Tradecraft & Analysis Learning using Intelligence Scenarios with Methods-Anchoring (TALISMAN)

Benjamin Bell, Ph.D.
Aqru Research and Technology, LLC
Doylestown, PA
bbell@aqru-llc.com

Michael Marks
Intelligent Decision Partners, LLC
Doylestown, PA
mbmarks@intelligentdecisionpartners.com

ABSTRACT

Analysts across the Intelligence Community (IC), including Department of Defense (DOD) intelligence components, face rapid growth in the volume and levels of fidelity of data to be transformed into intelligence. At the same time, the IC is experiencing a reduction of skilled senior analysts due to attrition and budget compression. At a time when all-source, multi-int, and open-source analysis are becoming critical to combating state-sponsored terrorism, transnational threats, and hostile proto-states, any knowledge, skills or experience gaps must be seriously examined and remedied.

These challenges are familiar but new influences are exacerbating these gaps. Open source information has grown dramatically, driven by traditional news outlets offering digital editions and nontraditional conduits such as blogs and social media. Open-source intelligence (OSINT) has assumed greater importance as conflict zones are often in regions that lack traditional infrastructure and communications networks. In summary, *analysts are facing unprecedented volumes of information and an acute requirement for advanced analytical techniques*.

A systemic improvement that could address these challenges is a new approach to training that embeds the effective use of proven, replicable methods for intelligence analysis in authentic scenarios. In this paper we describe a simulation enabled by online, scenario-based training incorporating a repeatable and proven analytic workflow. *Tradecraft & Analysis Learning using Intelligence Scenarios with Methods-Anchoring* (TALISMAN) applies scenario-based, technology-enriched training to create web-accessible interactive training scenarios. TALISMAN will equip analysts with the skills and knowledge to identify adversary locations, clandestine facilities, illicit activities, and other phenomenology using a proven composite signatures methodology.

ABOUT THE AUTHORS

Benjamin Bell is a Principal and founder of Aqru Research and Technology, LLC, where he applies artificial intelligence to simulation, training, human-machine interaction, and work support environments. Dr. Bell's research has addressed the use of simulation for training and education across a spectrum of applications, including K-12, higher education, military and national security training. He has held academic positions, leadership positions in industry, serves on the I/ITSEC conference committee and is an associate editor for the IEEE Transactions on Human-Machine Systems. Dr. Bell is an assistant adjunct professor at Embry Riddle, holds a Ph.D. from Northwestern University and is a graduate of the University of Pennsylvania.

Michael Marks is founder and CEO of Intelligent Decision Partners, LLC, a professional services and consulting firm that specializes in providing multi-source intelligence services to the government and private sector. Mr. Marks has served as an Adjunct Staff Member of the Institute for Defense Analyses (IDA) and as Vice President for Corporate Development for SAIC. He also served in government, holding a number of high-level policy positions in both the Executive and Legislative branches. Mr. Marks was Assistant Director, Office of Science and Technology Policy (OSTP), Executive Office of the President; Senior Policy Advisor to the Office of Director, DARPA; Senior Policy Advisor to the Under Secretary for Security Assistance, Science and Technology, U.S. Department of State; and Legislative Assistant for Foreign Affairs and National Security, for Senator Jake Garn.

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mbmarks@intelligentdecisionpartners.com

BACKGROUND

The volume of raw data to be transformed into information for intelligence production is growing at alarming rates. Each intelligence discipline (the "-INTs") is seeing collection technologies that provide data at significantly greater volumes and higher levels of fidelity. Analysts across the Intelligence Community (IC), including Department of Defense (DOD) intelligence components, are confronting these expanding data sets on a daily basis. At the same time, the IC is experiencing a reduction of skilled senior analysts. At a time when all-source, multi-int, and open-source analysis are becoming critical tools in counter-terrorism (CT) and other urgent national security needs, any gaps in knowledge, skills or experience must therefore be seriously examined and remedied.

These challenges are familiar but new influences are exacerbating these gaps. Open source information has grown dramatically, driven by traditional news outlets offering digital editions and nontraditional media such as blogs and social media. Open-source intelligence (OSINT) has assumed greater importance as conflict zones are often in regions that lack traditional infrastructure and communications networks. Insurgent groups thus employ social networks to rapidly disseminate their message. Innocuous social media can also mask clandestine communication and terrorist groups can employ steganography to exploit images and videos. In summary, *analysts are facing unprecedented volumes of information and an acute requirement for advanced analytical techniques*.

THE EXPERIENTAL GAP: CURRENT APPROACHES TO TRAINING ANALYSTS

The IC numbers seventeen agencies, each with its own training practices. These practices become particularly distinctive as analysts advance. Yet even at *ab initio* levels, each intelligence agency has an established schoolhouse and defined specialty progressions. DIA's Academy for Defense Intelligence, for example, oversees a comprehensive Enterprise Learning Architecture to support on-demand access to an array of mission essential learning content. At NGA, training is managed by the National Geospatial-Intelligence College (NGC), which offers courses, seminars, workshops and online training covering GEOINT related skills and technologies. The CIA's Sherman Kent School for Intelligence Analysis, the FBI's College of Analytical Studies, and ODNI's virtual National Intelligence University are other examples of such *ab initio* training.

Even within a single organization, the process of training analysts can differ across analysis disciplines, which employ different techniques and have evolved distinctive cultures. And most formal training of analysts is focused on organizational procedures, basic analytic techniques and reporting practices and style. The critical skills of thinking and reasoning in context and making intelligence judgments in accordance with proven methods are acquired through years of practice, through informal apprenticeships that evolve organically in the workplace. For this reason, a limiting factor in creating productive analysts is not the capacity of the schoolhouses but the availability of continual mentoring and first-hand encounters with the diverse and frenetic world of the analyst.

Tradecraft & Analysis Learning using Intelligence Scenarios with Methods- Anchoring (TALISMAN) proposes a systemic improvement to address these challenges through simulation that complements and enhances existing practices. The goals of our work are twofold. First, we seek to enhance analyst training through the use of proven analytic technologies applied in context. Second, we seek to accelerate proficiency across the analyst workforce by compressing the time it would normally take for an analyst to be exposed to challenging and instructive but seldom-encountered situations. Both objectives can be addressed through the use of *method-anchored scenarios*.

A SCENARIO-BASED APPROACH TO CONTEXTUALIZE AND ACCELERATE LEARNING

Simulated Scenarios for Making Learning Authentic

The guiding principle behind TALISMAN is method-anchored scenarios. *Method* refers to the intelligence analytic methodology being trained. *Scenarios* refer to chain-of-event story lines within which users can engage in learn-by-doing (Dewey, 1938). Scenario-based approaches to learning draw from several educational theories including constructivism (Duffy & Jonassen, 1992; Bednar, Cunningham, Duffy & Perry, 1992), situated learning (Lave & Wenger, 1991) and guided apprenticeship-styles of learning (Gott, 1989; Collins, Brown & Newman, 1989).

A framework influential in our conception of TALISMAN is goal-based scenarios (GBS). In a GBS (Schank, Fano, Bell & Jona, 1994) the user is engaged in pursuing a goal, within a simulated environment, in order to master a set of target skills. A central tenet of the GBS framework is that goals must be neither decontextualized nor pursued in isolation from each other; if the scenario is structured properly, successful completion of the mission is reliable evidence that the user has accomplished the target skills. This model provided a baseline framework that we augmented and tailored in deriving an instructional approach to TALISMAN.

Simulated Scenarios for Compressing Time to Achieve Proficiency

Research in expertise generally supports the close relationship between exposure to a broad array of problem-solving episodes and the ability to cope effectively with novel situations (Gott, Hall, Pokorny, Dibble & Glaser, 1992; Hatano & Inagaki, 1986). Contemporary definitions of expertise cite the capacity to function effectively when confronted by new problems as a hallmark of expert performance (Bransford, Brown & Cocking, 2000; Holyoak, 1991). Thus one reason for the lengthy process of achieving expert proficiency is that first-hand exposure to a broad range of problems can take years or even decades, since "novel" problems are, by definition, seldom encountered.

The use of simulated scenarios can compress this cycle by immersing the learner in challenging situations unlikely to be encountered in actual practice; situations that are plausible, relevant and important, yet highly infrequent. Scenarios can present the user with such events in a highly-compressed time frame. Establishing scenarios that are both challenging and varied can thus accelerate learning and shorten the duration for achieving threshold levels of proficiency (Hoffman, *et al.*, 2013; Hoffman, Feltovich, Fiore, Klein & Ziebell, 2009).

NEED FOR METHODOLOGY TRAINING

We discussed above the rapid growth in the volume of raw data confronting analysts, and the general contraction in the pool of skilled senior analysts. But specific factors are driving an acute need for methodological and tradecraft analyst training: (1) Insurgencies in alternatively-governed regions, remote conflict zones and denial and deception result in collection gaps; (2) Events unfold quickly; activity precursors can be conducted at rapid OPTEMPOs with short durations; (3) Analyst expertise is often both discipline-specific and region-specific, creating challenges in responding to new intelligence requirements in regions that had not been actively prioritized; and (4) The ability to fuse information from multiple disciplines has become more critical to generating timely and reliable alerting. However the process of bringing disparate products and analysts into an investigation can be ad hoc and is seldom trained or applied in a standardized fashion. In summary, analysts face unprecedented volumes of information and an acute requirement for advanced analytical techniques.

To address this need, the DOD and IC have invested significant resources in computational tools that parse, filter, fuse, correlate and summarize digital data. As a result, the productivity of intelligence analysts has been significantly augmented through a range of powerful, indispensable tools to combat the unprecedented volumes of information, an expanding demand for intelligence products, and a complex array of rapidly shifting threats. Despite these advances, the utility of an analyst still depends on experience and tradecraft. Moreover, the advantages that automation provides are attenuated by a user's skill level; advanced systems are best leveraged by users possessing a comprehensive understanding of the data sources and intelligence requirements influencing the analysis activity. The critical need for effective tradecraft is heightened by the emphasis on Activity-Based Intelligence (ABI), which has focused interest away from specific targets and more on events, movements and transactions in a given area. For analysts to succeed in providing understanding into adversary networks, conventional threats and asymmetrical warfare, effective tradecraft remains essential.

SCENARIO-BASED INTELLIGENCE METHODOLOGY TRAINING

Simulations that employ scenarios provide both an authentic context for learning and a mechanism for accelerating proficiency. What distinguishes TALISMAN from scenario-based approaches in general is the focus on training a specific analytic methodology; we call this method-anchored scenarios. Our premise is that proven methods are best taught in tangible, authentic contexts. In these contexts, users organically encounter the need to learn and employ target tradecraft and methodology skills in realistic situations.

Exemplar Methodology: Composite Signature Analysis

To illustrate the application of method-anchored scenarios, we select an exemplar methodology developed by Intelligent Decision Partners (IDP) based on the construct of composite signatures. Signature data typically are, or are derived from, "high-fidelity measurements of targets of interest, in the context of their application, use or production, to allow the current or future unique identification of such targets" (US Government Printing Office, 1996). A *composite signature* "is a group of signatures that are related in such a way to more completely or further define a target or operational endeavor at a higher fidelity" (Hawley, *et al.*, 2011). IDP developed a methodology for analysts to effectively employ composite signatures in identifying a range of phenomena, including illicit activity, clandestine locations, or enigmatic facilities. This methodology, called Location and Analysis of Secondary and Tertiary Signatures (LASETS), serves as the exemplar methodology to illustrate method-anchored scenarios.

The LASETS process (Figure 1) supports assessments of whether a specific phenomenon belongs to the category of interest and searches over regions of interest to flag possible occurrences. LASETS can identify facilities and track activity and can be applied to anything that generates observable or detectable evidence (directly or indirectly). This technique is thus well-suited for use across multiple disciplines, for instance cyber or the financial sector.
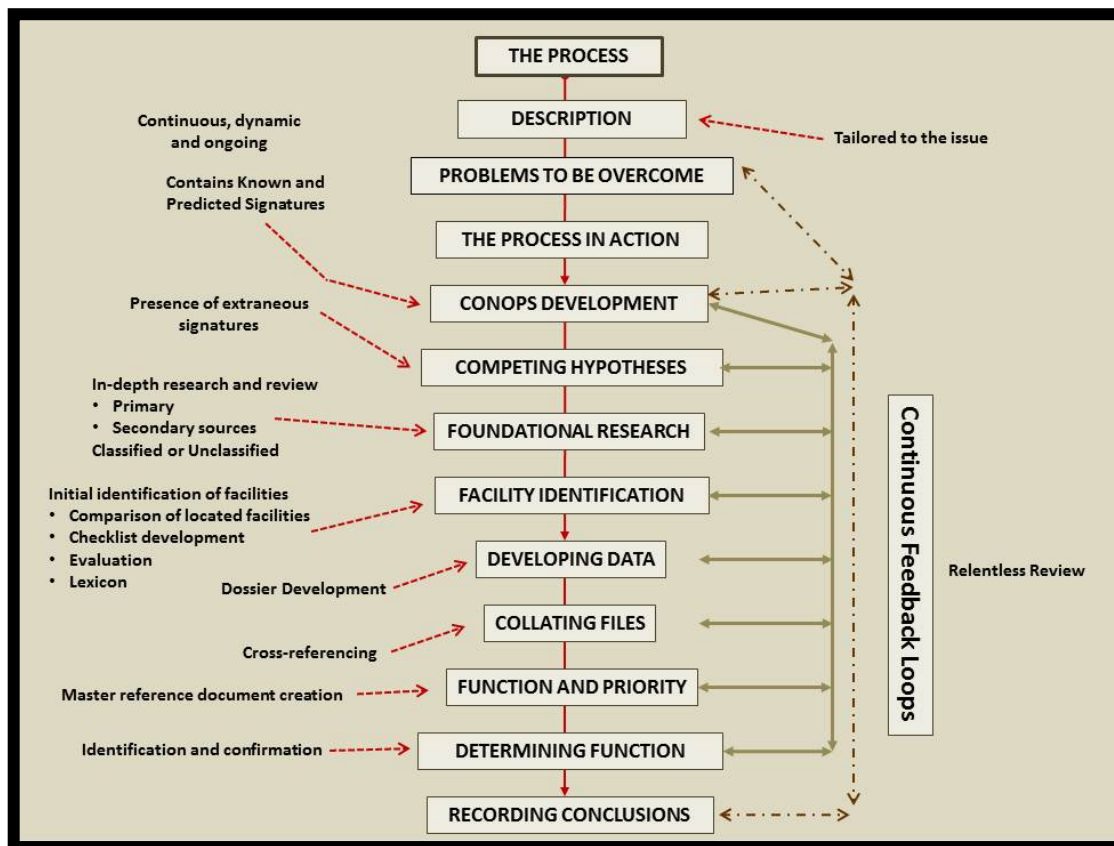

Figure 1. Schematic of LASETS process flow.

An analyst uses the LASETS process to fuse information developed from the various intelligence disciplines and reporting to develop a more complete assessment of observed events, facilities, installations, functions or activities. LASETS represents an analytic process that is both sustainable and repeatable.

Instantiating the Method in Training Scenarios

Designing a course of instruction based on the TALISMAN approach requires a principled, systematic and repeatable process (Table 1). Production, testing, evaluation and integration are not discussed here.

Table 1. Process for Instantiating Method-Anchored Scenario Training

Step 1: Front-End Analysis	Identify exemplar target(s) of interest, analyst audience, existing training tools, practices and gaps, operational requirements and current performance drivers. Create detailed training and performance objectives for applying the target methodology (*e.g.*, composite signatures analysis).
Step 2: Scenario-based Training Design	Develop instructional design and syllabus. Create the story context, event sequence and challenge problems that align with the training objectives created in Step 1. Scenarios should encapsulate all required performance objectives and be plausible, engaging and meaningful.
Step 3: Implementation Design	Design TALISMAN prototype to employ web-accessible training technologies; Identify automation support systems that are currently in use or envisioned, and tailor the training plan to adapt chosen analytic method into the current workflow.

Step 1: Front-End Analysis

During the front-end analysis (FEA), we define the exemplar target(s) of interest, intended analyst audience, existing training tools, practices and gaps, operational requirements and current performance drivers. Although scenarios are the focus of this paper, the use of any scenario must be driven first and foremost by the instructional objectives. Below are the general skills that our example training will address. Later we introduce an example, though the skills below are relevant across a spectrum of intelligence analysis.

- Locate, define and identify targets, functions, facilities and installations
- Investigate identified facilities through message traffic, imagery and HUMINT information
- Review collection strategies employed against the defined facility
- Identify secondary and tertiary signatures supporting the identified location
- Track identified secondary and tertiary signatures over time, from origin to present day
- Capture and define signatures for later use against additional targets
- Recommend the application of advanced technologies to determine the function of the identified facility
- Recommend or coordinate additional collection where possible and required
- Examine relationships between the suspect facility or activity and other identified functions
- Develop timelines of the identified function, facility or installation
- Document the identified function, facility or installation in its present-day state
- Document the developed methodology
- State outcomes and list conclusions
- Note gaps
- Identify key players at the national, regional, district or local level.
- Identify political, economic, scientific and military personnel
- Identify civil-military infrastructure
- Capture information on criminal elements supporting the activities investigated

- Develop constructive hypothesis testing (primary and competing hypotheses)
- Demonstrate sound rationale and investigating based upon characteristics, observables and signatures
- Effectively utilize IMINT and MASINT as appropriate to the problem set
- Apply HUMINT, SIGINT and OSINT as appropriate (*e.g.*, tip offs to location and insights to function)
- Apply existing technical intelligence systems to enigmatic facilities
- Examine relationships among factors rather than examining factors in isolation
- Develop relationships between military and civil infrastructure to identify high-value facilities
- Develop command and control hierarchies
- Correlate monetary, other resource investment as a measure of regime interest and involvement
- Provide conclusions which point to high-value activity
- Corroborate events
- Identify previously unknown high-value targets
- Validate existing target sets

Step 2: Scenario-based Training Design

The next step is to develop an instructional design plan for achieving the training objectives defined in Step 1 that encapsulates performance objectives within a scenario-based approach to training. The *Goal-Based Scenarios* (Schank, Fano, Bell & Jona, 1994) framework mentioned previously is highly applicable to intelligence analyst training. This step thus focuses on the authentic contexts where the user organically encounters the need to apply the target skills (as opposed to artificial examples that de-contextualize skills and knowledge). This scenario-based approach to training has been widely demonstrated, including previous work by the lead author in air-ground communication in coalition operations (Bell, 2012), counter-IED (Bell, Jarmasz & Nelson, 2011), US Air Force pilot training (Bell, *et al.*, 2010), tactical mission planning (Bell & Short, 2009), bridge watchstanding (Bell, White & Tompson, 2008), and close air support (Bell, Johnston, Freeman & Rody, 2004). A universal and expected outcome of this work is that the training effectiveness of this approach hinges on the scenarios themselves, including content, learning objectives and performance metrics. Development of effective scenarios thus requires deep experience in the domain, to create relevant and meaningful contexts, and in instructional design, to properly address requirements, sequencing (the order in which skills identified in Step 1 are trained) and performance assessment.

In this instance, each scenario must also be tailored to one or more automation systems in use within a specific user community (*e.g.*, image analysis, text analytics) – systems that an end-user already employs to support intelligence analysis. However, rather than simulating an automation system within our training solution and risk creating a narrow, one-off training solution, we adopt a broadly-applicable approach of ensuring that workflow, data sources and reporting procedures are aligned with the practices of the analyst using those systems (Clancey, 2006). The outcome of this step is a scenario-based training syllabus to align with current practices that trains analysts in effectively employing the target methodology.

Step 3: Implementation Design
A TALISMAN training course provides analysts with methods training using web-accessible technologies. The training will address the requirements (from Step 1) and training design (Step 2) to enable analysts to apply a proven, systematic methodology in intelligence analysis.

The architecture defines the functional components and the information linkages needed to support content management, delivery and learning management (LMS). Our emphasis is on developing new training, not on creating new technologies. There is an abundance of technology that the USG has already funded; COTS and GOTS products that can deliver a repeatable approach well-suited for methods-anchored scenarios and future expansion. For creating web-based training, there is a large number (138, based on preliminary research) of COTS tools and several GOTS products (*e.g.*, ROCCE, GIFT). However, because TALISMAN is intended to accommodate self-paced, classroom-based, or blended learning, it is necessary to present different views and privileges based on authenticated role (*i.e.*, student or instructor). A specific implementation can be built within, or integrated with, existing LMS, whether COTS (like Blackboard or Canvas), or GOTS (like AtlasPro or Joint Knowledge Online). Our initial focus is on the IC-wide Advanced Global Intelligence Learning Environment (AGILE).

EXAMPLE

To illustrate these principles, we present an abbreviated example of analyst training. The overall goal is to help analysts become proficient in effectively employing a given methodology, composite signatures analysis. The example material in this paper has been adapted to facilitate public release but is sufficient to illustrate our approach.
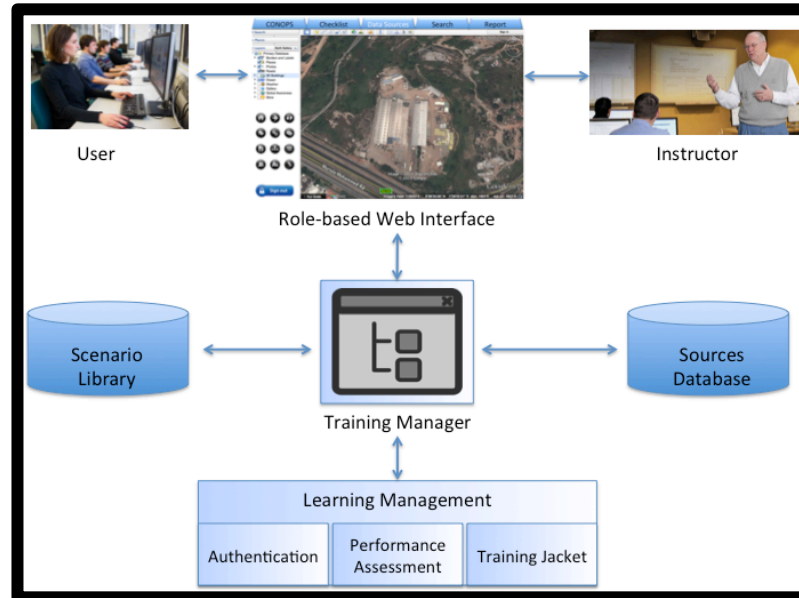
Figure 2. Schematic Depiction of TALISMAN Training Architecture.

Step 1: FEA

The Step 1 FEA results in the objectives listed below. The performance metrics will enable standardized, replicable and reliable assessments of user proficiency on these skills.

- Locates, defines and identifies targets, functions, facilities and installations
- Investigates phenomena using message traffic, imagery and HUMINT from open-sources or as available
- Reviews collection strategies employed against the defined facility, activity or process
- Tracks identified secondary and tertiary signatures over time, from origin to present day

Step 2: Scenario-based Training Design

The training syllabus is organized into four exercises, each addressing the identified performance objectives.

1. Concept of Operations (CONOPS) Development: In this exercise the student will create a CONOPS specifically tailored to the phenomenon (facility, process or activity) to be identified. The CONOPS is developed from research concerning the object, subject, or target that the process is to be employed against to identify the primary, secondary and tertiary characteristics, observable and signatures that should exist.

2. Competing Hypotheses: In this exercise the student will define and apply competing hypotheses to minimize bias when evaluating data. The CONOPS defines signatures that should be present; additional signatures found at the suspect location not related to the principal phenomenon generate further competing hypotheses.

3. Identification: In this exercise the student will identify facilities, activities or processes by comparing, contrasting and correlating data. The student will develop the information contained within the reporting into a listing of leads, facts or other key items of information that can be confirmed through imagery or other assets. Wherever possible the student will use original reporting and primary sources.

4. Determining Function: In this exercise, the student will identify activities by incorporating secondary and tertiary signatures analysis. Identifying activities from imagery sources is difficult. It is rare for messaging traffic to be confirmed through imagery analysis. Many functions required for certain activities are protected or hidden from view. Secondary and tertiary signatures, observations or characteristics, (*e.g.* those related to access to electrical power) can be used to identify the existence of many if not most functions.

The next step is the development of story contexts in which to embed these exercises. For illustration, we employ fictitious countries created for the Carana Training Scenario, originally developed in 2002-2003 by the United Nations Department of Peacekeeping Operations (UN DPKO). We situate the intelligence problem in the border region between Carana and Sumora. A terrorist group calling itself "The Way of Truth" has been staging cross-border attacks in Carana's capital, Galasi. The growing sophistication of these attacks suggests multiple training facilities have been established. The analyst is to utilize open sources including satellite images, news feeds and social media to locate terrorist camps where training activities are taking place and to identify activities related to sites where new camps are in the process of being established.

The method-anchored scenario approach in this example is focused on composite signatures analysis as specified in the LASETS methodology, though any fully articulated method can be adapted to anchor scenarios. In this case, the analyst is engaged throughout with refining and applying a composite signature to identify and locate terrorist training camps. The actual composite signature developed for this purpose is comprehensive, specific and not publicly releasable. The highly-abbreviated and genericized version below is illustrative of the observables that the analyst is to compile and evaluate (each observable partially characterizes the target but does not indicate the availability of intelligence to verify that observable; that is part of the analyst's task).

Physical Appearance
·   Evidence of close-order drill and ceremonies.
·   Recognizable vehicular traffic patterns within the camp.
·   Arrangement of shipping containers, rocks and lumber to simulate cultural features
Structures
·   Presence of permanent buildings.
·   Presence of tents.
·   Use of tarps in tent construction.
Security
·   Evidence of outward patrolling along roads and trails.
·   Manned ambush sites along roads and trails.
·   Semi-permanent security checkpoints.
Training areas
·   Identifiable small arms training area.
·   Evidence of an explosives training area (blast marks).
·   Long, straight, open area used for rocket and rocket grenade training.

As part of the scenario, the analyst has access to the open sources that would typically be examined in this type of analysis. Examples of open source satellite imagery relevant to this scenario appear below, along with illustrations of images taken from social media and open source news feeds.
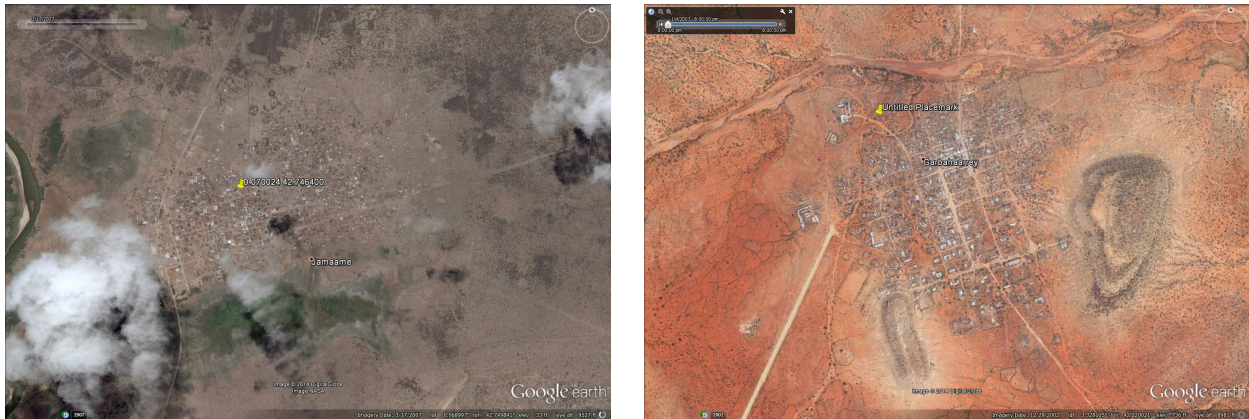
Figure 3. Example open source satellite imagery available in training scenario.

Figure 4. Examples of images extracted from social media available in training scenario.

CONCLUSION AND FUTURE WORK

Simulation as used in training contexts is a term applied to a broad range of approaches. We adopt the metaphor of simulation in this paper to illustrate a replicable approach based on a proven instructional framework that uses method-anchored scenarios to train a specific analytic methodology, composite signatures analysis. We presented an abbreviated example of applying prescribed design steps to develop instructional objectives and a scenario created to engage the user in accomplishing those objectives in an authentic context. The use of this training framework is ideally suited for intelligence applications across a broad spectrum of national security, defense, and commercial sectors. However for the TALISMAN framework to be fully implemented, adopted and standardized, the process of creating scenarios that are aligned to training goals and performance objectives must be better supported by automation. Tools for creating tutoring systems are widely reported (*e.g.*, Sottilare, Graesser, Hu & Brawner, in press), and tools for creating goal-based scenarios in particular have been previously documented (Bell, in press; Bell, 2003). TALISMAN scenarios, though, are built around training a specific method or procedure. A tool is needed that supports training developers in crafting sequences of scenario events that engage the user in the application of the specific method being trained. We plan to report in future publications the specifications for such a tool.

REFERENCES

Bednar AK, Cunningham D, Duffy TM, and Perry JD (1992). Theory into practice: how do we link? In: Duffy TM, Jonassen DH (eds.), *Constructivism and the Technology of Instruction: A Conversation*. Hillsdale, NJ: Erlbaum, 1992; pp. 18-33.

Bell, B. (in press). One-Size-Fits-Some: ITS genres and what they (should) tell us about authoring tools. In R. Sottilare, A. Graesser, X. Hu, and K. Brawner (Eds.), *Design Recommendations for Intelligent Tutoring Systems: Volume 3 – Authoring Tools*. Orlando, FL: U.S. Army Research Laboratory.

Bell, B. (2012). The Dane from Spain Trains Mainly in Bahrain: Improving Communication in Coalition Tactical Exercises. Presented at the *2012 International Training and Education Conference* (ITEC), London, UK.

Bell, B. (2003). Supporting Educational Software Design with Knowledge-Rich Tools (2003). In T. Murray, S. Blessing, and S. Ainsworth (Eds.), *Authoring Tools for Advanced Technology Learning Environments: Toward cost-effective adaptive, interactive, and intelligent educational software*. Kluwer: Dordrecht, Netherlands.

Bell, B. and Short, P. (2009). Spoken Dialogue: Extending Embedded Virtual Simulation with a Very Human Dimension. In *Improving Human Effectiveness Through Embedded Virtual Simulation,* NATO Research and Technology Organisation Scientific Publication RTO-MP-HFM-165, Oct 2009.

Bell, B., Jarmasz, J., and Nelson, I. (2011). Development of Scenario-Based Pre-deployment Counter-IED Training. In *Proc. of Interservice/Industry Training, Simulation, and Education Conf* (I/ITSEC), Dec, 2011.

Bell, B., Johnston, J., Freeman, J., & Rody F. (2004). STRATA: DARWARS for Deployable, On-Demand Aircrew Training. In *Proc. of Interservice/Industry Training, Simulation, and Education Conf (I/ITSEC)*, Dec., 2004.

Bell, B., White, M. and Tompson, G. (2008). Enhancing PC-based Bridge Training with Electronic Navigation and Speech-Interactive Agent Capabilities. Presented at the *Doha International Maritime Defence Exhibition & Conference* (DIMDEX 2008), Doha, Qatar.

Bell. B., Billington, S., Bennett, W., Billington, I., and Ryder, J. (2010). Performance gains from speech-enhanced simulation in military flying training. *Journal of Defense Modeling and Simulation*, *7*(2), 67-87.

Bransford, J. D., Brown, A. L. & Cocking R. R. (2000) How People Learn: Brain, Mind, Experience, and School (expanded edition). Washington: National Academy Press

Clancey, W.J. (2006) Observation of work practices in natural settings. In A. Ericsson, N. Charness, P. Feltovich & R. Hoffman (Eds.), Cambridge Handbook on Expertise and Expert Performance. New York: Cambridge University Press, pp. 127-145.

Collins A, Brown JS, and Newman S. (1989). Cognitive apprenticeship: teaching the crafts of reading, writing, and mathematics. In: Resnick LB (ed.), *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser*. Hillsdale, NJ: Erlbaum, 1989; pp. 453-94.

Dewey J. (1938). *Experience and Education*. New York: Macmillan, 1938.

Duffy TM, and Jonassen DH (1992). Constructivism: new implications for instructional technology. In: Duffy TM, Jonassen DH (eds.), *Constructivism and the Technology of Instruction: A Conversation*. Hillsdale, NJ: Erlbaum, 1992; pp. 1-15.

Gott SP (1989). Apprenticeship instruction for real-world tasks: the coordination of procedures, mental models, and strategies. In: Rothkopf EZ (ed.), *Review of Research in Education*, Vol. 15. Washington, DC: American Educational Research Association, 1989; pp. 97-169.

Gott, S., Hall, P., Pokorny, A., Dibble, E., & Glaser, R. (1992) A naturalistic study of transfer: Adaptive expertise in technical domains In D. Detterman & R. Sternberg (Eds.) *Transfer on Trial: Intelligence, Cognition, and Instruction* 258–288. Norwood, NJ: Ablex.

Hatano, G. and K. Inagaki (1986). Two courses of expertise. *Child development and education in Japan*: 262–272.

Hawley, C.T., Carpenter, T., Cappelaere, P.G Frye, S., Lemoigne-Stewart, J.J., Mandle, D., Montgomery, S., and Williams-Bess, A. (2011). Developing composite signatures. *Proc. SPIE 8040, Active and Passive Signatures II*, 804002 (08 Jun 2011); doi:10.1117/12.888883.

Hoffman, R. R., Feltovich, P. J., Fiore, S. M., Klein, G., & Ziebell, D. (2009). Accelerated Learning (?). *IEEE Intelligent Systems, 24(2),* 18-22.

Hoffman, R. R., Ward, P., Feltovich, P. J., DiBello, L., Fiore, S. M., and Andrews, D. (2013). Accelerated expertise: Training for high proficiency in a complex world. New York, NY: Psychology Press.

Holyoak, K. J. (1991) Symbolic Connectionism: Toward third-generation theories of expertise In K. A. Ericsson & J. Smith (Eds.) *Toward a General Theory of Expertise: Prospects and Limits* 301-335. Cambridge, UK: Cambridge University Press.

Lave J, and Wenger E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge: University of Cambridge Press, 1991.

Schank RC, Fano A, Bell BL, and Jona MK (1994). The design of goal based scenarios. *Journal of the Learn Sciences* 1994; **3**: 305-45.

Sottilare, R., Graesser, A., Hu, X., and Brawner, K. (Eds.) (In press), *Design Recommendations for Intelligent Tutoring Systems: Volume 3 – Authoring Tools*. Orlando, FL: U.S. Army Research Laboratory.

US Government Printing Office (1996). IC21: The Intelligence Community in the 21st Century, Staff Study, Permanent Select Committee on Intelligence, House of Representatives, 104th Congress. USGPO, June 5, 1996.