM (MEC) job task analysis method to identify training gaps and the core competencies, developmental experiences, knowledge and skills required to be a member of the ASOC. MECs are “higher order individual, team, and inter-team competencies that a fully prepared pilot, operator, crew or flight requires for successful mission completion under adverse conditions in a non-permissive environment”, (Alliger, Beard, Bennett, & Colegrove, p. 606, 2012). MECs were developed initially to support Air Combat Commands DMO program. The goal of MECs was to optimize the use of advanced simulation in aircrew training programs. The introduction of MECs provided a systematic way to move way from event-based training to a competency-based training. With the introduction of MECs the operational community can explore training options that are not aimed at “one size fits all” (Colegrove & Bennett, 2006).

Rather than focusing on the fundamental or beginner skills required to learn the job, the MEC methodology focuses on identifying the competencies required for mission completion during combat and the constituent knowledge, skills, supporting competencies and experiences. Furthermore, this process relies on expert input to prioritize both experience importance and the environments/methods by which experiences are best gained (Bennett, Alliger, Colegrove, Garrity, & Beard, 2013).

During the ASOC MEC process, eight MECs were identified. An example MEC is: *coordinates with joint and coalition services*. Within the MEC process supporting competencies are also defined. These are sets of high-level skills that are demonstrated in the context of operational conditions and constraints. The ASOC MEC product identifies eleven supporting competencies such as *crew resource management* and *critical thinking*. The next component of the MEC process includes the identification of the knowledge sets and skills required by position for each member in the ASOC. Knowledge is defined as information or facts that can be accessed quickly under stress and skills are compiled actions that can be carried out successfully under stress. ASOC experts identified forty-five knowledge items, such as *asset availability*, and sixty-one skills, such as *check-in and check-out aircraft*, required for MEC proficiency. Finally, eighty experiences were identified during the MEC process. An experience is a developmental event in the training and/or career of a warfighter that is necessary either to gain knowledge or skills, or practice a MEC or supporting competency under operational conditions. An example of an ASOC experience is *executing immediate close air support requests*. The information identified within the MEC process provides resources to develop survey tools which are administered to ASOC personnel to identify training gaps.

JTAGSS DESCRIPTION

The ASOC MECs provided a baseline for the experiences that need to be trained to in a full fidelity simulator. JTAGSS consists of the nine ASOC positions that are previously described in the introduction of this paper. JTAGSS also includes two instructor operating stations. An illustration of the JTAGSS system is shown in Figure 1. Unlike the aircraft platforms in the Air Force the ASOC warfighters use computers and displays for their everyday job. As you can see this is not much different than a standard office environment. Since the equipment is similar to that of what most of us use on a daily basis there are great benefits for integration but it also presents some unique challenges as well.



Figure 1. Joint Theater Air Ground Simulation System illustration

The software that is used in the ASOC is available as commercial or government off the shelf equipment. This makes the acquisition of the piece parts (hardware and software) required to build JTAGSS easily attainable. However, integrating these components to work seamlessly as one system is not trivial. Therefore, for the simulation system itself (not including reflex agents) the engineering is centered on integration not development. The integration challenge of JTAGSS makes it even more important to follow industry standards (e.g., IEEE and SISO). JTAGSS is being developed align with industry standards and to be DIS (distributed interactive simulation) compliant. Figure 2 provides a list and the corresponding function of all of the software that together creates JTAGSS.

Whereas in aircraft simulators it is difficult to replicate many aspects of a live aircraft (e.g., the operational flight models) the live system for the ASOC uses standard every day computers and well established software. Therefore, the JTAGSS architecture is able to integrate much of the actual software that ASOC warfighters use in the operational environment. This provides an environment where warfighters can train like they fight. JTAGSS includes two modern and easy to use Instructor/Operator Stations allowing for more than one instructor to interact with the trainees. Ultimately, the goal for JTAGSS is the capability to replace all of the trainee positions, and the external roles player positions with automated reflex agents thus eliminating the need for human role players to support the training of one or more positions of the ASOC team. This will allow for maximum training flexibility and will allow for any combination of positions to be trained at any time.

Modern Air Combat Environment (MACE)	<ul style="list-style-type: none"> • Provides realistic flight and weapons modelling • Takes in the Air Tasking Order and Air Control Order
Tactical Air Control Party Close Air Support System (TACP-CASS)	<ul style="list-style-type: none"> • Tracks Blue Force • Displays MACE tracks
Joint Automated Deep Operations Coordination System (JADOCS)	<ul style="list-style-type: none"> • Displays MACE tracks • Joint Data Translator changes Link-16 for Cursor on Target
Strategic Worldwide Integration Capability (SWIC)	<ul style="list-style-type: none"> • Generates Air Tasking Order • Generates Air Control Order • Provides updates of Air Support Request to TACP-CASS
Instructor Operator Station	<ul style="list-style-type: none"> • Generates and manages training scenarios • Modifies MACE settings • Induces air platform events • Assigns reflex agents and overrides reflex agents
Falcon View	<ul style="list-style-type: none"> • Maps for battlespace situational awareness

Figure 2. JTAGSS software and functions

DEVELOPMENT OF THE REFLEX AGENTS

There are two different types of reflex agents required for the JTAGSS effort, internal and external agents. The internal agents are to replicate the nine different positions inside of the ASOC. Whereas, the external agents are to replicate the assets that typically coordinate with the ASOC. The JTAGSS research team approached building external agents first because the external positions are more procedural and therefore easier to model. The majority of the information needed by the external agents is easily generated in DIS packets within the simulated environment. Once the external reflex agents are mastered, the lessons learned can be used to develop the more complex internal reflex agents. The difficulty with the internal agents lies in the need to replicate human interaction with the others in the simulation and the ASOC command and control network all within the closed ASOC system. Simulating the internal ASOC environment requires the replication of human interaction. The internal agents are tasked to interact with humans in the JTAGSS environment. Many of the conversations in an ASOC are face to face and therefore this creates a technology and fidelity challenge to integrate natural language and ASOC doctrinal communication into the internal agents. The initial assumption was that it would not be difficult to develop agents that would meet engineering requirements, the difficulty would be developing agents realistic enough that warfighter would be willing to train with them.

The initial development of the external agents proved to be simple in some respects, and complex in others. Opting for a relatively straight forward approach, the team developed a finite lexicon appropriate to two external positions in the ASOC environment, the Joint Terminal Attack Controller calling in for close air support and a response aircraft. With the help of subject matter experts, the lexicon was weighted as to the statistical probability of the word or phrase being associated with another word or phrase. Because the training scenarios were based on scripts, developing the associations was time consuming but not particularly difficult. Using this approach, the system interprets the speech to acquire enough information to perform a specific action, be it answering a question about air

speed, altitude, fuel status, target location, etc. The context was fixed in the system and was represented as a set of parameters so that the system could take action on them. Due to the simplicity of the approach, it was possible to build a reasonably robust language-production capability that could be taken and expanded to other external positions without too much difficulty. Since a full linguistic analyses of a complete language is not needed, most information could be extracted through patterns designed for the external position. For example, given the utterance “Skywalker, provide fuel status and ETA to target, Over” pattern- matching techniques could identify values for the following parameters: Skywalker (answer: the Pilot), the event (answer: ETA), and the location (answer: Target). Even if speech recognition was poor, and the recognized utterance was “Skywalker ETA target,” the patterns could still extract the nature of the request and continue the dialogue. Developing these agents in a closed system was not at all difficult, however, having the agents interact inside of the DIS environment proved to be very difficult.

Agent development becomes more complex when one agent begins interacting with another agent as well as the JTAGSS subsystems. These tasks were too complicated to be represented as a series of parameterized contexts. In fact, these tasks required the system to maintain an explicit model of the tasks, and reason about these tasks. The language and the dialogues become significantly more complicated, and the team had to start explicitly modeling the collaborative problem-solving process that the system and user might engage in to adjust to and monitor a dynamically changing environment.

Subsystem Interactions with the Reflex Agents Server

There are a large number of subsystems and applications integrated into JTAGSS. The Reflex Agent Server interacts with these subsystems and applications. Voice Interface receives input from Instructor/Role-Players or Students from simulated Radio/Phone communications. A list of the interaction is shown below and figure Figure 3 details how the Reflex Agent Server interfaces with the other subsystems.

1. Speech Recognition decodes the speech input in accordance with Lexicon Data.
2. Text Input Interface receives XMPP chat communications from Instructor/Role-Players or Students.
3. Communications Agent determines the agent reaction in accordance with Agent Data
4. Behavior Agent determines actions in accordance with Communication Agent output, MACE entity states, and Instructor/Role-Player inputs.
5. Action Output facilitates MACE entity reactions in accordance with the Behavior Agent output.
6. Text Output Interface provides XMPP chat communications responses.
7. Speech Synthesis provides voice communications output for simulated Radio/Phone.
8. All messages are logged.

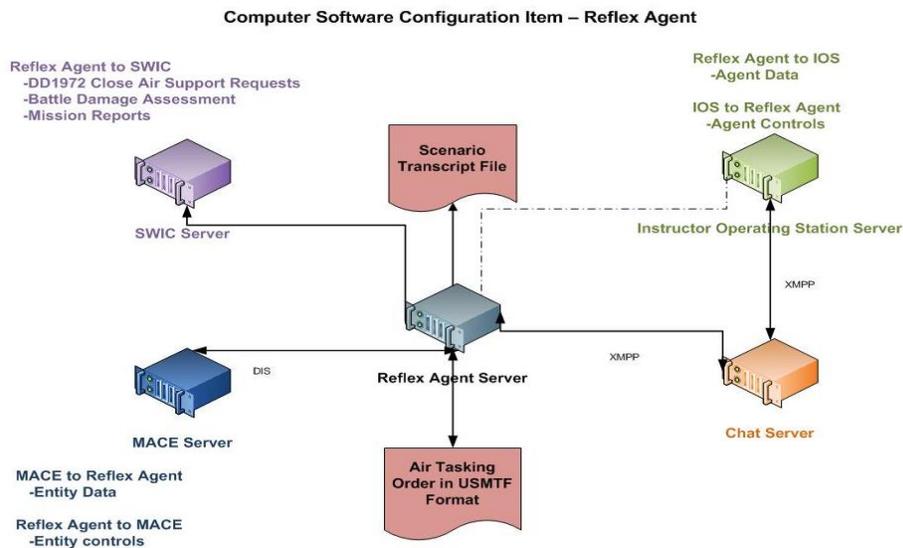


Figure 3. Reflex Agent Server Interface Control Diagram

The Instructor Operator Station Interaction

The Instructor Operator Station (IOS) has control over the total system and the subsystems as shown in Figure 4. In order for the system to be user friendly for the instructors, a user interface was built and consists of number of scenario controls agent controls, event controls and triggers, and typical system controls such as help menus and system navigation menus. The Main Window Scenario Control (MWSC) software unit is a user interface along the top of the IOS client window area that contains the current scenario name, status, scenario time and Zulu time, and contains controls for initializing, starting, freezing, and ending a scenario.

The Network Infrastructure for the IOS consists of IOS Client Interface, Reflex Agent Interface, and XMPP Interface software units. The IOS Client Interface software unit handles the login of IOS client stations, such as the Primary IOS client and additional IOS role player stations to the server. It also handles synchronization of scenario state and network packing of traffic to and from the server. The XMPP Interface software unit handles the connection of the IOS client station to the XMPP server, receives notifications about the status of XMPP entities on the network (chat room statuses) and sends and receives XMPP chat messages. It is also capable of sending custom XMPP formatted messages (as defined by the IOS-Reflex Agent Interface). For example, with regard to chat, the IOS Server interacts with the Reflex Agent interface using standard XMPP communications protocol to transfer chat messages. The XMPP messages are managed by the Chat Server which facilitates delivery to the correct chat client.

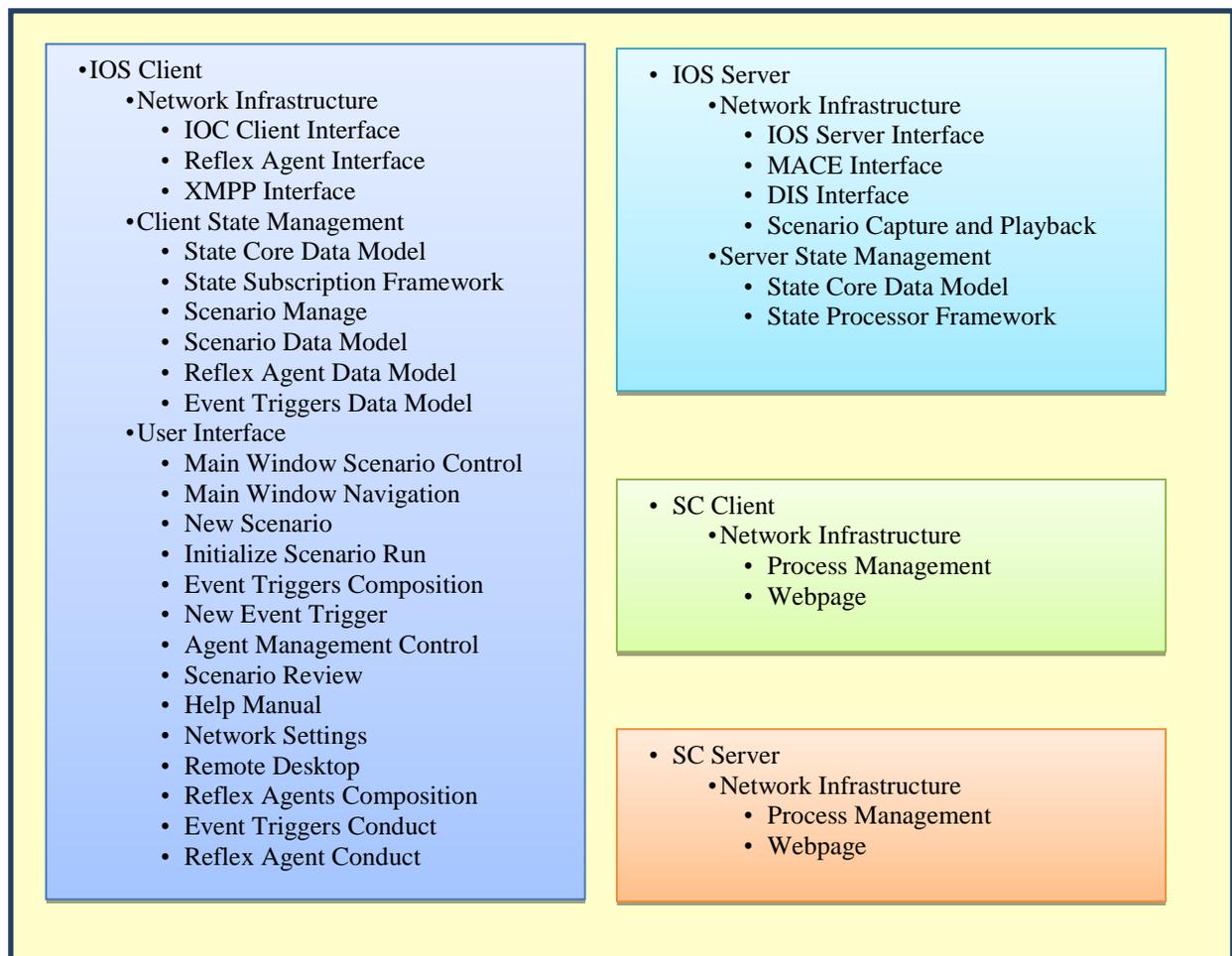


Figure 4. IOS Software Configuration

Example 1 serves to demonstrate the complexity of the task in a scripted training scenario as launched from the IOS.

EXAMPLE 1: Preplanned request -- JTAGSS tells MACE to launch stored mission

1. JTAGSS works out whatever communication / approval / etc necessary.
2. When the mission is ready to be executed, JTAGSS sends MACE a DIS SetData PDU which fills in / executes a given 9-line mission. MACE will respond if it can do the mission via DIS PDUs.
3. JTAGSS may send MACE a cleared hot or abort command via DIS SetData PDU. MACE will report its progress on the mission via DIS PDUs.
4. MACE will report when it has completed the mission via DIS PDUs.

In addition to the 9-line attack command, JTAGSS can send to MACE:

- Loiter at point.
- Fly heading/speed/altitude.
- Set a target.
- Return to route.

Queries -- Example: What is the ordnance of HOG01?

In order for the reflex agents to interact successfully in the scripted training scenario, the Reflex Agent Interface software unit builds upon the XMPP Interface to provide the ability to generate the custom XMPP formats used to communicate between the IOS client station and the Reflex Agent Software via XMPP. This supports the messages defined in the IOS-Reflex Agent messaging protocol.

The Reflex Agent software for the external entities, (i.e., aircraft, JTAC, AWACS), is a user interface component that allows the instructor to define each external position being played during the scenario. Each external position contains a corresponding call-sign (for those positions with attached synthetic platforms), an IOS Station which is responsible for that position (if any), and a reflex agent which is controlling that position (if any). The Conduct interface allows the instructor to make adjustments to the external position roles. For example, a role player could relinquish control of a role at run-time and it could be assigned to another IOS client station. This control is also capable of changing the state of a corresponding agent at run time.

CONCLUSION

During the first spiral of the JTAGSS effort MECs were created and validated for ASOC warfighters. The JTAGSS team was able to successfully replicate an ASOC environment by integrating existing GOTS and COTS products into a simulated environment. A dynamic and easy to use IOS was built to effectively tie all of the GOTS and COTS products together in order to have one system controlling all of the software. Even without agents integrated into the system, the current hardware/software configuration will serve as a training research testbed to collect ASOC behavioral data to help model the future agents.

Reflex agents were developed for both the pilot and JTAC positions and adequately communicate both digitally and verbally; however, these agents do not fully adapt to the DIS environment. An alternate pilot agent was created within the environment generator (MACE) and effectively communicates via spoken language with the ASOC system. The second spiral of the JTAGSS will primarily focus on the research and development of additional reflex agents and furthering the robustness of these agents.

In conclusion, JTAGSS is aimed at providing a training capability to warfighters that does not exist today. The outcomes of this research open up endless possibilities for furthering live, virtual and constructive training ultimately benefitting the warfighter by increasing training fidelity and driving down the cost of training resources. Reflex agents have the potential to help minimize manning for large scale live and simulated exercises. This creates for a more enduring and affordable training solution that can be used within the DoD and even extended to our coalition partners.

REFERENCES

- Alliger, G. M., Beard, R., Bennett, W., & Colegrove, C. M. (2012). Understanding Mission Essential Competencies as a Job Analysis Method. In M. A. Wilson, W. Bennett, S. Gibson, & G. M. Alliger, *The Handbook of Work Analysis Methods, Systems, Applications, and Science of Work Measurement in Organizations* (pp. 603-624). New York: Routledge.
- Alliger, G. M., Beard, R., Bennett, W., Jr., Symons, S. R., & Colegrove, C. M. (2013). A psychometric examination of mission essential competency (MEC) measures used in Air Force distributed mission operations training needs analysis. *Military Psychology, 25*, 218–233.
- Bennett, W., Alliger, G.M., Colegrove, C.M., Garrity, M., & Bear. (2013). Mission essential competencies: A novel approach to proficiency-based live, virtual, and constructive readiness training and assessment. In C. Best (Eds.), *Fundamental Issues in Defense Training and Simulation*. Ashgate Publishing, Limited.
- Chairman of Joint Chiefs of Staff. (2014). *Command and Control of Joint Air Operations*. Washington D.C.: Department of Defense. Retrieved 06 01, 2014, from www.dtic.mil/doctrine/new_pubs/jp3_30.pdf
- Chapman, R. & Colegrove, C. (2013). Transforming Operational Training in Combat Air Forces, *Military Psychology, 25*(3), 177-190.
- Colegrove, C. M., & Bennett, W. (2006). *Competency-based Training: Adapting to Warfighter Needs*. Mesa: Air Force Research Laboratory.
- Foster, R. E. & Fleeter, J.D., (2013). Toward Training Transformation. *Military Psychology, 25*, 308-317.