

**Use of a Virtual Biological Threat Environment to Support Test and Evaluation  
(T&E) of the Biological Aerosol Warning System (BAWS) in the Integrated  
Biodetection Advanced Technology Demonstration  
(Bio ATD)**

*Ralph Liebert*

West Desert Test Center  
Dugway Proving Ground  
STEDP-WD-L, Life Science Division  
Dugway, UT 84022  
rliebert@dugway-emh3.army.mil

*Dennis L. Jones*

ITT Industries, Systems Division  
Huntington Ave.  
Alexandria, VA  
703-329-7181  
dennis.jones@itt.com

*Michael J. O'Connor*

ITT Industries, Systems Division  
600 Boulevard South, Suite 208  
Huntsville, AL 35806  
256-650-2732  
michael.oconnor@itt.com

*Dr. David Sickenberger*

Program Director for Biological Defense  
Edgewood Chemical Biological Center  
Soldier and Biological Chemical Command  
Aberdeen Proving Ground, MD 21010  
david.sickenberger@sbccom.abgea.army.mil

*Walter Zimmers*

Defense Threat Reduction Agency  
6801 Telegraph Rd  
Alexandria, VA 22310  
703-325-1135  
walter.zimmers@dtra.mil

Keywords:

Virtual Testing, Sensors, Environments, Virtual Proving Grounds

**ABSTRACT:** This paper discusses the development and application of a system enabling virtual testing of the Biological Aerosol Warning System (BAWS) and the results of BAWS operators evaluation generated from virtual trials conducted at the West Desert Test Center (WDTC), Dugway Proving Ground (DPG), Utah. The Army's Edgewood Chemical Biological Center (ECBC) is developing the BAWS as part of the Army's Integrated Biodetection Advanced Technology Demonstration (Bio ATD). The BAWS is an array of point biological aerosol detectors networked to detect biological agent aerosol attacks while mitigating false alarms. As part of the Bio ATD, WDTC challenged the BAWS using live (biological agent simulants) and virtual test techniques to generate data for BAWS operators evaluation. To support virtual testing, a Hazard Environment MICAD Interface (HEMI) provided digital stimulation to the BAWS sensors providing computer-generated hazard environment information. The virtual test capability allowed for expanded operational testing, easily modifiable test configurations for the assessment of

parameters not feasible in live tests, and continued system evaluation during periods which meteorological conditions were not within correct parameters to allow live testing..

## 1. Introduction and Background

The troops of the United States and its Allies are facing the increased threat of adversary employment of biological weapons. The DoD is investing considerable resources in the development of systems to mitigate the effects of such weapons. These initiatives include counterproliferation systems focused on denying the threat prior to use; active defenses such as Patriot missile defense system; passive defense systems including detection and warning and reporting networks; and individual and collective protection gear. To support the detection and warning mission, the Army's Edgewood Chemical Biological Center (ECBC), since fiscal year 1996, has been developing the Biological Aerosol Warning System (BAWS) as part of the Army's Integrated Biodetection Advanced Technology Demonstration (Bio ATD). An exit criterion for the ATD is a Battle Lab Warfighting Experiment (BLWE) that the Army (led by the Maneuver Support Center) is conducting in phases from Dugway Proving Ground, Utah, and from a number of locations in support of various DoD training exercises [1]. This BLWE use soldiers working with a hybrid hardware/software system to demonstrate the military worth of the ATD technologies and provide soldier interface data.

The BAWS is an array of point biological aerosol detectors networked to detect biological agent hazard attacks while mitigating the likelihood of false alarms. It employs multiple sensors and complex sensor logic to screen out background spikes that often provide false alarms. BAWS program managers are employing modeling and simulation to support the testing of the BAWS. The Army first demonstrated the virtual test system in a series of tests conducted between Librascope's Glendale, California, facility and ITT Industries, Systems Division's Alexandria, Virginia, Simulation Laboratory. Results of this testing are documented in a report by Michael O. Kierzewski, *et al.* of OptiMetrics, Inc. [1].

In this paper, we discuss the BAWS components and architecture and the supporting live and virtual testing. We also discuss benefits derived from BAWS virtual testing, the use of existing environment and sensor simulations and architectures developed by a consortium led by ECBC and the Defense Threat Reduction Agency (DTRA), data collection techniques, and calibration of the systems with live sensor data. We conclude with our observations on the correlation of live and virtual testing and the applicability of the architecture in supporting operational evaluations and potential virtual testing.

### 1.1 BAWS

The BAWS consists two sensors: Tier I and Tier II. For the set of virtual trials reported in this paper, only the Tier I sensor was challenged in controlled tests at DPG, while the Tier II sensor was digitally challenged during some training exercises. The Tier I sensor is a Met One sensor (particle sizer/counter) that uses laser light scattering technology to provide particle counts and determines particle size between two size ranges, 2 and 10 microns ( $\mu\text{m}$ ). The Tier I calculates a running mean of the particle concentration and variance from that. These parameters are used in the sensor's internal logic to determine when it "sees" a suspicious event that may be a biological agent attack. For virtual testing the Army modified the Tier I sensors to accept simulated agent counts from the MICAD display/controller (BAWS Base Station). The BAWS treats these simulated particle counts as actual agent particle counts, adding them to any naturally occurring background counts currently being detected. The decision logic for the digitally stimulated BAWS remains unchanged, and the operation of these modified sensors is identical to that of the unmodified sensors. [1]

The Tier II sensor, developed by MIT-Lincoln Labs, uses three lasers of differing wavelength to enumerate biological particles, rather than all particles, present in an aerosol cloud. Currently the BAWS is deployed with fewer Tier II sensors those are placed advantageously for the protection of a vulnerable assets, in an attempt to reduce the overall cost of the protection system. The Tier II sensor is designed to accept simulated data.

The BAWS are deployed as a network of sensors reporting to the BAWS base station (BBS). The sensors continuously count background particles. When the BAWS detects a three-sigma (depending on meteorological conditions) rise in particle count it sends an alert to the BBS. Localized non-hazard events can cause an individual BAWS sensor to alert. To reduce false alarms, the BBS only generates an alarm when three or more co-located BAWSs generate a simultaneous alerts or if the Tier II sensor detects biological particles.

Testing of the BAWS requires trigger of sensors spread over a relatively large geographical area with approved biological agent simulants. The hazard environments used in live testing—if they are to be representative of real threats—must be correlated at each of the sensors.. Stimulating individual BAWS sensors with uncorrelated triggers (*vs.* a coherent hazard representation) will lead to inadequate and unreliable detection algorithms. These

factors limit live testing to the WDTC. Testing in other locations requires a virtual cloud representation.

### 1.2 West Desert Test Center

The WDTC, located at Dugway Proving Ground, Utah, is the DoD focal point for test and evaluation (T&E) of chemical and biological (CB) weapons defense equipment. The CB defense test mission centers around testing equipment and methodology for contamination avoidance, decontamination, and collective and personnel protection. Testing is conducted with real chemical and biological weapons agents in surety and biosafety level-3 laboratories and with agent simulants in outdoor field testing. The DoD has focused resources at WDTC providing the infrastructure and expertise for a Joint Service (JS) developmental and operational CB defense testing capability unsurpassed throughout the world. Additionally, WDTC is home to an internationally recognized meteorological division, which plays an integral role in the CB defense test mission.

WDTC is developing and implementing computer modeling and simulation (M&S) and digital testing to augment and enhance the CB defense test mission in coordination with the US Army Developmental Test Command (DTC) Virtual Proving Ground (VPG). The DTC VPG will be the T&E cornerstone for DoD's Simulation Based Acquisition (SBA) initiative, a revolutionary process for conducting traditional DoD acquisitions. As part of a new way to conduct CB defense equipment testing, the WDTC is developing and acquiring models and simulations that provide digital representation of important test parameters and systems under test. WDTC has teamed with ITT Industries to provide a digital representation of the CB threat environment using the Nuclear, Chemical, Biological, and Radiological Environment Simulator (NCBR).

The Bio ATD is the first test at WDTC incorporating both live and digital stimulations of test hardware, the BAWs Tier I units. Digital representations of biological threat clouds from the NCBR and real biological threat simulants from aerial disseminations were used in complementary fashion during a four-week test period to evaluate the performance of US Army and Marine personnel in their operation of the BAWs Base Station (BBS). Digital challenges from the NCBR were used solely to evaluate system connectivity and performance following deployment of the BAWs by *average* soldiers. Digital stimulation of the BAWs was conducted during nighttime trials when unfavorable meteorological conditions persisted, precluding dissemination of live biological agent simulants—and during daytime trials conducted after BAWs deployment exercises.

Additional components of the BLWE consisted of supporting two live training exercises for the US Army and the US Air Force. The BAWs was deployed at the Ft. Lewis Yakima Army Training center in support of Ulchi-Focus Lens subexercise and at Nellis AFB in support of the Joint Expeditionary Forces Exercise – 99 (JEFX-99). The BAWs was solely challenged with simulated aerosol clouds for both of these exercises.

## 2. Simulations

The BAWs testing used a mix of existing simulations and new simulations linked using distributed simulation standards. The first round of testing used the Distributed Interactive Simulation (DIS—as defined in IEEE 1278.1a) for simulation connectivity. Future versions will use the DoD's High Level Architecture (HLA) and the Real-time Platform Reference (RPR) Federation Object Model (FOM). Version 1 of the RPR FOM does not contain objects corresponding to the Environmental Process PDU in IEEE 1278.1a-1998, so the Army, DTRA, and supporting contractor organizations are supporting standards development activities to ensure that these data representations are supported for future testing. DTRA is currently sponsoring the migration of NCBR to the HLA as part of its Weapons Effects Conformation—High Level Architecture initiative managed by the DTRA Counterproliferation Support and Operations Directorate's WMD Assessment and Analysis Center.

The NCBR and the Hazard Environment MICAD Interface (HEMI) served as the two principal simulation tools for the BAWs testing. The Army's ModSAF provided operational context for the trials. The MaK Stealth and Data Logger supported 3D visualization and data logging for after-action review and analysis. Figure 2-1 shows the architecture used in support of the BAWs virtual testing.

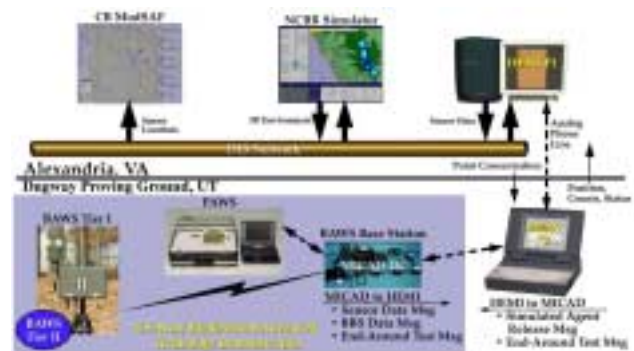


Figure 2-1: The BAWs simulation architecture leveraged existing software applications.

## 2.1 Hazard Environment MICAD Interface (HEMI)

The HEMI provides the digital hazard representation for the BAWs sensors. The Army's Edgewood Chemical Biological Center sponsored HEMI development to support BAWs testing. The HEMI receives the biological hazard cloud as a series of Gaussian puffs generated by the NCBR. The BBS sends the location of each BAWs to the HEMI. Using the location and virtual hazard cloud, the HEMI calculates the number of particles for each sensor. The HEMI sends the simulated particle count for each BAWs to the BBS. To facilitate integration ITT Industries and Librascope developed an interface control document (ICD) to define the messages between the HEMI and BBS. The HEMI and the BBS are connected via a serial interface. For the initial testing, the HEMI and BBS were connected directly with a serial cable. The communications facilities at WDTDC did not support a direct connection, so the HEMI and BBS were linked with radio modems.

The bandwidth required for communications between the HEMI and BBS is low. The bandwidth required to support the hazard cloud puffs is high. The serial connection between the HEMI and BBS required that the HEMI be physically close to the BBS. The high bandwidth requirement for the puffs required the HEMI to be located with the NCBR. These competing needs required the HEMI to be in two places at one time. To accomplish this the HEMI is divided into two parts, referred to as HEMI P1 and HEMI P2. The HEMI P1 is generally co-located in simulation facility with the NCBR and other simulation tools. The HEMI P2 is located on the testing range with the BBS. The P1 and P2 are connected via modem/routers making the connection appear to each as a 10Base T Ethernet. The bandwidth required between the P1 and P2 can be carried over standard phone lines. This provides a reach-back capability from the range to a simulation center.

Efficient management of the Gaussian puffs received from the NCBR is a significant part of the HEMI. Puff management is discussed in detail in *Developing Biological Hazard Detection Tactics, Techniques, and Procedures Using Distributed Simulation 98F-SIW-140* [2].

## 2.2 Nuclear, Chemical, Biological, and Radiological Environment Simulator (NCBR)

The NCBR is an existing simulation developed by a consortium led by the Army's Edgewood Chemical Biological Center and the Defense Threat Reduction Agency to provide hazard clouds for distributed simulation. In real time, the NCBR calculates a high-fidelity, three-dimensional (3D) hazard environment as a function of hazard delivery system (source term),

meteorological conditions and complex (3D) terrain. The DTRA SCIPUFF and the Naval Surface Warfare Center's VLSTRACK Gaussian puff models provide the means for the NCBR to calculate CBR hazard environments. The NCBR makes the data available to other simulations via full 3D representations of the environments (instantaneous air concentration), 2D grids (dose, deposition, air concentration, and lethal dose, or LD, contours), and at a point via a subscription process. Figure 2.2-1 portrays a sample 2D conformal (to terrain) NCBR instantaneous air concentration calculation showing the effect of complex terrain on the cloud. SBCCOM has served as the proponent for configuration control and release of the NCBR and DTRA WMD Analysis and Assessment Center is supporting the migration of the tool to the DoD's emerging High Lever Architecture (HLA) standard for distributed simulation.

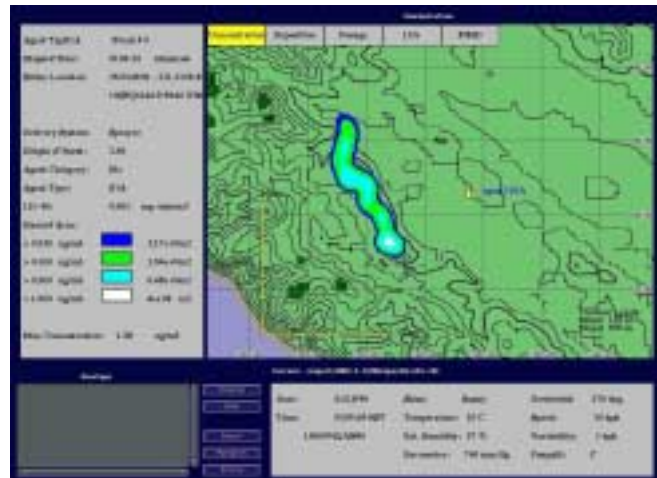


Figure 2.2-1 NCBR 2D Concentration Contour

The NCBR met the BAWs testing requirements by developing dynamic and coherent hazard cloud representations (see discussion in section 1.2). The Bio ATD architecture used the HEMI to calculate particle counts at each sensor's location based upon simulated threat biological weapons attacks.

The NCBR has been discussed in associated SISO papers including *Transferring Ownership of ModSAF Behavioral Attributes 99S-SIW-097* [3] and *Developing Biological Hazard Detection Tactics, Techniques, and Procedures Using Distributed Simulation 98F-SIW-140* [2].

## 3. Test Plan

The Army developed the Bio ATD/BLWE test plan to demonstrate the military utility of the ATD technologies and provide soldier interface data. The BLWE uses a combination of live biological simulant aerosol challenges

and virtual biological aerosol challenges to stimulate the BAWs Tier I sensor array, providing BBS operators with a realistic representation of a biological weapon attack. The test plan defines a preliminary two-week test period in March 99 as a preparation for live and virtual test procedures and methodologies. Live biological simulant aerosol testing was scheduled for a four-week test period in June 99 with two weeks of virtual testing concurrent with live testing supporting evaluation of BBS operators. The final week of testing—for the evaluation of soldiers deploying the BAWs—consisted solely of virtual challenges. Additionally, evaluation data from two live training exercises is included in the BLWE assessment.

Traditional live testing for agent-sensing devices consists of a series of simulant aerosol clouds generated in a fashion as to emulate a BW attack. Limitations in dissemination technologies for live simulant releases result in a reduced capability for testers at WDC to emulate BW attacks. Generation of simulant aerosol clouds from ground and airborne dissemination devices can only approximate a cloud from a BW munition. Additionally, meteorological conditions must exist which favor transport and diffusion of the cloud at ground level across an established test grid on which the test devices are located. Dissemination limitations and unfavorable meteorological conditions reduce the effectiveness of live field-testing.

Incorporation of a virtual test system in the Bio ATD/BLWE test plan allows for continued evaluation of the BAWs and BBS operators performance during periods of unfavorable meteorological conditions. Additionally, a variety of BW attacks with variances in munition type, detonation location and meteorological conditions were scheduled to stimulate the BAWs Tier I sensor array. Plans were established to run simulations similar to live trials, in attempt to develop data to be used for calibration of the simulation and to develop the basis for future validation studies.

### 3.1 Live Tests

Live biological simulant aerosol challenges consist of non-pathogenic, innocuous bacteria, virus or protein used to emulate pathogenic biological weapons agents dispersed from an aerosolizing device mounted on a ground or aerial platform, which can be stationary or moving. Live biological simulant testing for the Bio ATD consisted of the simulant for *Bacillus anthracis* spores, *Bacillus subtilis* var. *niger* (commonly referred to as BG), disseminated from a compressed air dissemination device mounted on a small aircraft. The pilot flew the aircraft approximately 50 feet above ground level, disseminating on a line of one to five km over a 12-second interval. Each release contained from 8-12 kg of BG.

Meteorological conditions favorable for release include winds in the one- to six- m/s range and preferably from the south. However, test personnel could release simulants from other locations if prevailing winds dictated a change.

Live aerosol clouds, generated to challenge BAWs sensors, were refereed with TSI aerodynamic particle sizers (APS) and New Brunswick Slit Samplers (NBSS) that were co-located with the BAWs Tier I units. APS data provided total particle concentration and particle size distribution in the 0.4 to 15 micron size range. The slit samplers provided viable (live—there is a decay of the live particles with time) particle concentration. APS data are also used to determine presence of the aerosol cloud at the BAWs Tier I sensors, which is the indication for the NBSS to be started. Five NBSS were used at each site. Four were set to collect data for two minutes and were actuated in series, while one was set to collect running background data for 30 minutes. Evaluators compared data from the BAWs Tier I sensors and the referee devices.

### 3.2 Virtual Tests

Virtual trials consisted of digital representations of aerosol threat clouds generated in the NCB. The HEMI calculated particle counts for each BAWs Tier I sensor from the NCB-generated virtual hazard. Particle counts calculated by the HEMI were transmitted to the real Tier I sensors via a hardware link from the HEMI to the BBS (see Figure 2-1). The total particle counts (simulated and real background summed) were then sent back to the BBS through the normal radio communication channels for the BAWs and analyzed by the BBS with the BAWs logic to make an alarm if criteria were met. Virtual challenges can represent varying munition types, detonation locations, and meteorological conditions. Virtual challenges are limited by the ability of the underlying physics-based models to represent real environments or test items.

### 3.3 Data collection

Data collection for live testing focuses on the dissemination parameters for aerosol generation, meteorological conditions during the trial and characterization of biological simulant aerosol at the BAWs Tier I sensor locations. The primary purpose of the data generation is to determine the approximation to a real BW weapons attack and to provide additional data for BAWs alarm logic development. Data collection for virtual trials focuses on input parameters to the transport and diffusion model VLSTRACK, which generates the virtual threat cloud, including munition type, detonation location, and meteorological conditions. Data generated from the BAWs Tier I sensor output from the simulated

trials is recorded to observe the effects of varying simulation parameters. Both virtual and live stimulation of the BAWs Tier I array is used in BBS operator evaluation.

Conducting live and virtual challenges coincident to one another provides a potential opportunity to calibrate simulation output to actual data as well as validate the simulation. Calibration and validation require that simulation input parameters match actual parameters recorded during a trial. Meteorological conditions and dissemination parameters in the live and virtual trials must be similar for a data comparison. The intrinsic differences between the representation of BW attacks generated in live and virtual testing and the difficulty in representing environmental and meteorological conditions in the simulation complicate both calibration and validation.

The emphasis of the Bio ATD is the BBS operator performance evaluation and not validation of the simulation to actual data collected from live trials. Resources for a validation of the simulation are not within the scope of this study, although actual results will be analyzed to determine if they may be used for calibrating the simulation in an attempt to better emulate live field trials. Simulation of live trials could then lead to a test design enabling validation studies. Currently simulation approximates BW munitions not aerial releases from small aircraft of biological simulants.

#### 4. Test Results

The BAWs testing at WDTC had two kinds of results, enhanced operational testing and simulation calibration. The operational testing support was the primary interest of the BAWs developer (ECBC). The simulation calibration results were used to improve the simulations and provide data for future VPG actives at WDTC.

The BLWE for the Bio ATD conducted at the WDTC in June 99 provides an analysis of the performance of the BAWs in the hands of soldiers, primarily the BBS operators and the capability of *average* soldiers to setup the equipment. Additionally, live data will be analyzed to determine usefulness for simulation calibration for future robustness in system evaluation and potential validation studies. Live and virtual testing served to stimulate the BAWs Tier I sensor array to provide realistic simulated biological weapons attacks for BBS operators to respond and to check the proper connectivity of BAWs after setup. The evaluation of soldier performance in the setup and operation of the BAWs is critical to evaluation of the detection system for continued acquisition decisions.

Soldier performance evaluation for the BLWE was supported with 18 live trials conducted on 16 nights during a four week period. Experimenters conducted 44 virtual challenges during two nights of night tests and two days of day tests in a two-week period. Both series occurred in June 1999. Live trials were not conducted in accordance with specific test plan parameters. Rather, experimenters altered test configuration and execution to enable dissemination from the aircraft in locations dictated by the winds. The array of 10 BAWs Tier I sensors were configured in an east-to-west orientation 500 m apart with the preferred dissemination from the south with southerly winds (secondarily from the north if northerly winds are present). Some live trials were conducted in east/west orientations due to unfavorable wind directions in an attempt to leverage the live test configuration due to financial concerns related to the high cost of live testing. Analysis of soldier performance with the BAWs in response to live test data will be detailed in the Bio ATD/BLWE test report.

The 44 virtual trials conducted for the BLWE included a variety of BW attack scenarios providing robustness in sample number and variation. Primarily two munitions types were used as input parameters to VLSTRACK. Unitary and cluster bomblet medium range missiles with varying payload quantities served as the basis for the simulated biological aerosol clouds. Detonation location and height of the missile and meteorological conditions were varied in the simulations. Virtual tests were conducted coincident to live testing to provide continued evaluation of BBS operators during live test down times. Periods of favorable meteorological conditions were dominated by live trial attempts and left little or no time to conduct similar virtual trials. Without data from similar virtual and live trials conducted coincident to one another a comparison of soldier response to real and simulated stimulation of the detection system is hampered.

##### 4.1 Operational Testing Value

The financial investment required for the resources and infrastructure necessary to conduct live biological simulant aerosol testing is very large compared to that required for digital challenges. Live testing in the CB environment will always be required for a final check of a system's utility, capability, and readiness for battlefield deployment. However, simulation provides an economical vehicle for conducting large numbers of tests covering broad parameter spaces. These data augment live testing operational evaluation but can also be used to determine the best conditions and scenarios for live testing, preserving live testing resources for use in the most advantageous manner. Value in operational testing is the beginning to developing better simulations for use

in developmental testing, creating embedded training, and providing an organic situational analysis tool for deployment situations.

## 5. Future Plans

The recent rounds of testing of the BAWS at WDTC were part of a longer, multi-year test plan. The BAWS program will use the same simulation infrastructure to support virtual testing in FY99 at Ft. Lewis, Washington, pending funding allocation for FY00. The FY00 BAWS test program is currently configured to rely solely on virtual testing. WDTC will also use hardware and software of the BAWS for future virtual proving ground initiatives at Dugway.

### 5.1 BAWS Testing

The Army has established an aggressive test schedule for fiscal year 2000. The FY 00 testing will rely solely on digital stimulation of the BAWS networks. The Army has currently scheduled testing for Camp Smith, Hawaii, Langley Air Force Base, Virginia, Camp Pendleton, California, Panama City, Florida, Ft. Lee, New Jersey, Ft. Leonard Wood, Missouri, Ft. McDill, Florida, and the JRTC. In each case, these sites can not accommodate live testing with biological agent simulants. Virtual testing will enable testing of the BAWS at sites otherwise precluded from live testing.

### 5.2 VPG at WDTC

As part of the VPG program at WDTC, the NCBR simulation will be used to plan and execute operational tests and provide digital CB environment challenges to hardware and models of systems under test. Acquisition of the hardware and software required for simulation operation at WDTC is providing an additional tool in the arsenal of test infrastructure and methodologies. The existing simulation may be modified to support operational testing for both point and stand-off CB sensing equipment. Advances in the underlying physics-based models and incorporation of additional sensor inputs in the simulation, such as direct weather inputs, will allow for more robust testing and prepare the way to provide digital stimulation to engineering-level models representing sensor technologies. WDTC considers this a first step toward the role of the CB community to provide a T&E portion of SBA.

### 5.3 Simulation Improvements

The simulations used for the Bio ATD testing provided significant value to the testing. However, the testing revealed the need for additional capabilities. These included the capability to provide live meteorological conditions to the simulations, provide virtual

meteorological conditions to the live sensors, integrate an urban transport and dispersion model, and develop a standard verification and validation (V&V) methodology for each test use of the simulation. These added capabilities will be developed and implemented when funding is available.

Currently, at the time the test begins, the meteorological conditions are loaded into the simulations. If the live conditions change, the change is not reflected in the virtual world. The proposed capability would capture live conditions and feed them to the simulations. The virtual hazard cloud would then respond to changing conditions.

The virtual test capability is very useful when the live conditions do not permit release of a simulant cloud. Currently, during this type of test, the meteorological sensor on the BAWS would detect the live conditions which would not match the conditions used by the simulation. This mismatch has the potential to impact the detection algorithm. The proposed improvement is to provide the BAWS meteorological sensors virtual data similar to the way simulated agent counts are provided to the particle counter. This would require changes to the simulations as well as changes to the BAWS software.

The hazard cloud simulations used for BAWS testing can not model transport and dispersion in urban environments. There are proof-of-principal urban transport and dispersion models, but most do not run in real-time. In addition to running in real-time, the model must publish the hazard data in a format that can be transmitted to and used by the sensor model. Future plans include adding urban transport capability to the NCBR.

Plans for a standard V&V methodology for CB testing with the NCBR are under way. Data collected during the BAWS testing will assist laying the ground rules for the process for additional tests.

The authors, at the time of the writing of this paper, were also in the final stages of the DTRA-funded migration of the NCBR Environment Simulator to the DoD's mandated architecture for distributed computing, the HLA. Because the DoD had yet to fund the migration of any of the high-fidelity sensor models to the HLA, the NCBR developers plan to test NCBR HLA compliance and interoperability (Real-time Platform Reference Federation Object Model) with the Chemical/Biological ModSAF (variant of ModSAF undergoing incorporation into the ModSAF/OneSAF baseline) using the Army Simulation, Training, and Instrumentation Command's DIS/HLA Gateway. It will require nominal future effort to modify the existing DIS sensor models for HLA compliance.

## 6 Conclusions

While several communities have conducted virtual testing, this effort proved the benefits of using simulation to support the live testing of biological detection systems. Distributed simulation standards enabled rapid development of a BAWS virtual test capability. The Integrated Biodetection Advanced Technology Demonstration personnel modified and integrated an existing modeling and simulation infrastructure with fielded BAWS sensor in a short (few month) timeframe. This provides the DoD with a capability to test the BAWS under a broad range of test conditions, when existing meteorological conditions were unfavorable, and without releasing large quantities of biological agent simulant. The use of virtual testing provides the soldier trainees with a broader experience base and wastes less of their time waiting for favorable/acceptable meteorological conditions.

Bio ATD personnel also learned the importance of data collection. It is necessary to collect the same data (and of the same fidelity) from virtual and live tests in order to make an adequate comparison. It is also necessary to select the correct metrics when making these comparison. For example, in operational testing, it is necessary to compare soldier and system response to the live and synthetic stimuli, not necessarily specific particle counts at a specific sensor.

The Army and DTRA are exploring the use of the architecture developed and used for this effort (and previous effort—see Ref. [2]) to support a broader array of virtual testing activities. The modular nature of the architecture supports the affordable development and testing of other virtual systems.

## 7 References

- [1] Kierzewski, Michael O., *et al.* “Integrated Biodetection ATD Battle Lab Warfighting Experiment Hardware/Software Integration Demonstration” OptiMetrics, Inc., Bel Air, MD, January 1999.
- [2] O’Connor, Michael J., *et al.* “Developing Biological Hazard Detection Tactics, Techniques, and Procedures Using Distributed Simulation” 98F-SIW-140, Fall 98 Simulation Interoperability Workshop, September 1999.
- [3] LaVine, Nils., *et al.* “Transferring Ownership of ModSAF Behavioral Attributes” 99S-SIW-097 Spring 99 Simulation Interoperability Workshop, March 1999.

## Author Biographies

**RALPH E. LIEBERT** is the Virtual Proving Ground program director for the West Desert Test Center at Dugway Proving Ground, Utah. He has a background in microbiology and has managed biological weapons defense laboratory and field testing for four years. For the last two years, Mr. Liebert has managed programs supporting the development of virtual testing in biological defense testing and ground truth studies for the validation of transport and diffusion modeling. He is a member of the Synthetic Environment Focus Group for the US Army DTC Virtual Proving Ground, developing standards and integrated digital representations of test environments for Army acquisition.

**DENNIS L. JONES** is the Manager of ITT Industries Simulation Systems Section of the Simulation and Training Department in Alexandria, VA. He manages programs dealing with modeling and simulation tool development and application for WMD environments, effects, and sensor systems. He has a 13-year background in strategic and theater missile defense, counterproliferation, system integration, and weapons of mass destruction effects.

**MICHAEL J. O’CONNOR** is a senior software engineer for ITT Industries Simulation and Training Department. Mr. O’Connor leads the software development of the Nuclear, Chemical, Biological, and Radiological Environment Simulator (NCBR). Additionally he specifies requirements and develops architectures for other department products. Mr. O’Connor is an active participant in the development of distributed simulation standards as a member of the RPR FOM drafting group and the SISO Standards Activity Committee (SAC).

**DR. DAVID SICKENBERGER** is the manager of the BAWS Bio ATD development effort. He is in the office of the Program Director for Biological Defense, Edgewood Chemical Biological Center, Soldier and Biological Chemical Command.

**WALTER ZIMMERS** is Chief of the Weapons of Mass Destruction Assessment and Analysis Center, Counterproliferation Support and Operations Directorate, Defense Threat Reduction Agency.