



**Local-Rapid Evaluation of Atmospheric Conditions
(L-REAC™) System,
Volume 4 (System Evaluation)**

by Gail Vaucher

ARL-TR-5848

December 2011

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Local-Rapid Evaluation of Atmospheric Conditions (L-REAC™) System, Volume 4 (System Evaluation)

Gail Vaucher

Computational and Information Sciences Directorate, ARL

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14. ABSTRACT The U.S. Army Research Laboratory (ARL) has been studying urban environments in response to the increased urban warfare facing the U.S. Armed Forces. In the early 2000s, ARL conducted three progressively more complex urban atmospheric field studies aimed at characterizing the airflow and stability around a small cluster of urban buildings. Three disaster response drills were executed during the final field study. From this experience, the need to link health and safety professionals with timely and relevant atmospheric-environment data came into focus. After surveying available technologies and system implementations, ARL saw a niche for and has constructed an emergency first responder's operational decision aid called the "Local-Rapid Evaluation of Atmospheric Conditions (L-REACT™) System". As part of the technology transfer process, a detailed evaluation of the L-REACT™ System was conducted by volunteer and professional emergency first responders. This report documents the evaluation process, results and recommendations. In short, all evaluators independently stated that they would recommend the L-REACT™ System for purchase.					
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Contents

List of Figures	v
List of Tables	v
Acknowledgments	vi
Executive Summary	vii
1. Background	1
1.1 Field Study to First Responder Tool	1
1.2 Decision Aid Development	3
1.3 The Basic L-REAC™ System Design.....	4
1.4 The Operational L-REAC™ System.....	4
2. L-REAC™ System Improvement Evaluation Task	5
2.1 L-REAC™ System Improvement Evaluation Objectives	6
2.2 Method of Evaluation (Training II and Questionnaires)	7
2.2.1 Evaluation of System Functionality	8
2.2.2 Evaluation: Administrative Questions.....	11
2.3 Tabulating Results	11
3. System Improvement Evaluation Results	12
3.1 Implemented Evaluation Results.....	12
3.2 Administrative Questionnaire—Overall System Evaluation	13
3.2.1 Overall Impression of the L-REAC™ System.....	14
3.2.2 Integrating L-REAC™ into the Emergency Response Community	15
3.2.3 Applying the L-REAC™ System.....	17
3.3 System Functionality Questionnaire – Detailed Review of Product	19
3.3.1 Evaluating the L-REAC™ System Communication Design.....	19
3.3.2 Basic Feature Recognition on the 1-Plot and 2-Plot EUD Outputs	20
3.3.3 Key L-REAC™ System Features for Decision Makers.....	22
3.4 Future Vision and Final Comments from the Evaluators.....	25

4. Discussion	26
4.1 Detailed Review of the L-REACT™ System Product	27
4.2 Overall System Evaluation.....	27
4.3 Evaluator Future Vision and “Final Comments”	29
5. Summary	30
6. Final Comments by Author and Evaluators	32
7. References	34
Appendix A. System Functionality Questionnaire–Evaluator Results	37
Appendix B. Administrative Questionnaire–Evaluator Results	47
List of Symbols, Abbreviations, and Acronyms	55
Distribution List	57

List of Figures

Figure 1. EPA/NOAA wind tunnel results show the airflow pattern around a single building. Streamling flow is from left to right. The “canyon flow” is not shown (Snyder and Lawson, Jr., 1994).....	2
Figure 2. The L-REAC™ System PoC included three core modules: the Sensor, the Model and the EUD Modules.....	3
Figure 3. One-Plot EUD image without a Plume. The blue arrows show the model wind field at 2.5-meters (m) AGL. The red arrow indicates a measured value at 10-m AGL.	8
Figure 4. One-Plot EUD image with a Plume. The blue arrows show the model wind field at 2.5-m AGL. The red arrow indicates a measured value at 10-m AGL. The Plume includes a three tiered gradient of human health effects overlay, with each tier explained on the display.	9
Figure 5. Two-Plot EUD image without a Plume. The wind direction is represented with black arrows on the wind flow chart. Wind speed is indicated by scaled color gradients. The scale is below the plot. The solid black geometric shapes represent buildings.	9
Figure 6. Two-Plot EUD image with a Plume. The wind flow chart includes black arrows which indicate wind direction, and color gradients that indicate the wind speed. The plume overlay uses the same 3-tiered system displayed on the 1-Plot, with the tiers explained below the Toxic Plume image.	10

List of Tables

Table 1. Multiple organizations owning an L-REAC™ System.	16
Table 2. One IOC running L-REAC™ System.	17
Table 3. System Functionality Question #1.1.....	20
Table 4. System Functionality Question #1.2.....	20
Table 5. System Functionality Question #2.1 (1-Plot Graphic).....	21
Table 6. System Functionality Question #2.1 (2-Plot Graphic).....	22
Table 7. System Functionality Question #2.2.1 (1-Plot Output).	23
Table 8. System Functionality Question #2.2.2 (2-Plot Output).	24
Table 9. System Functionality Question #2.3.2 (2-Plot Output).	25

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Executive Summary

The U.S. Army Research Laboratory (ARL) has been studying urban environments in response to the increased urban warfare facing the U.S. Armed Forces. Within the first decade of 2000, three progressively more complex urban atmospheric field studies were conducted at White Sands Missile Range (WSMR), NM. These studies examined airflow and stability around urban buildings. Concurrent with the final study, emergency first response drills were executed. Based on the ARL collaboration with the local emergency response professionals, the need for first responders to have real-time atmospheric data at their figure-tips was witnessed.

ARL responded to the civilian/military emergency responder need, by designing the Local-Rapid Evaluation of Atmospheric Conditions (L-REAC™)* System. From 2009 to 2011, ARL went from a sketched L-REAC™ System concept to a mature Operational L-REAC™ System. The current operational system is an automated, 24/7 emergency response decision aid for airborne toxic release incidents. The basic design of the L-REAC™ System includes five modules: the Sensor, Quality Control (QC), Model, End User Display (EUD) and Archive Modules. The Sensor Module perpetually acquires meteorological data used as input by both a wind field and plume model. These models continually run, producing near real-time, mapped wind field and plume (when applicable) outputs, which are accessible to authorized end users. An Archive Module saves both the measured data and, when the user has selected this option, the image output. The System is designed to run attended by an operator or without an operator.

As part of a technology transfer process, the L-REAC™ System was subjected to several informal and formal evaluations. The first evaluation examined the intuitive nature of the output. About thirty *Gains in the Education of Mathematics & Science* (GEMS) high school students/teachers were asked to use the system to assess the wind flow and safe zone locations. Later, several Force Protection Exercises and Drills provided user feedback. In April 2011, the L-REAC™ System was requested to provide wind field projections for assisting fire fighters in the real-world Abrams Fire Incident. Training sessions were subsequently requested by the emergency organizations. Within these training sessions, the first formal L-REAC™ System improvement evaluations were conducted. The results are the subject of this report.

The evaluation was organized into two questionnaires: (1) An Administrative Questionnaire, which looked at the System from an overview and future vision perspective; and (2), a more detailed review of the System Functionality. The second questionnaire also served as an informal test for the students who had just completed their Training I course. The Functionality Questionnaire was divided into three cases/scenarios: Case I (No Plume Scenarios), Case II (Plume Scenarios), and Case III (No Plume/Plume Scenarios, in multiple locations).

* The L-REAC System trademark is owned by the Department of the Army, Washington DC, 20310.

The results of the Administrative Questionnaire reported that, from the remote accessing of communications through the perpetually updated wind and plume images, the system was easily understood and utilized. Evaluators unanimously stated that they would recommend the system. Their reasons for recommending the System aligned with the original System design objective of “saving lives.” The comments also underscored the challenge of finding funding resources to support system development costs.

The individual evaluator applications listed for the L-REACT™ System consisted of Chemical, Biological, Radiological and Nuclear Effects (CBRNE) Force Protection applications, Installation Operations Centers (IOC), Emergency Operations Centers (EOC), Fire/Rescue and Emergency Dispatch. All evaluators reported that the L-REACT™ System would be an asset to their profession/application.

System strengths cited included five comments which praised the ease of use, understandability of end products, and the “great” potential of the System.

Two scenarios for integrating L-REACT™ into the operational emergency environment were offered (1) Multiple L-REACT™ Systems owned and operated by various organizations. (2) One L-REACT™ System owned and operated by a single organization serving multiple users representing different organizations.

The evaluators offered a third arrangement: Two (or three) organizations owning L-REACT™ Systems with one organization as the primary operator serving multiple users of different organizations. The second System would be installed at a different location, and would serve as a backup unit, should the primary unit/location suddenly lose power or network connectivity. Based on current national economics, this third option may be the best arrangement.

Evaluators unanimously selected the Fire and Rescue Department (Fire Dept)/Medical and the IOC as appropriate System owners, with the majority also selecting the EOC and the Incident Command (IC) on location. The least recommended owners were the installation command offices. The top recommendation for prospective System users was the Fire Dept/Medical, with the IOC, EOC, Police, IC on location, IC in IOC and Garrison Commander also suggested by the majority of evaluators. The least recommended user was again the installation command office. The “Dispatch” office was a written-in suggestion for both an owner and user.

The directions for accessing L-REACT™ System output were unanimously evaluated as “easy to follow” and the output was flagged as timely. The output details were assessed as “enough” (versus “too many details”). The Operator’s zoom in capability was considered *very useful in the EM* (emergency management) *arena*.

Regarding the two main output display products (current wind field and plume overlays mapped onto a given area of interest), the majority of evaluators considered the product features useful, with 78% of evaluators indicating ALL information as “most useful.”

All evaluator comments were extremely helpful in calibrating the value of the L-REAC™ System to the emergency response community. While funding may limit future System development, the fact that the System has already proven to have a positive impact on both the local ARL safety procedures and the surrounding military/civilian communities indicates that this technology has the potential to continue making a constructive difference. And, with proper support, the L-REAC™ System will resume being a candidate for use by ARL's primary customer, the U.S. Army Soldiers.

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1. Background

In recent years, the U.S. military has seen an increase in the number of combat missions within an urban environment. Consequently, the U.S. Army Research Laboratory (ARL) has been investigating the atmospheric effects within urban scenarios. In the early 2000s, ARL conducted three progressively more complex urban field studies aimed at characterizing the airflow and stability around a small cluster of urban buildings. As part of the final Study, three Disaster Response Drills were executed. Observing the emergency response within the thickly instrumented urban field site, the need for a tool to link health and safety professionals with relevant atmospheric-environment data became apparent. A survey of existing technologies offered potential solutions. However, the ARL saw a niche for a timely, relevant, user-friendly tool that had not yet been filled, and consequently, has been developing an interactive information system to satisfy this need. This system is called the “Local Rapid Evaluation of Atmospheric Conditions,” or “L-REACT™” System. The L-REACT™ System was developed into an operational tool between 2009 and 2011. Once the system was exposed to the “real world,” the developers sought a detailed system evaluation by volunteer and professional emergency first responders. The focus of the evaluation was to identify practical system improvements. This report documents the results of that solicitation.

In this technical report, section 1 summarizes the evolution from research to a decision aid concept, to an operational tool. This section also gives a quick description of the basic and Operational L-REACT™ Systems. Section 2 describes the two part System Improvement Evaluation questionnaire. The evaluator responses to the questionnaires are reported in section 3, with a tally of all evaluator selections and comments in appendices A and B. Section 4 offers an elaboration and comments regarding the evaluator responses. Section 5 summarizes the evaluation process and key findings from this evaluation exercise. The last section (6) offers some final comments from both the author and the evaluators.

1.1 Field Study to First Responder Tool

In the early 2000s, ARL conducted three progressively more complex urban field studies which focused on the airflow and stability around a single urban building. The first of these studies was called *White Sands Missile Range (WSMR) 2003 Urban Study* or “W03US” for short. W03US sought to verify a 1994 Environmental Protection Agency (EPA)/National Oceanic and Atmospheric Administration (NOAA) wind tunnel study published by Snyder and Lawson, Jr. (1994), which identified flow patterns around various building sizes/dimensions. This EPA/NOAA study also identified flow features that appeared to be repeatable as building dimensions were varied. Translating the wind tunnel’s millimeter scale into a real-world meters-

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scale, ARL strategically located atmospheric sensors around a rectangular office building. The sensor data purpose was to verify seven airflow features: the fetch flow, velocity acceleration, velocity deficit, cavity flow, leeside corner eddies/vortices, the re-attachment zone, and the canyon flow. Six of the seven features are displayed in figure 1. The seventh feature is the “canyon flow,” which is an accelerated flow that occurs between two parallel buildings.

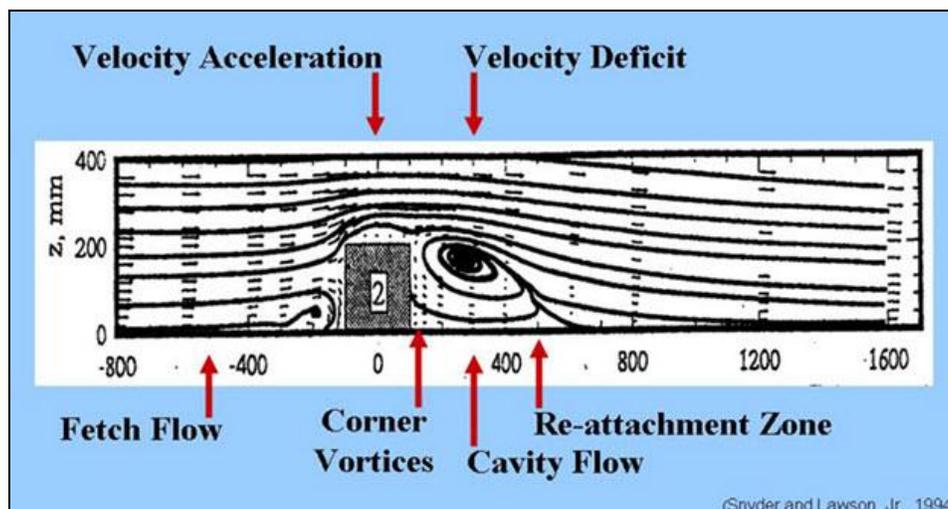


Figure 1. EPA/NOAA wind tunnel results show the airflow pattern around a single building. Streamling flow is from left to right. The “canyon flow” is not shown (Snyder and Lawson, Jr., 1994)

Based on the successful *W03US* results, two subsequent urban studies were executed around the same urban environment, each with an increased density of dynamic and thermodynamic measurements. These studies were called *WSMR 2005 Urban Study (W05US)* and *WSMR 2007 Urban Study (W07US)*, respectively. ARL technical reports documenting these studies and their findings include:

- FIELD STUDY OVERVIEW: Vaucher, 2006;
- DATA PROCESSING: Vaucher et al., 2008 (*Volumes DP-1, DP-2, DP-3; 2007*);
- DATA ANALYSIS: Vaucher, 2011 (*Volume DA-1*);
- ATMOSPHERIC STABILITY (Data Analysis): Vaucher, 2007 (*Volume AS-1; 2007*); Vaucher, 2008 (*Volume AS-2; 2008*); Vaucher, 2009 (*Volume AS-3; 2009*).

Concurrent with the *W07US* data acquisition were simulated disaster response drills. These drills included a Fire/Smoke Release Drill, a Simulated Bomb Threat Drill and a Simulated Airborne Chemical Release Drill. The drills involved not only the ARL field study personnel, but the entire local ARL workforce and local Emergency First Responder units. From the *W07US/Drills* experiences, the need for a near real-time atmospheric evaluation system was identified. A post-*W07US* study compared the drill responses with the coincident atmospheric conditions. The

results of this study confirmed the need for an emergency first responder decision aid that would provide timely and relevant atmospheric data (Vaucher, 2011). Thus, the concept for the L-REAC™ System Decision Aid was initiated.

1.2 Decision Aid Development

A survey of atmospheric emergency first responder technologies was conducted, following the *W07US* (Vaucher and Brice, 2010). While several promising units were found, the proposed L-REAC™ System showed unique qualities. Thus, in 2009, ARL constructed an L-REAC™ System Proof of Concept (PoC), using a Linux-Windows dual operating system (OS). The PoC included three core modules linked by specialized networks. These modules consisted of a Sensor Module, a Model Module, and an End-User-Display (EUD) Module (see figure 2). The L-REAC™ System PoC was documented in the *L-REAC™ System, Design and Development, Volume 1* (Vaucher et al., 2009).

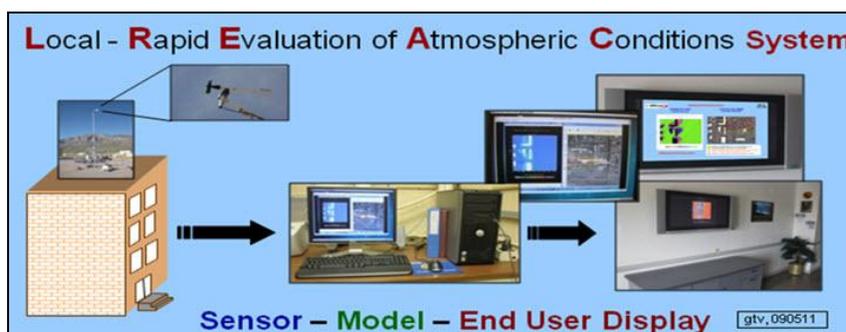


Figure 2. The L-REAC™ System PoC included three core modules: the Sensor, the Model and the EUD Modules.

In 2010, the L-REAC™ System “Prototype” was constructed using a single Windows OS. This “Prototype” consisted of five core modules. The original three core modules were significantly enhanced, and two system features within the earlier design were re-designated as full modules. These two “new” modules were labeled the Quality Control (QC) Module and Archive Module. The “Prototype” System was documented in the *L-REAC™ System, Design and Development, Volume 2* (Vaucher et al., 2010).

In 2011, an Operational L-REAC™ System was completed which continued to integrate “bullet proofing” design improvements to each system module. The Operational L-REAC™ System was documented in *L-REAC™ System, Design and Development, Volume 3* (Vaucher et al., 2011). One of the goals for this Operational L-REAC™ System was to bring the operational system into a “real world” environment, where professional emergency first responders could provide a practical end user evaluation of the product. A detailed presentation of their results is the goal of this report.

Currently, the developers are working on a “mobile” version of the L-REAC™ System. This system, if funded, will more tightly manifest some of the original concepts for ensuring data relevancy. In the next section, the basic L-REAC™ System design will be presented.

1.3 The Basic L-REAC™ System Design

The L-REAC™ System is an automated, 24/7, emergency response decision aid designed for airborne toxic release incidents. The current Operational L-REAC™ System is composed of five core modules, which include a Sensor Module, QC Module, Model Module, EUD Module and an Archive Module. The Sensor Module is designed to provide continuous, real-time and relevant atmospheric data from a single and/or an ensemble of meteorological sensors. The QC Module allows the operator to instantly create, view and evaluate time series of all variables sampled by the dedicated L-REAC™ System sensor(s). The time series extends from local midnight to midnight. The imported data from meteorological mesonets are not yet part of the QC, since the operator has no control over their status.

The Model Module interprets the matrix of current meteorological data by generating a local wind field over an area of interest (AOI). This wind field is continuously updated by the Sensor Module data feed and the output is displayed by the EUD Module. When an airborne hazard occurs, a trained operator keys in the hazard specifications (for example, hazard type, amount, release method, and so forth) to a fast-processing, emergency response plume model, which is also part of the EUD Module. The EUD Module then automatically assimilates and synchronizes the wind and plume model outputs into both building- and regional-scaled images for the end user to utilize in assessing safe/hazard zone decisions. The EUD output is distributed to end users over their established networks. Updates to the wind field (and plume) outputs are automatically transmitted to the end users after each wind field model run is completed. A dedicated System communications design ensures a timely information flow (on the order of 1–2 minutes [min] for building scales and 8–10 min for regional scales) from the atmospheric sensors and models, to the decision-maker EUD displays. An “Instantaneous Save” option allows the system operator to zoom in/out of an end-user-specified AOI and immediately transmit these images, between the automated cycles.

The Archive Module saves the ingested L-REAC™ data, and when the user selects the option, saves all incident-EUD imagery as well. These archive files can be used for incident reviews and Post-Event data analyses.

1.4 The Operational L-REAC™ System

The Operational L-REAC™ System was distinguished from the “basic” L-REAC™ PoC unit by the System’s capabilities and functionality. As the L-REAC™ System evolved from a PoC to an operational system, several automating functions and code reliability improvements were integrated. The goal of the operational system was to minimize the user technology

requirements and maximize the application opportunities. The System was also required to run reliably over extended time periods with and without an operator, and to produce results that would satisfy the intended customer requirements.

For the L-REAC™ System developers to better identify what the customer requirements were, the System was periodically submitted to end user evaluations. The progression of significant interactions is summarized in section 2. Each customer interaction served as a step forward along the path of technology transfer.

2. L-REAC™ System Improvement Evaluation Task

The L-REAC™ System technology transfer effort began by subjecting the System to evaluations by a sample of selected end users. In 2009, the intuitive nature of the L-REAC™ output was assessed by presenting the mapped output to teenagers and public school teachers during an ARL sponsored *Gains in the Advancement of Mathematics and Science* (GEMS) summer program. The students and teachers were given a brief tutorial on reading maps and the most basic concepts of wind flows and plume projections around buildings. They were then asked to evaluate the airflow direction by visually assessing the orientation of the dedicated L-REAC™ System anemometer mounted on the classroom building's roof. Students drew the results on a worksheet, where they also sketched a projected "plume" cloud based on their observed airflow. Their wind and plume sketches were then compared to the "live" wind field and plume model outputs of the L-REAC™ System simultaneously displayed in the building's lobby. The ease at which the students verbally compared their results to the "live" L-REAC™ System PoC output confirmed their intuitive understanding of the system output. The students took special interest in the cavity flow feature mapped by L-REAC™ System wind field output. Walking between the L-REAC™ System lobby display output and the parking lot, they individually verified the flow reversal. That is, they identified the cavity flow pattern on the L-REAC™ System "live" display and then quickly walked out to the parking lot to visually witness the roof direction via the dedicated L-REAC™ anemometer on the roof, and simultaneously feel the reversed flow direction against their backs. The student's ability to identify and match the model output with "real world" events re-enforced the effective interpretation and intuitive nature of the L-REAC™ System output design.

From 2009–2011, the ARL workforce was exposed to the L-REAC™ System output during various Shelter-in-Place (SIP) Exercises. The L-REAC™ System displayed a "live" output while the workforce was in their SIP location. As primarily atmospheric scientists and meteorologists, these peers quickly discerned the airflow status and offered instantaneous analysis of the airflow and plume outputs.

The greatest benefactors of the L-REACT™ System are the professional civilian and military Emergency First Responders. In 2011 April, the local area experienced an extensive fire that threatened the entire WSMR base community. This incident, known as the Abrams Fire, escalated to the point where serious consideration for a site-wide evacuation had to be considered by the Commanding General. Early on during this multi-day incident, the WSMR Installation Operations Center (IOC) called on the L-REACT™ System for consultation. Communication links between ARL and the WSMR advisors to the Commanding General were immediately authorized for a live feed. For the next three days, the L-REACT™ System produced timely and relevant wind field and sampled data output for the WSMR Directorate of Plans, Training, Mobilization and Security (DMPTS)/IOC, DMPTS/Fire and Rescue Department (Fire Dept), and New Mexico Bureau of Land Management. Decisions to NOT evacuate the site, and when to implement a preventative “back” fire were made, in part, on the L-REACT™ System output. Post-incident review prompted such a strong interest in the L-REACT™ System that training sessions were organized for the voluntary and professional WSMR emergency first responders.

Two training sessions were subsequently designed to prepare the WSMR emergency response volunteers and professionals to be L-REACT™ System users. Training was given to representatives from three directorates in ARL-WSMR, the DPTMS/Fire Dept and the DTPMS/IOC. Training I provided an interactive learning of the L-REACT™ System output. Training II “tested” the Training I students on their newly acquired understanding and doubled as a detailed L-REACT™ System improvements evaluation. The students were not graded on their answers, so their responses could be candid.

Following the L-REACT™ System User’s Training, the WSMR IOC requested additional instruction to become L-REACT™ System Operators. Three more levels (for a total of five training levels) of training were given. These levels covered experience with the wind field model, the plume model, and Operator responsibilities (startup, QC, operate, archive and shutdown). Of the 37 people who signed in for the 11 classes given over a 1-month period (FY11), 28 were listed as users and 5 as operators. Some were unable to complete the training, due to scheduling conflicts and occupational demands.

The real-world L-REACT™ System experience of April 2011 was a catalyst for soliciting a detailed System analysis from volunteer and professional emergency first responders. In the next section, the L-REACT™ System Improvement Evaluation task objectives, methods and execution will be described.

2.1 L-REACT™ System Improvement Evaluation Objectives

The purpose of the L-REACT™ System Improvement Evaluation was to solicit practical and visionary improvements from volunteer and professional emergency responders. The improvements that were deemed feasible by the developers were to be immediately

implemented. The suggestions requiring additional resources or skills were noted for future work.

This evaluation exercise also served as an informal “test” for those who had completed the L-REACT™ System Training I class. Training I was a prerequisite for the evaluation exercise. For most participants, this evaluation period was the first time they had independently viewed (from their office space) an Operational L-REACT™ Output. Although the scenarios were simulations, the pace of visual output changes was in keeping with real world incidents. When the evaluation results appear to reflect a learning curve of the evaluators, a note flagging this potential bias is given.

2.2 Method of Evaluation (Training II and Questionnaires)

The evaluation project was designed as part of the L-REACT™ System training program. This choice was required due to a fiscally-driven reduction in personnel (for the L-REACT™ project), which coincided with the training request by the WSMR IOC. Consequently, the method for evaluating the system was an ungraded “test” of understanding, as well as an opportunity for the trainees to offer detailed feedback on what they had learned.

TRAINING I: As mentioned earlier, each trainee was required to go through the Training I: *L-REACT™ System Introduction and Demonstration*. At the end of session I, the trainee was given two evaluation forms and picked a random number out of an envelope. Only the trainees were aware of their number, and used this number for the top of their evaluation forms (in place of their name). A brief survey of the questions introduced them to the questionnaire content during Training I, and allowed them to ask for clarification regarding any question.

TRAINING II: The Training II *System Improvement Evaluation* was conducted in the trainee’s own office, without an L-REACT™ System developer present. Prior to the start of the Training II session, the L-REACT™ Trainer contacted each student to confirm network connectivity between their approved office personal computer (PC) and the L-REACT™ output. At a pre-set time, the L-REACT™ System was initiated from the L-REACT™ System Operations Room. Following the script of actions explained on the evaluation form, three Cases (scenarios) were executed. Students entered their responses for each Case. After the Case III concluded, the students completed a second questionnaire that focused on the administrative (bigger picture) angle of the L-REACT™ System. The following day, a designated person collected the questionnaires in a large folder. When the participant’s work schedule required it, questionnaires were returned several days later and anonymously shuffled into the large envelope.

Each of the two questionnaires will be described in the next two subsections.

2.2.1 Evaluation of System Functionality

The first questionnaire filled in by the students focused on the L-REAC™ System output functionality. The output consisted of two automatically updating hypertext markup language (*html*) images labeled “1-Plot” and “2-Plot.” In the “1-Plot” image, the user viewed the current wind field represented in vectors and streamlines, overlaid onto a Google Earth Image (see figure 3). If a plume output was available, this plume footprint was also overlaid onto the same Google Earth Image (see figure 4). The “2-Plot” image consisted of the same wind field and plume information, only scaled for building imagery and separated into two mapped images showing a wind field and a plume display, respectively. When a plume was not required, a message replaced the plume image, indicating this “no known airborne threat” status. The Plume and No Plume versions of this 2-Plot image are shown in figures 5 and 6.

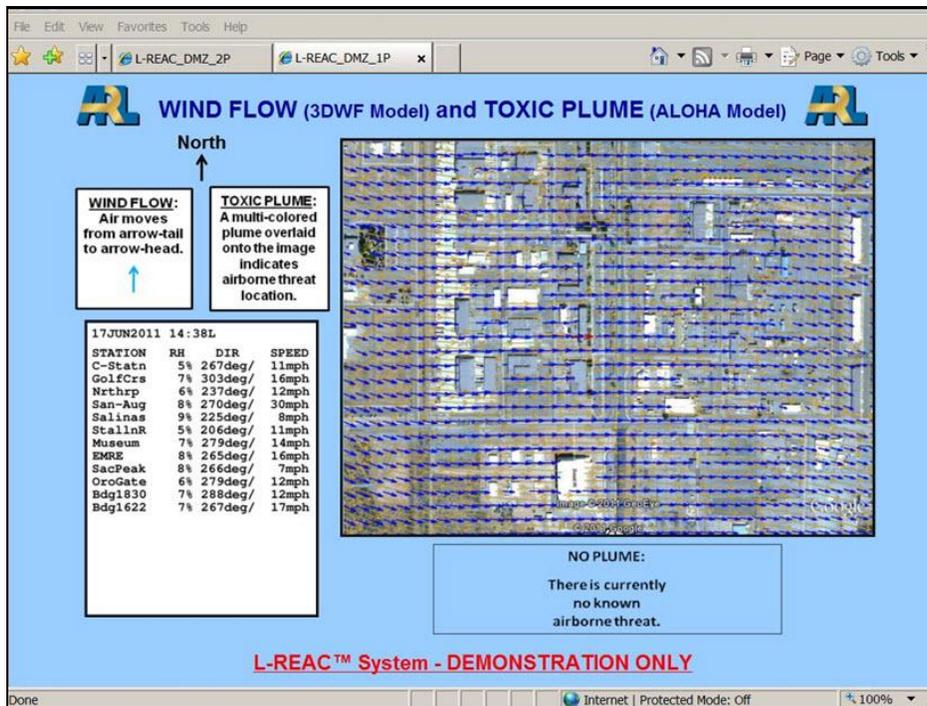


Figure 3. One-Plot EUD image without a Plume. The blue arrows show the model wind field at 2.5-meters (m) AGL. The red arrow indicates a measured value at 10-m AGL.

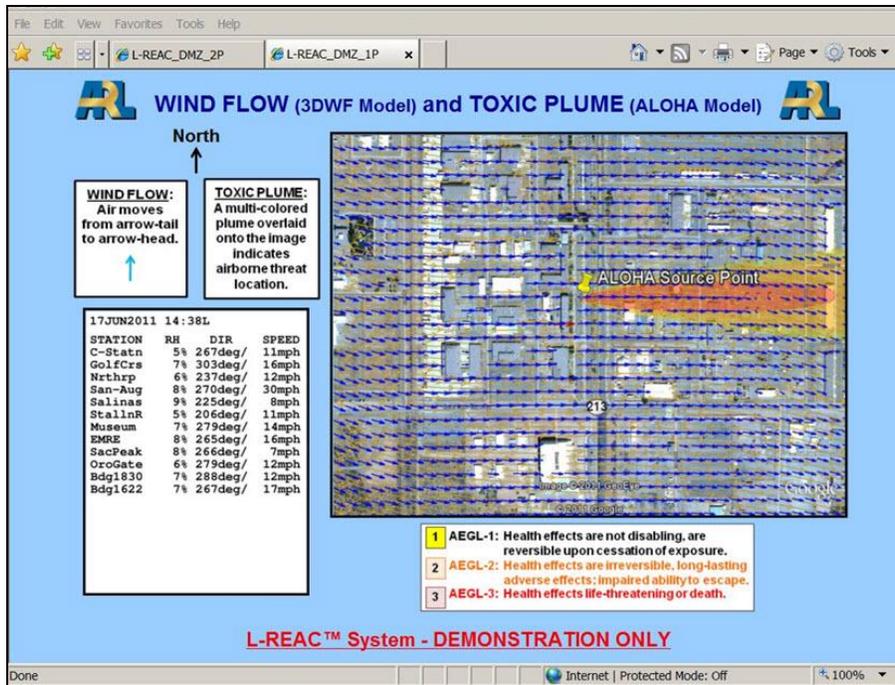


Figure 4. One-Plot EUD image with a Plume. The blue arrows show the model wind field at 2.5-m AGL. The red arrow indicates a measured value at 10-m AGL. The Plume includes a three tiered gradient of human health effects overlay, with each tier explained on the display.

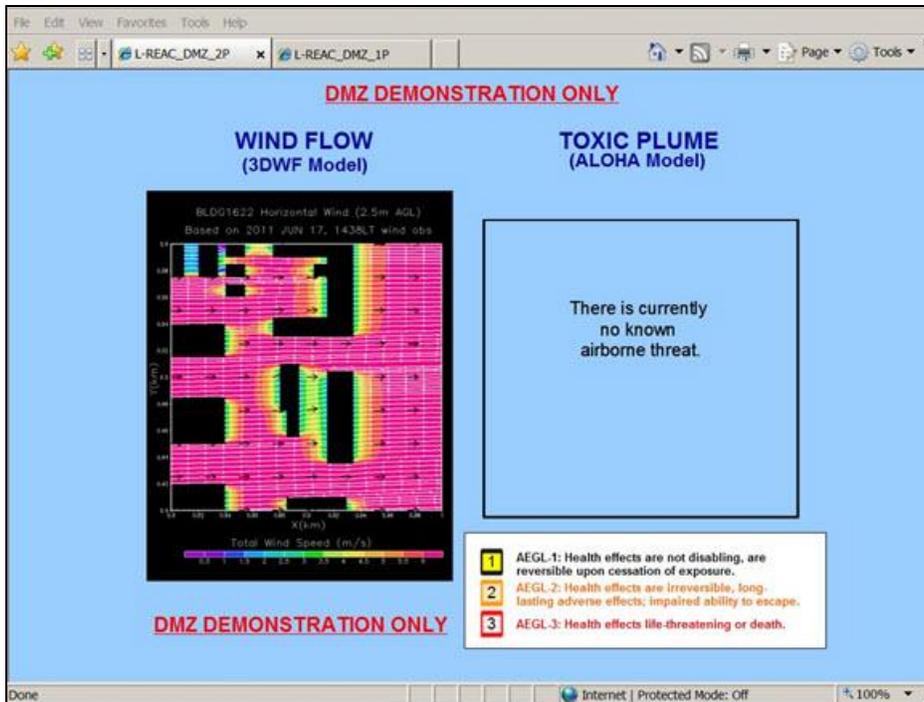


Figure 5. Two-Plot EUD image without a Plume. The wind direction is represented with black arrows on the wind flow chart. Wind speed is indicated by scaled color gradients. The scale is below the plot. The solid black geometric shapes represent buildings.

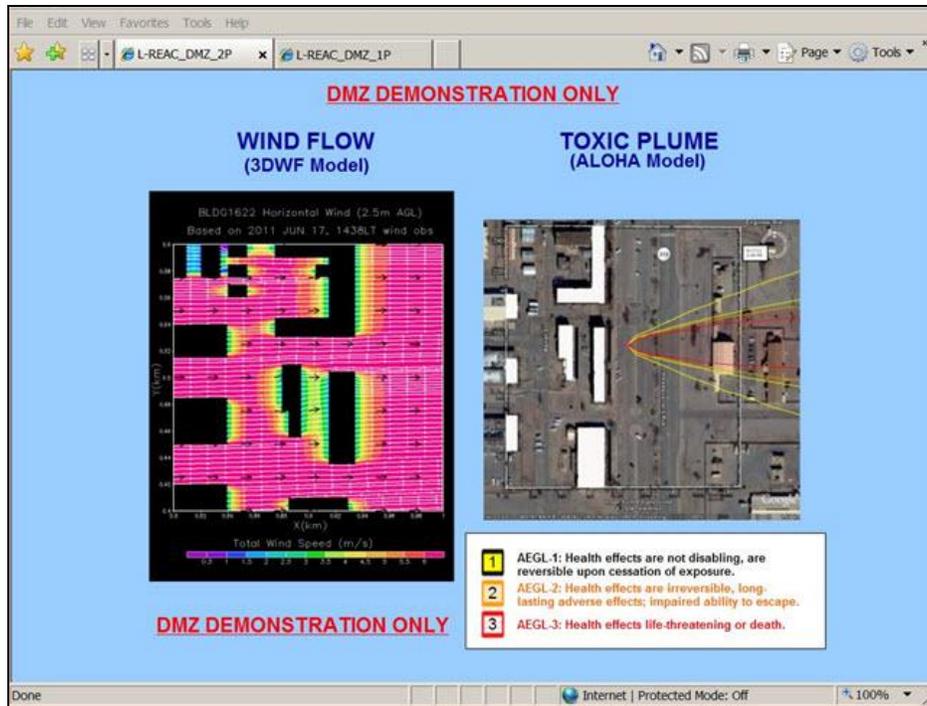


Figure 6. Two-Plot EUD image with a Plume. The wind flow chart includes black arrows which indicate wind direction, and color gradients that indicate the wind speed. The plume overlay uses the same 3-tiered system displayed on the 1-Plot, with the tiers explained below the Toxic Plume image.

The System Functionality Questionnaire was subdivided into three Cases, each representing foundational functions for the L-REAC™ System output. These Cases were:

Case I: No Plume Scenarios:

- STATUS: Wind Field Model and No Plume.
- SCENARIOS: Entire AOI, three Mesonet Locations, Medical Facility, a User Selection.

Case II: Plume Scenarios:

- STATUS: Wind Field Model and Pre-determined Plume.
- SCENARIOS: Training site–large image (1) and zoomed-in images (3).

Case III: No Plume/Plume Scenarios, with multiple locations:

- STATUS: Wind Field Model with No Plume & Plume scenarios.
- SCENARIOS: Training site-No Plume & Plume; Plume at user-selected site within AOI.

In Case I, the trainees were able to orient themselves using the first wind field image, which covered the entire AOI. Each scenario step was updated twice, to ensure that the trainees had enough time (about 4–5 min) for entering evaluation feedback onto the forms. After the entire AOI was viewed (twice), the L-REAC™ System Operator went to the meteorological mesonet locations listed, enabling the students to assess measured (red) and modeled (blue) wind vectors. The Medical Facility was used as a familiar site to most trainees. The “user selection” of Case I,

allowed one of the trainees to select any site for the L-REACT™ System Operator to locate within the AOI. This action simulated the challenge of describing an incident site over a communication line, while not being able to physically point to it on a map.

Case II added the plume output to the wind field, using a source point in the vicinity of the training site. The trainee group then evaluated various overview (spatial) scales provided by the L-REACT™ System Operator.

Case III started with only a wind field at the training site. The removal of the plume flagged the start of Case III. The plume was subsequently added. A trainee (volunteered in advance of the session) was then tasked to describe “the correct” location for the plume. Again, a secondary goal of this exercise was to give trainees the opportunity to experience effective field-to-operator communications while under a simulated deadline. Finally, this same trainee selected a completely different location for the wind field and plume. The need to communicate efficiently and effectively, and the need for the other end users to wait patiently for this information to be delivered and processed, was the main educational point of this last task of Case III.

The System Improvement Evaluation exercise was concluded when the main images of the 1-Plot and 2-Plot were returned to the statement, “The L-REACT™ System is currently off-line.” At this point, the evaluator/trainee proceeded to the second questionnaire, which is described in the next section.

2.2.2 Evaluation: Administrative Questions

The second questionnaire focused on administrative (“big picture”) questions and applications. The first elements evaluated were the instructions for accessing the L-REACT™ System, and the L-REACT™ System Output with respect to the evaluator’s professional requirements. A short prose (written) section allowed them to describe their overall impression, where they thought the L-REACT™ product future vision should be, and to make marketing suggestions. The questionnaire concluded by soliciting “Final Comments.”

2.3 Tabulating Results

Once the questionnaires were collected, a “key” was created on which the “filled-in-the-blank” responses were collated and the evaluator comments were transcribed. Tallies were converted into percentages based on the total number of forms completed. Appendices A (Functionality Questionnaire) and B (Administrative Questionnaire) present the tally of all evaluator selections and comments. For the three Cases System Functionality questionnaires, ten forms were completed. For the Administrative Questionnaire, nine forms were completed.

Some of the evaluators skipped questions. In these situations, the percentage was still based on the total questionnaires filled out. However, a note was logged with the response indicating that the actual percentages may actually be higher.

A series of questions examining the ease of entering plume model information was included on the evaluation forms. Since the Training II level did not include entering plume model information, these questions were ignored.

3. System Improvement Evaluation Results

At the ARL “After Action Review” for the 2011 April Abrams Fire Incident, a direct line of communication between the L-REACT™ System developers and the WSMR DPTMS/Fire Dept and DPTMS/IOC was established. As part of this direct feedback, several details for system output improvements were defined, tasked for action, and then implemented.

In the next three sections, a sample of the implemented System improvements from the After Action Review is given, along with a summary of the administrative and more detailed, functionality evaluation questionnaire results.

3.1 Implemented Evaluation Results

As mentioned earlier, the Abrams Fire Incident allowed WSMR Fire Fighters direct access to the L-REACT™ System output while executing their professional tasks. Consequently, the gaps in Fire Fighter requirements and the System design were easily discerned. One such gap was a need to access specific meteorological measurements for completing calculations that assessed “back burns” and fire status conditions. These calculations require specific units of measure. Consequently, the L-REACT™ System was re-designed to include a list of the available, relevant dedicated, and mesonet meteorological data with the 1-Plot image. The units of measure selected were based on those units requested. The time-relevancy of the measurement was defined as no more than 31 min from the current time. The spatial-relevancy of the data (how close the measurement was to a given incident) was left to the Fire Fighter’s discernment, as all mesonet stations were included in the list displayed on the EUD 1-Plot output. This decision by the designers accommodated those potential incidents that may extend to multiple sites.

Note: If no mesonet data are available, the wind field model is still able to function, underscoring the value of having a dedicated sensor as part of the original L-REACT™ System design.

A second practical suggestion by the First Responders came as a consequence of viewing the EUD output under brilliant sunlight. Computer screens are already difficult to read under normal sunlight. For the L-REACT™ System output, we needed to intensify color contrasts, enabling the end user to issue a quick glance at the current wind flow and plume patterns to glean an immediate discernment of application. The primary target for this improvement was the plume model output.

The current plume model creates a three-tiered gradient for plume concentrations, as well as an uncertainty curve. On paper, these colors were sometimes difficult to view when overlaid onto a detailed satellite map. In the field, especially over a desert terrain, the yellows and oranges, in particular, can be even more difficult to discern. Thus, the L-REACT™ designers set out to improve the color contrasts. The suggested software “fix” was conveyed to the plume model developers, who acknowledged the task by issuing a code improvement and informed us that their next plume model release will also include this enhancement.

A third practical suggestion came from the System Operators (who were also the developers) responding to a request to extend the system applications to a larger AOI. The scaling of the 5-m high resolution model was sufficient for building environments in a local community. However, when the threat was in the surrounding mountains (such as a wild fire), this scale needed to be expanded. A 100-m resolution wind model was already within to the L-REACT™ System design. However, since the length of processing time exceeded the 1–2-min period, this model scale had not been included in the automated scripts. Based on the end user feedback, the 8–10-min wait for this output was considered reasonable when balanced with the application. Consequently, the L-REACT™ System was redesigned to include three scales within the automated operational system. These scales have been labeled “building” (horizontal AOI is about 2 km × 2 km), “cantonment” (AOI is about 25 km × 25 km) and “regional” scales (AOI is about 50 km × 50 km).

A fourth System improvement came after implementing the three model scales into the automated operational system. Even though the users insisted that 8–10 min was worth waiting for (they made this assessment while sitting in a conference room), the high pressure reality of the first responder environment seemed to prove otherwise. Consequently, the L-REACT™ designers devised an “Instant Save” button for the L-REACT™ System Operator. The function of this iconic button is to save whatever is currently being displayed for the AOI map, winds and/or plume outputs. The intended purpose of this feature is to allow the operator to send “new” imagery while a slower processing regional scale model is running. The “new” imagery could be an expanded or “zoomed in” view of the existing wind field over a given AOI. Or, if no model data are available (such as during the start up or switching locations), the Operator can still send an image of the requested AOI, to confirm that the incident location and image perspective are correct and optimal for the user’s application.

3.2 Administrative Questionnaire—Overall System Evaluation

The Administrative Questionnaire allowed the voluntary and professional emergency first responders to evaluate (1) their overall, initial impression of the L-REACT™ System, (2) where they thought the L-REACT™ System might best be integrated into the existing first response network of users, and (3) to assess end product details that were most relevant to their applications. Each area will be addressed in a separate subsection.

Note: Evaluator #24 did not fill out this questionnaire form, making the total number of persons completing this form equal to nine. Also, Appendices A (Functionality Questionnaire) and B (Administrative Questionnaire) present the tally of all evaluator selections and comments.

3.2.1 Overall Impression of the L-REAC™ System

Evaluators were asked: *Would you recommend this system be purchased? If so, why?*

All evaluators who responded to this question answered in the affirmative! (#11 missed this question). Their explanations for “why?” included:

- *It can save lives!* (#16)
- *It would be useful with local & county dispatch/fire & EOC [Emergency Operations Center]’s.* (#10)
- *This tool would be helpful for emergency response and building evacuations all over post.* (#13)
- *It provides real-time meteorological information to the end user allowing him/her to make timely and important decisions.* (#14)
- *It has virtually every bit of information first responders need.* (#8)
- *Useful tool in determining any wind plume threats.* (#3)
- *This tool’s ability to determine wind flow around structures is very useful for Fire Fighters and EM (emergency management). Selling the product would be great; too bad those that need it most would most likely not afford it.* (#18)

Evaluator #18’s observation that *those that need it most would most likely not afford it*, has, unfortunately, proven correct. However, we were encouraged by the subsequent findings that elaborated on the above favorable responses.

The evaluators were asked to describe the application(s) for which they would use the L-REAC™ System. Their responses, in numerical order, were: L-REAC™ application is (for)...

- *Ops (Operations) Center and CBRNE (Chemical, Biological, Radiological and Nuclear Effects).* (#8)
- *For all of the above (Fire/Rescue, Dispatch) plus for emergency use such as plume data.* (#10)
- *IOC.* (#11)
- *Force Protection/personnel notification/evacuation.* (#13)
- *CBRNE applications for displaying plume modeling for decision makers.* (#14)

- *IOC/EOC.* (#15)
- *Emergency MST (management) which encompasses Fire/Police/Dispatch and providing info for decision makers.* (#18)

All responding evaluators reported that “yes,” the L-REAC™ would help them do their work (#18 missed this “yes”/“no” question).

What the evaluators liked about the system included:

- *A great tool with potential.* (#11)
- *Very easy to understand and read winds.* (#15)
- *Clear and concise output and (user friendly).* (#16)
- *Easy to use & understand. It helped with the initial overview done... a week prior.* (#10)
- *Clear and concise. Displays the most pertinent information.* (#8)
- *Everything: wind flow, speed, current data, (and) toxic plume data.* (#18)

Noteworthy attributes cited were:

- *Real time data and visual with buildings and surrounding area.* (#3)
- *It gives real time information and can also produce a plume (if necessary).* (#14)
- *The capabilities for real world use as a force protection tool.* (#13)

The System strengths recognized by the evaluators were:

- *Ease of use.* (#11 and #14)
- *It gives enough information so that if someone outside the organization came to assist, they should be able to assess the situation relatively quickly.* (#8)
- *The amount of different data elements.* (#16)
- *Wind speed, direction and flow.* (#18)
- *Wind speed and direction—the probability of the plume direction, and safe points.* (#3)
- *The ability to add a plume.* (#10 and #15)
- *The ability to determine hazards plume areas for personnel evacuation purposes.* (#13)

3.2.2 Integrating L-REAC™ into the Emergency Response Community

The evaluators were given two choices for how the L-REAC™ System might be integrated into an existing community’s Emergency Operations. Using the context of a Government Range

(such as WSMR), one option was that multiple organizations would each have their own dedicated L-REACT™ System. The second option was that one organization would have a dedicated System with multiple organizations viewing the output (current design). Their responses showed that 56% favored multiple organizations with each having a dedicated L-REACT™, 33% chose one organization running the L-REACT™ for multiple organizations, and one evaluator did not answer the question.

Those who favored multiple organizations explained their choice with the following:

- *Maybe 2 or 3 organizations, in the case that 1 organization went down, no electricity, etc. (#3)*
- *It would be good to have at least another organization with the system, in case the initial L-REACT™ System is down or destroyed. (#10)*
- *Can conceptualize the situation fast. (#11)*
- *Each organization would be able to adapt for specific mission requirements. (#13)*
- *Everyone would have different uses. (#15)*
- *WSMR IOC operates 24/7 and having on hand availability is important. No need for ARL operators to arrive. (#18)*

The evaluators who preferred a single organization with multiple users offered these explanations:

- *It would be best for different organizations to have a common point of reference. (#8)*
- *This would allow for one-source information dissemination to multiple agencies and avoid confusion and distortion of information. (#14)*
- *Better uniformity and control of data. (#16)*

Presuming that multiple organizations could have their own dedicated L-REACT™ System, the evaluators were asked to select a variety of potential organizations to own a System, and/or add their own selection. Table 1 shows the results of the recommended organizations:

Table 1. Multiple organizations owning an L-REACT™ System.

Organization	IOC	Fire/ Medical	EOC	Police	*IC: in IOC	^IC: on location	Garrison Commander	Commanding General	+Other: Dispatch
% of evaluators selecting this option	100% (9)	100% (9)	78% (7)	4% (4)	44% (4)	56% (5)	33% (3)	22% (2)	11% (1)

*IC: in IOC = Incident Command in the IOC.

*IC: on location = Incident Command at the location of the incident.

+User-entered selection was: *WSMR dispatch (#18)*

Presuming that the L-REACT™ System was run in an IOC, the evaluators were asked to select, to what groups or professionals would they recommend the L-REACT™ System output be sent?

Table 2 shows the results for organizations that should receive output:

Table 2. One IOC running L-REACT™ System.

Organization	IOC	Fire/ Medical	EOC	Police	*IC: in IOC	^IC: on location	Garrison Commander	Commanding General	+Other:
% of evaluators selecting this option	89% (8)	100% (9)	89% (8)	89% (8)	67% (6)	78% (7)	56% (5)	33% (3)	22% (2)

*IC: in IOC = Incident Command in the IOC.

*IC: on location = Incident Command at the location of the incident.

+OTHER:

- *Senior commanders tend to overreact with too much info(ormation;) Best to keep the info(ormation) at the responder and dispatcher level(s). Also, would like DES 911 center added. (#18)*
- *CBRNE (Operations) as well. (#8)*

3.2.3 Applying the L-REACT™ System

The instructions for accessing the L-REACT™ output from a remote location were unanimously assessed as “easy to follow.” The L-REACT™ System output was assessed as being timely, with the following comments added:

- *Good to have live data when presented questions from the IOC. (#3)*
- *Yes; but during an emergency it would be nice to have update quicker when there was a plume involved. (#10)*
- *But I think that we could lessen the update times (if possible). (#14)*

The level of details provided in L-REACT™ System output was evaluated as “enough” (versus “too many details”). The subsequent comments were provided:

- *Yes; it might be more helpful if there were more known (RED) arrows in the area.(#10)**
- *Enough detail for now → I use it and a large map to view immediate then potential effects. (#11)*
- *From my perspective the system has the required details. (#13)*
- *It is providing what is needed for decision makers to get timely and up-to-date data to deal with the crisis at hand. (#14)*
- *Perhaps the type of chemical and the N-hour could be included. (#8)*
- *Enough details. (#16 and #18)*

*Note: The red arrows displayed are measured meteorological values (versus the blue model-generated wind vectors). The red-arrowed data are ingested from a mesonet of sensors, which is outside of the L-REAC™ System control.

A zoom-in and -out capability was integrated into the evaluation process, as a secondary feature. Some of the comments regarding this capability were:

- The zoom in/out feature *Focuses in the area of interest.* (#3)
- *This makes it easier to be sure where on WSMR the incident is located for those unfamiliar.* (#8)
- *Yes, very useful in the emergency mgt (management) arena.* (#18)

The details within the 1-Plot and 2-Plot EUD outputs were assessed, with respect to the evaluator's applications. The results below indicate the percentage of evaluators which considered the plot features useful:

Note: Figures 3 through 6 display a sample EUD output with the details that the evaluators were assessing.

1-plot graphic:

<u>100%</u>	An area of interest (AOI) map (Google Earth Map).
<u>100%</u>	The data time stamp.
<u>100%</u>	The height of output winds presented.
<u>100%</u>	The wind field model wind arrows (blue).
<u>100%</u>	The wind field model streamlines (yellow).
<u>100%</u>	The measured wind arrows (red).
<u>89%</u>	A "No Plume" notice.
<u>100%</u>	A plume overlay.
<u>100%</u>	A plume gradient description of the gradients used.
<u>100%</u>	The Surface Automated Meteorology System (SAMS) data list.

2-plot graphic:

<u>100%</u>	Two area maps.
<u>100%</u>	Time stamp of wind data.
<u>100%</u>	The height of output winds (Left plot header).
<u>100%</u>	The wind model streamlines (Left plot).
<u>100%</u>	The color-gradient wind speeds (Left plot).
<u>89%</u>	A "No Plume" notice.
<u>100%</u>	A plume overlay (Right plot).
<u>100%</u>	A plume gradient description (Right plot).

After the evaluator selected which feature was useful, they were asked which feature(s) were MOST useful to their application. Seventy-eight percent of the evaluators (7) indicated that ALL

the information was “most useful.” Evaluator #11 did not answer the question. And, evaluator #18 selected the following as “most useful” items:

1-plot graphic: (#18)

- An area of interest (AOI) map (Google Earth Map).
- The wind field model wind arrows (blue).
- The wind field model streamlines (yellow).
- The measured wind arrows (red).
- A plume overlay.

2-plot graphic: (#18)

- Two area maps.
- The wind model streamlines (Left plot).
- A plume overlay (Right plot).

The Administrative Questionnaire included two sections entitled “Future Vision” and “Final Comments.” The responses from these questions will be given in the final subsection of this section.

3.3 System Functionality Questionnaire – Detailed Review of Product

The L-REACT™ System functionality was examined through three scenarios, as explained in an earlier section. For summary purposes, each scenario will be given the following labels based on their primary focus:

- Case I: No Plume Scenario.
- Case II: Plume Scenario.
- Case III: No Plume/Plume Scenario.

3.3.1 Evaluating the L-REACT™ System Communication Design

An evaluation of the communication design was performed. This network design linked the remotely located evaluator with the L-REACT™ System output. All but one person reported that the connection ran without any interruptions. The single exception occurred during Case II, with no description of the interruption provided. Table 3 summarizes the results from System Functionality question #1.1.

Table 3. System Functionality Question #1.1.

1.1 Experience with L-REACT™ output access.	Case I: No Plume	Case II: Plume	Case III: No Plume/Plume
(a) DMZ connection ran <i>without</i> any interruptions.	90% (9)	70% (7)	80% (8)
(b) DMZ connection ran <i>with</i> interruptions. (Describe)	0% (0)	10% (1)	0% (0)
(c) Other	0% (0)	0% (0)	0% (0)
Total Evaluators:	9**	8***+	8***+

**Total Evaluators (a, b, c) → #24 missed this question 1.1 for Cases I, II, III.

+++Total Evaluators (a, b, c) → #8 missed this question 1.1 for Cases II and III.

The frequency of output updates was determined to be sufficient by the majority of evaluators (refer to table 4).

Table 4. System Functionality Question #1.2.

1.2 Frequency of output updates.	Case I: No Plume	Case II: Plume	Case III: No Plume/Plume
(a) Frequency of output updates was sufficient.	70% (7)*	60% (6) ⁺	50% (5)
(b) Frequency of output updates needs to be more often.	10% (1)	20% (2)	30% (3) [^]
(c) Frequency of output updates can be less often.	0% (0)	0% (0)	0% (0)
(d) Other	10% (1)*	0%	0%
Total Evaluators:	9**	8***+	8***+

**Total Evaluators (a, b, c) → #24 missed this question 1.2 for Cases I, II, III.

+++Total Evaluators (a, b, c) → #8 missed this question 1.2 for Cases II and III.

Comments (1.2): Frequency of output updates

*Case I: (a) *For this case.* (#10)

(d) *Was sufficient; temporarily dropped out.* (#3)

⁺Case II: (a) *With use of the F5 key every now and then.* (#10)

[^]Case III: (b) *Might need quicker updates in dealing with a plume.* (#10)

3.3.2 Basic Feature Recognition on the 1-Plot and 2-Plot EUD Outputs

Evaluators established a baseline of understanding for the L-REACT™ System Output by identifying up to 10 items on the 1-plot EUD. For the No Plume scenario (Case I), all evaluators were able to locate the AOI map, date/time stamp, wind height, model wind arrows and model streamlines. The measured wind vector and “SAMS” (mesonet) data list were also recognized by the majority of evaluators.

When the plume was added to the scenario (Case II, 1-Plot), all evaluators located the AOI map, date/time stamp, plume notice, and plume gradient description. Nearly all evaluators identified the model wind arrows, model streamlines, and mesonet/SAMS data list on the 1-Plot. The two features that challenged the evaluators were: wind height and the measured (red) wind arrows. This response is understandable, since the wind height is implied from the 2-plot (as taught in the training classes) and the measured wind arrows are limited to their sparse distribution. These sampled (red) wind vectors may also not be in view to the end user, if the L-REACT™ System Operator narrows (zooms in) the field-of-view for the user’s application. For either output type

(“in view” or “out of view”), all time-relevant and available mesonet data are listed on the 1-Plot with each update.

Case III (1-Plot) included both plume and no plume scenarios. All evaluators identified the AOI map. The majority of evaluators located the remaining output features. Table 5 tallies the results from System Functionality question #2.1 (1-Plot Graphic).

Table 5. System Functionality Question #2.1 (1-Plot Graphic).

2.1 During the evaluation period, which of the following was seen on your output display? 1-Plot Graphic	Case I: No Plume	Case II: Plume	Case III: No Plume/Plume
(a) An area of Interest map (Google Earth Map)	100% (10)	100% (10)	100% (10)
(b) The date and time stamp.	100% (10)	100% (10)	90% (9)
(c) The height of the output winds.	100% (10)	70% (7) ⁺	80% (8)
(d) The wind field model wind arrows (blue).	100% (10)	90% (9)	90% (9)
(e) The wind field model streamlines (yellow).	100% (10)	90% (9)	90% (9)
(f) The measured wind arrows (red).	90% (9)	70% (7)	70% (7) [^]
(g) A “No Plume” notice. [If not relevant, put N/A on line.]	90% (0)	100% (10)	80% (8)
(h) A plume overlay.	N/A	N/A	70% (7)
(i) A plume gradient description of the gradients used.	N/A	100% (10)	70% (7)
(j) The WSMR Surface Automated Meteorology System (SAMS) data list (text box).	90% (9)	90% (9)	90% (9)

Comments: 2.1 L-REAC™ System Output (1-plot graphic)

⁺Case II: (c) *I missed the red arrow on the first screen, did not see it on the second zoomed in screen. (#10)*

[^]Case III: (f) *Barely. (#18)*

For the 2-Plot Graphic (see table 6), the evaluator response indicated an improved comprehension between Case I (No Plume) and Case II (Plume) for the “two area maps” and “a plume gradient description.” All evaluators who answered the questions found the wind data time stamp, wind height, wind model streamlines, and color-gradient wind velocities.

Case III (No Plume/Plume, 2-Plot) had high scores for all the elements, especially the wind data time stamp, wind height, wind model streamlines and color-gradient wind velocities. Table 6 tabulates the results. Note that there were some questions regarding evaluator #16 entries; which may have been a function of the legibility of the written responses. Each Case ran sequentially without interruption. If an evaluator had a distraction during a Case sequence, or needed to reconsider an entry, the net result would likely have been a missed question.

Table 6. System Functionality Question #2.1 (2-Plot Graphic).

2.1 Identifying output display features. 2-Plot Graphic	Case I: No Plume	Case II: Plume	Case III: No Plume/Plume
(a) Two area maps	50% (5)*	90% (9) ⁺	90% (9)
(b) Time stamp of wind data.	90% (9)*	90% (9) ⁺	100% (10)
(c) The height of output winds (Left plot header).	90% (9)*	90% (9) ⁺	100% (10)
(d) The wind model streamlines (Left plot).	90% (9)*	90% (9) ⁺	100% (10)
(e) The color-gradient wind velocities (Left plot).	90% (9)*	90% (9) ⁺	100% (10)
(f) A “No Plume” notice (Right plot). [If not relevant, put N/A.]	60% (6)*	N/A	60% (6)
(g) A plume overlay (Right plot)	N/A	90% (9) ⁺	80% (8)
(h) A plume gradient description (Right plot).	60% (6)*	90% (9) ⁺	80% (8)

Comments: 2.1 L-REACT™ System Output (2-plot graphic)

*Case I: Total Evaluators (a-h) → #24 did not answer this question.

⁺Case II: Total Evaluators (a-h) → #16 penned check marks were difficult to read for this question.

3.3.3 Key L-REACT™ System Features for Decision Makers

Three key elements of the L-REACT™ System wind and plume graphical outputs were flagged for assessment in the functionality questionnaire. For the wind field graphics, these elements consisted of:

- Finding compass North
- Determining airflow direction
- Determining airflow speed

Compass North was a “key” element because the correct map orientation is critical to all subsequent decision aid applications. Identifying the current wind direction and speed were also flagged as crucial, since one of the very first questions normally demanded of any responder, following an airborne toxin release, involves the current winds. Thus, the L-REACT™ user will need to instantly locate and retrieve this information.

For the plume graphical output, the three key elements were:

- Finding compass North
- Determining the (general) hazardous areas generated by the plume
- Determining the most/least hazardous areas

Again, map orientation is crucial to a successful communication of decision aid results and receiving field observations. Interpreting the EUD for the hazardous areas, as well as, identifying the most and least hazardous areas is the primary objective for this decision aid.

Note: When there is not enough hazardous materials information available to calculate a plume overlay, the perpetual wind field still empowers incident responders/commanders with decision-able material.

In the next two sections, the evaluators demonstrate their understanding of these critical elements.

3.3.3.1 Wind Field Model Output

For the 1-Plot/Wind Field output (see table 7), nearly all evaluators were able to find compass North for each of the three Cases. All evaluators defined the determining of the airflow direction as “easy” for Cases I and III. In Case II, one person selected “sort of” easy, while all others found the task “easy”. The airflow speed was a little more challenging, as they had to refer to the mesonet (SAMS) data table and locate the measured vector on their visual output. Still, the majority labeled the task as “easy”. Table 7 summarizes the results from the 1-Plot evaluation of the Wind Field Model output; evaluator comments are documented after the table.

Table 7. System Functionality Question #2.2.1 (1-Plot Output).

2.2.1 Evaluating wind field model output. 1-plot (Google Earth) Output	Easy	Sort of Easy	Difficult	Not Relevant	Total Number of Evaluators
(a) Finding compass North – Case I	90% (9)	10% (1)*	0% (0)	0% (0)	10
(a) Finding compass North – Case II	90% (9)	10% (1) ⁺	0% (0)	0% (0)	10
(a) Finding compass North – Case III	90% (9)	10% (1) [^]	0% (0)	0% (0)	10
(b) Determining airflow direction – Case I	100% (10)	0% (0)	0% (0)	0% (0)	10
(b) Determining airflow direction – Case II	90% (9)	10% (1) ⁺	0% (0)	10% (1) ⁺	10 ⁺
(b) Determining airflow direction – Case III	100% (10)	0% (0)	0% (0)	0% (0)	10
(c) Determining airflow speed – Case I	80% (8)	10% (1)*	10% (1)*	0% (0)	10
(c) Determining airflow speed – Case II	70% (7)	10% (1) ⁺	20% (2) ⁺⁺	0% (0)	10
(c) Determining airflow speed – Case III	90% (8)	10% (1)	0% (0)	0% (0)	10

Comments: 2.2.1 Wind Field Model Output (1-plot graphic)

*Case I: (a) Sort of Easy - *Blended in with text box. Suggest relocate to right of plot map.* (#18)

*Case I: (c) Sort of Easy - *I know that north is always up.* (#10)

*Case I: (c) Was difficult – *No reference.* (#18)

⁺Case II: (a) Sort of Easy – *Location of indicator.* (#18)

⁺Case II: (b) The 10 entries to this question come from #14 answering “Was Easy” **and** “Not Relevant”.

⁺Case II: (b) Sort of Easy – *Blue arrows were very small, had to use yellow stream arrows to tell direction.* (#10)

⁺Case II: (c) Sort of Easy – *By looking at the station and the speed there.* (#10)

⁺Case II: (c) Was difficult – *No scale.* (#18)

⁺Case II: (c) Was difficult – *The colors indicating the concentrations blend into the background. The lines are extremely thin. (Plume concentrations)* (#24)

[^]Case III: (a) Sort of Easy – *Same.* (#18)

[^]Case III: (c) Sort of Easy – *No scale.* (#18)

For the 2-Plot/Wind Field output (see table 8), even though the percentages were lower, still the majority of the evaluators found compass North “easy” for each of the three Cases. The airflow direction was also considered “easy” for those who answered the question (#24 did not answer the question). The wind speed assessment was “easy” for the majority of responses. The consistent increase in percentages between Case I and II implied an improved understanding, and

served as a reminder that most of the evaluators were still assimilating the L-REACT™ Training I information. Table 8 displays the evaluator results for the System Functionality question 2.2.2.

Table 8. System Functionality Question #2.2.2 (2-Plot Output).

2.2.2 Evaluating wind field model output. 2-plot (Wind and Plume) Output	Easy	Sort of Easy	Difficult	Not Relevant	Total Number of Evaluators
(a) Finding compass North – Case I	70% (7)	10% (1)*	10% (1)*	0% (0)	9*
(a) Finding compass North – Case II	80% (8)	10% (1) ⁺	10% (1) ⁺	0% (0)	10
(a) Finding compass North – Case III	80% (8)	10% (1) [^]	10% (1) [^]	0% (0)	10
(b) Determining airflow direction – Case I	90% (9)	0% (0)	0% (0)	0% (0)	9*
(b) Determining airflow direction – Case II	100% (10)	0% (0)	0% (0)	0% (0)	10
(b) Determining airflow direction – Case III	100% (10)	0% (0)	0% (0)	0% (0)	10
(c) Determining airflow speed – Case I	70% (7)	20% (2)**	0% (0)	0% (0)	9*
(c) Determining airflow speed – Case II	90% (8)	10% (1) ⁺	0% (0)	0% (0)	10
(c) Determining airflow speed – Case III	90% (9)	10% (1) [^]	0% (0)	0% (0)	10

Comments: 2.2.2 Wind Field Model Output (2-plot graphic)

- *Case I: Total Evaluators (a, b, c) → #24 did not answer this question.
- *Case I: (a) Sort of Easy – *I know that north is always up.* (#10)
- *Case I: (a) Was difficult – *No “N” indicator.* (#18)
- *Case I: (c) Sort of Easy – *Had to mark a known speed off the right plot then measure on the left plot.* (#10)
- *Case I: (c) Sort of Easy – *Flipping back to measure the red arrow to get a speed.* (#15)
- ⁺Case II: (a) Sort of Easy – *Knowing that North is always up.* (#10)
- ⁺Case II: (a) Was difficult – *No indicator.* (#18)
- ⁺Case II: (c) Sort of Easy – *By going off the station and speed there.* (#10)
- [^]Case III: (a) Sort of Easy – *Known North.* (#10)
- [^]Case III: (a) Was difficult – *No indicator.* (#18)
- [^]Case III: (c) Sort of Easy – *Using color chart at bottom.* (#10)

3.3.3.2 Plume Model Output

Case I did not use a plume and therefore was not included in the questionnaire’s plume assessment portion. When the 1-Plot showed a plume (Cases II and III), the baseline understanding answers reported that evaluators were able to identify the plume and the hazard-gradient information. To better focus on the plume output details, the questionnaire referenced only the 2-Plot’s use of the plume display.

For the Plume/2-Plot output (see table 9), the majority of evaluators found compass North “easy” (in both Cases II and III). Where an evaluator reported the task as “difficult”, this answer was understandable. The 1-Plot openly shows “North” by using a labeled arrow pointing up (to the top of the page). To reduce visual clutter, the 2-Plot also uses “up” as North but this orientation is implied from the 1-Plot and taught as a part of the training class.

The hazardous areas were “easy” to locate for the majority of evaluators. A user request for measured distance was raised in this section. The L-REAC™ System was designed to use landmarks from the overhead satellite imagery. There are horizontal scales on the 2-Plot/wind field. The 2-Plot/Plume output comes with a subtle white distance scale on map, though this feature is not always discernable at the remote user’s terminal. The scale is available on the operator’s terminal display.

The most and least hazardous areas were considered “easy” to find by the majority of evaluators. The suggestion to darken the contrast within the plume gradients was addressed in the “immediate improvements” section. Table 9 tabulates the results from the plume interpretation question.

Table 9. System Functionality Question #2.3.2 (2-Plot Output).

2.3.2 Evaluating Wind Field Model Output. 2-plot (Wind and Plume) Output	Easy	Sort of Easy	Difficult	Not Relevant	Total Number of Evaluators
(a) Finding compass North – Case II	80% (8)	0% (0)	10% (1) ⁺	0% (0)	9 ⁺
(a) Finding compass North – Case III	60% (6)	0% (0)	10% (1) [^]	0% (0)	7 [^]
(b) Determining hazardous areas generated by plume – Case II	80% (8)	0% (0)	10% (1) ⁺	0% (0)	9 ⁺
(b) Determining hazardous areas generated by plume – Case III	70% (7)	10% (1) [^]	0% (0)	0% (0)	8 [^]
(c) Determining most/least hazardous areas – Case II	80% (8)	10% (1) ⁺	0% (0)	0% (0)	9 ⁺
(c) Determining most/least hazardous areas – Case III	70% (7)	10% (1) [^]	0% (0)	0% (0)	8 [^]

***Comments: 2.3.2 Evaluating the Plume Model (2-plot graphic)**

*Case I did not use the plume model and is therefore not listed in this table.

⁺Case II: Total Evaluators (a, b, c) → #8 did not answer this question.

⁺Case II: (a) Was difficult – *No indicator.* (#18)

⁺Case II: (b) Was difficult – *No distance scale to reference.* (#18)

⁺Case II: (c) Sort of Easy – *Lines very thin, better when you filled in the red area.* (#18)

[^]Case III: Total Evaluators (a, b, c) → #13 did not answer this question.

[^]Case III: Total Evaluators (a) → #16 did not answer the Compass North (a) part of this question.

[^]Case III: (a) Was difficult – *No indicator.* (#18)

[^]Case III: (b) Sort of Easy – *Would help to fill most hazardous with color.* (#18)

[^]Case III: (c) Sort of Easy – *Should fill area with AEGL-3 [Acute Exposure Guideline Level - 3] with red.* (#18)

3.4 Future Vision and Final Comments from the Evaluators

The Administrative Questionnaire concluded with an invitation to suggest improvements for the current L-REAC™ System, and to make any “Final Comments”. The following improvements were recommended by the evaluators:

- *Phone applications, web access if evacuated off post.* (#3)

- *Add N-hour and the type of chemicals released. (#8)*
- *The ability to cover a wider area & zoom in to your area of interest like on Google Earth. Off main cantonment areas like the F.B.R. (Fast Burst Reactor) for use during a radiological plume. (#10)*
- *More locations providing real-time data (red arrow); APP creation for smart phones. (#11)*
- *My future vision for L-REACT™ would be a system with real time display to incorporate multiple Plume data. (#13)*
- *Would like to see graduation to hand-held that soldier could use in the field. (#16)*
- *(1) Ability to search for multiple chemical presence; (2) Continuous/autonomous system monitoring/operational; (3) Monitor multiple locations. (#18)*

The Evaluator's final comments included:

- *Good & easy system to use. Is this the system used by the weather people on TV that show wind maps of the area; or can they be tied in together. (#10)*
- *Keep the visuals (GUI) [Graphical Users Interface] clean. (#11)*
- *Keep up the great work. (#14)*
- *I think the IOC could use a bigger map for the wall, so that when things get hopping, we don't have a crowd behind a computer. Also, it would help (to) show the bigger picture. (#15)*
- *Great demonstration. (#16)*
- *Incredible what comes out of burning crap! Also, would like one day a week for a month or so to train operators by having L-REACT™ on-line and processing data requests from the IOC. (#18)*

4. Discussion

The purpose for this L-REACT™ System improvement evaluation task was to solicit practical and visionary improvements from volunteer and professional emergency first responders. The evaluation's implementation also served as an opportunity for the Training I students to test their newly acquired skills with the L-REACT™ System output. Keeping these two perspectives in mind, the results were most encouraging.

4.1 Detailed Review of the L-REACT™ System Product

Beginning with the detailed questionnaire, the communication method for gaining access to the L-REACT™ System output was easily understood and implemented. The basic features of the 1-Plot and 2-Plot EUD outputs were easily located. Key features from which decisional actions are anticipated were defined as “easy” to find, by the majority of evaluators.

For the wind field output, an isolated “difficulty” in finding the wind speed in the 1-Plot/Case I and II scenarios was linked to a zoomed-in, narrow field-of-view image with no available reference vectors. L-REACT™ has no control over the number or placement of mesonet reference vectors. Another isolated “difficulty” flagged the locating of compass North on a 2-Plot output. This response was assessed to be a function of student learning. As explained earlier, 1-Plot images have a labeled arrow pointing up (top of page) indicating North. To reduce visual clutter, the simultaneously issued 2-Plot image implies North as up (top of page). This presumed pattern for the 2-Plot was explained during Training I. Aside: some Training I students took the training after completing a 10-hr shift, which no doubt challenged the ability to absorb all the many details presented during the training session.

For the plume output evaluation, the majority of evaluators found the key features of the 2-Plot easily. The “difficulty” reported concerned color discernment and a North reference. The latter was explained above. The color discernment was resolved as part of the implemented evaluation results prompted after the 2011 Abrams Fire Incident. That is, tailored color hues and outlines more conducive to a desert background image and the viewing of a computer screen under natural sunlight, were selected for the EUD output.

4.2 Overall System Evaluation

Evaluators unanimously agreed that they would recommend the L-REACT™ System to be purchased. Their reasons were listed in section 3.2.1. Two volunteered responses in particular capture the primary system’s goal and greatest challenge. These were:

- It (the L-REACT™ System) can save lives!
- This tool’s ability to determine wind flow around structures is very useful for Fire Fighters and EM (emergency management). Selling the product would be great; too bad those that need it most would most likely not afford it.

The evaluator applications for the L-REACT™ System consisted of CBRNE Force Protection applications, IOC, EOC, Fire/Rescue and Emergency Dispatch. All evaluators reported that the L-REACT™ System would be an asset to their profession/application.

Strengths cited for the System included five comments which praised the ease of use, understandability of end products, and the “great” potential of the System. The (near) real-time capability was favorably emphasized in two evaluator comments, as well as, the applicability for

real world usages. System strengths applicable to the evaluator's profession included both the wind field and plume elements. The "ease of use" was again emphasized as a significant strength by these first responders.

To better inform the System designers regarding the operational emergency management environment, two scenarios for integrating the L-REACT™ System into the emergency response community were offered:

- Multiple L-REACT™ Systems in various organizations.
- A single L-REACT™ System with multiple users (representing different organizations).

The evaluators offered a third arrangement:

- Two (or three) L-REACT™ Systems: One organization would serve as the primary L-REACT™ System operator with multiple users (representing different organizations). The second system would be installed at a different location, and would serve as a backup unit, should the primary unit suddenly lose power or network connectivity.

The most favored arrangement was to have multiple organizations own an L-REACT™ System. Based on current economic restrictions, the author suspects that the ideal arrangement for integrating an L-REACT™ System into the emergency response community would be the third suggested option.

Under a multiple organization ownership design, the following agencies were unanimously suggested for owning a System: the Fire Dept/Medical and the IOC. Seventy-eight percent of the evaluators included the EOC. The least recommended owner was installation commanders.

With a single unit ownership design, the unanimous, top recommendation for receiving system output was the Fire Dept/Medical. The IOC, EOC, Police, IC on location, IC in IOC and Garrison Commander were also suggested by the majority of evaluators. The least recommended for receiving user output was the installation Commanding General.

One of the evaluator suggestions for potential owners and users of the L-REACT™ System was the "Dispatch" office. Dispatch has a distinct function from the IOC and EOC, so this office is definitely a suggestion that needs to be considered.

Directions for "how to access the L-REACT™ System remotely" were sent to each evaluator. These instructions were unanimously evaluated as "easy to follow" and the System output was labeled as timely. The output details were assessed as "enough" (versus "too many details"). The Operator's zoom-in capability was considered *very useful in the emergency mgt (management) arena*.

Focusing on the System output details, almost all evaluators considered the listed 1-Plot and 2-Plot features as useful. Seventy-eight percent indicated ALL information as "most useful." The lowest rated feature (89%) was the "No Plume" notice.

4.3 Evaluator Future Vision and “Final Comments”

The evaluators provided their future L-REACT™ vision by suggesting System improvements. Several items suggested reinforced designs already flagged for future L-REACT™ Systems. For example: Regarding the phone applications suggestions—In 2010–2011, a feasibility test was successfully conducted, which overlaid the L-REACT™ System plume output on an iPod’s AOI display. Subsequently, plans for sending the output to an Android (an Army endorsed hand-held phone) are being considered. The ultimate goal of this effort is to bring the hand-held technology to our Soldiers in the field.

Regarding the request to cover a wider AOI—The L-REACT™ System now includes the ability to cover three scales of wind field AOIs. The outer extremes of these scales include the building scale (covering ~2-km width) and the regional scale (covering ~50-km width). See section 3.1. The latter scale covers the suggested FBR site mentioned in the evaluator comments.

The ability to provide more measured data (red arrows) is a function of the organizations that sponsors the mesonet resources. While L-REACT™ has no direct influence on those decisions, should the opportunity to express the evaluator’s suggestion arise, it will be shared.

Searching for multiple chemicals, such as using a chemical sniffer sensor, was considered in the original L-REACT™ System design for the Sensor Module. Due to budgetary constraints, this option had to be tabled. Currently, integrating sniffer technology is still pending funding.

Being able to display multiple plumes is another vision that was in the original L-REACT™ System design. The implementation of this vision began with the inclusion of measured quantities in the output display. The designers purposefully did not impose a spatial-relevance limitation on the mesonet data listing on the output. This decision was to accommodate the potential for multiple fire/toxic release locations occurring simultaneously.

Continuing with the concept of multiple plumes, the original L-REACT™ System design included running multiple plume (and wind) models, concurrently. The core L-REACT™ quick response models would continue to run as designed, while a second tier of plume models would be executed as background computer jobs. Within these slower, second tiered plume models, multiple chemical releases could be addressed without impacting the immediate decisions still needing to be made from the core modules/models.

The evaluator “Final Comments” were most encouraging to the L-REACT™ System designers. The suggested bigger map for the IOC wall has been addressed in that the referenced-IOC can now project the L-REACT™ Output onto their wall via their local computers/IOC wall projector.

The “burning chemicals” reference in the last comment stems from a 2009 CNN article, which reported that the Department of Defense (DoD) found burn pits, which were used instead of incinerators on some bases/outposts in Iraq and Afghanistan in 2007, could have caused short term effects to the U.S. Soldiers. The publishing of this article coincided with the initial design

and development of the L-REACT™ System “Proof of Concept”. The article reinforced the relevancy of this decision aid to the U.S. Army soldier and, to the trainee’s credit, was included as one of the earliest slides in the Training I briefing. The website article is:

<http://www.cnn.com/2009/POLITICS/12/18/military.burn.pits/index.htm> (CNN, 2009).

In response to the evaluator’s training request, the L-REACT™ Group has since offered training to all Evaluation-participating organizations. The sessions were initially conducted over a one-month time period in fiscal year 2011 (FY11). Five levels of training were offered: Levels 1–2 prepared the student to be an L-REACT™ System user (able to correctly interpret the L-REACT™ output). Levels 3–5 prepared the trainee for being an L-REACT™ System operator. In fiscal year 2012 (FY12), additional requests for training were received and completed. At the time of this report, there have been 41 participating trainees for FY11-12, and nine trainees have reached the Operator responsibility.

5. Summary

ARL has been studying urban environments in support of the increased urban warfare. Within the first decade of 2000, three progressively more complex urban field studies were conducted at WSMR, NM. These studies examined airflow and stability around urban buildings. Concurrent with the final study *W07US*, emergency first response drills were executed. During *W07US*, the need for first responders to have access to near real-time atmospheric data was noted. This observation was later documented in ARL-TR-5706 (Vaucher, 2011), which also justified the current ARL-WSMR safety procedure update and the use of an active L-REACT™ System by ARL.

ARL responded to the civilian/military emergency responder need, by designing the L-REACT™ System. From 2009 to 2011, the viewgraph concept was converted into a “Proof of Concept,” Prototype and finally, an Operational System. The current L-REACT™ System is an automated, 24/7 emergency response decision aid designed for airborne toxic release incidents. The basic design of the L-REACT™ System includes five modules: the Sensor, QC, Model, EUD and Archive Modules. The Sensor module continuously acquires meteorological data used as input by both a wind field and plume model. These models continually run and produce a 1-Plot and 2-Plot *html* output, which is accessible by authorized end users. The output shows an overview map of an AOI, with wind field and plume (when applicable) overlays. These overlays are updated every 2–8 min, depending on the resolution of the wind field model. An archive continually saves both the measured data and (when the user has selected this option) the image output. The System is designed to run attended by an operator or without an operator.

As part of the technology transfer process, the L-REACT™ System was subjected to several informal and formal evaluations. The first evaluation was an informal demonstration of the

System to about 30 GEMS high school students/teachers, who used the system to assess the wind flow and safe zone locations. Several Force Protection Exercises and Drills have provided user feedback throughout the development phases. In April 2011, the L-REACT™ System participated in the “real-world” event called, “the Abrams Fire.” Training sessions were subsequently requested by the emergency first response organizations. Within these training sessions, the first formal L-REACT™ System improvement evaluations were conducted. The results are the subject of this technical report.

The evaluations were organized into two questionnaires: An Administrative Questionnaire, which looked at the System from an overview and future vision perspective. The second questionnaire focused the System Functionality, and included a more detailed review of the System output. This questionnaire also served as an informal test for the students who had just completed their Training I course. The Functionality Questionnaire was divided into three cases/scenarios: Case I (No Plume Scenarios), Case II (Plume Scenarios) and Case III (No Plume/Plume Scenarios).

The results of the Administrative Questionnaire reported that, from the remote communications through the continuously updated wind and plume images, the system was easily understood and implemented. The few isolated items flagged as “difficult” could be explained in the context of students learning (this evaluation was the first time some had seen the System in operation). The viewing output difficulty was addressed when the color contrasts were enhanced for desert environment backgrounds.

Evaluators unanimously stated that they would recommend the system. The explanations for why they would recommend the System captured the System objective of “saving lives,” and the challenge of finding funding resources to support system development costs.

The evaluator applications for the L-REACT™ System consisted of CBRNE Force Protection applications, IOC, EOC, Fire/Rescue and Emergency Dispatch. All evaluators reported that the L-REACT™ System would be an asset to their profession/application.

System strengths cited included five comments which praised the ease of use, understandability of end products, and the “great” potential of the System.

To edify the System designers regarding how the L-REACT™ might be integrated into the operational emergency environment, two scenarios were offered:

- Multiple L-REACT™ Systems in various organizations.
- A single L-REACT™ System operated, with multiple users (representing different organizations).

The evaluators offered a third arrangement:

- Two (or three) L-REACT™ Systems: One organization would serve as the primary operator with multiple users (representing different organizations). The second system would be installed at a different location, and would serve as a backup unit, should the primary unit suddenly lose power or network connectivity.

While the most favored arrangement was to have multiple organizations own an L-REACT™ System, economics may limit the arrangement to the third option. With multiple organizations each owning a System, the Fire Dept/Medical and the IOC were unanimously selected as potential owners. Over three-fourths of the evaluators included the EOC, as a potential owner. The least recommended prospective owners were the installation command offices.

With a single, central-owner design, the unanimous top recommendation for a user was the Fire Dept/Medical. The IOC, EOC, Police, IC on location, IC in IOC and Garrison Commander were also suggested for users by the majority of evaluators. The least recommended user was the installation Commanding General. The “Dispatch” office was suggested as both an owner and user.

“How to access the L-REACT™ System remotely” directions were unanimously evaluated as “easy to follow” and the System output was flagged as timely. The output details were assessed as “enough” (versus “too many details”). The Operator’s zoom in capability was considered *very useful in the emergency mgt (management) arena*.

Focusing on the output details, the majority of evaluators considered the listed 1-Plot and 2-Plot features as useful. Seventy-eight percent indicated ALL information as *most useful*. The “lowest” rated feature (selected as *useful* by 89% of the evaluators) was the “No Plume” notice.

6. Final Comments by Author and Evaluators

All the evaluator comments have been extremely helpful in calibrating the value of the L-REACT™ System to the emergency response community. While funding may limit its future development, the fact that the System has already proven to have a positive impact on both the local ARL safety procedures and surrounding military/civilian communities indicate that, at the right time (when funded), this technology will continue to make a constructive difference. And, with proper support, the System is still a candidate for use by ARL’s primary customer, the U.S. Army Soldiers.

In the meantime, the “final comments” for this report are provided by the evaluators:

- *(The L-REAC™ System is) Good & easy system to use. Is this the system used by the weather people on TV that show wind maps of the area; or can they be tied in together. (#10)*
- *Keep the visuals (GUI) clean. (#11)*
- *Keep up the great work. (#14)*
- *I think the IOC could use a bigger map for the wall, so that when things get hopping, we don't have a crowd behind a computer. Also, it would help (to) show the bigger picture. (#15)*
- *Great demonstration. (#16)*
- *Incredible what comes out of burning crap! Also, would like one day a week for a month or so to train operators by having L-REAC™ on-line and processing data requests from the IOC... (#18)*

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Appendix A. System Functionality Questionnaire–Evaluator Results

The *System Functionality Questionnaire* allowed the voluntary and professional emergency first responders to provide a detailed review of the L-REAC™ System products. This review was gleaned through three scenarios or Cases, each representing foundational functions for the L-REAC™ System output. The Cases included:

Case I: (No Plume Scenarios)

- STATUS: Wind Field Model and No Plume.
- SCENARIOS: Entire AOI, 3 Mesonet Locations, Medical Facility, a User Selection.

Case II: (Plume Scenarios)

- STATUS: Wind Field Model and Pre-determined Plume.
- SCENARIOS: Training site – large image (1) and zoomed-in images (3).

Case III: (No Plume/Plume Scenarios, with multiple locations)

- STATUS: Wind Field Model with No Plume & Plume scenarios.
- SCENARIOS: Training site-No plume & Plume; Plume at user-selected site within AOI.

For an explanation of the System Functionality Questionnaire and the three Cases, see section 2.2.1.

The statistical results presented in the *L-REAC™ System Evaluation: Case I, II, II (System Functionality)* include data and comments from all ten *System Functionality Questionnaires* returned. Where an evaluator skipped or missed a question, a note was placed after the question, but the tally was still based on ten total submissions.

Note: If the tallies had been based on the actual number of evaluators responding to the question, the tallies would have been higher in magnitude.

L-REACT™ SYSTEM EVALUATION: CASE I - System Functionality

Case I: The 1-Plot and 2-Plot Evaluation, No Plume: (30 minutes)

- STATUS: Wind Field Model (5m resolution) and No Plume.
- SCENARIOS: WSMR Post, 1622, Museum, Golf Course, Medical Clinic, User Selection.

Evaluator #: **3, 8, 10, 11, 13, 14, 15, 16, 18, 24** [10 total]

Evaluation Date/Time: _____ MT

1. Access to L-REACT™ System Output: (#24: Not answer 1.1 and 1.2 questions.)

1.1. Describe your experience with the DMZ network connection (L-REACT™ output access):

90% (9) - The DMZ connection ran *without* any interruptions.

_____ The DMZ Connection ran *with* interruptions. (please describe) _____

_____ Other: _____

1.2 Frequency of output updates:

70% (7) - The frequency of output updates was sufficient.

10: for this case

10% (1) - The frequency of output updates needs to be more often.

_____ - The frequency of output updates can be less often.

10% (1) - Other _____

3: Was Sufficient, temporarily dropped out.

2. The L-REACT™ System Output:

2.1 During the evaluation period, which of the following was seen on your output display?

(Select all that apply):

1-plot graphic:

100% (10) - An area of interest (AOI) map (Google Earth Map).

100% (10) - The date and time stamp.

100% (10) - The height of the output winds.

100% (10) - The wind field model wind arrows (blue).

100% (10) - The wind field model streamlines (yellow).

90% (9) - The measured wind arrows (red).

90% (9) - A "No Plume" notice. [If not relevant, put N/A on line.]

90% (9) - The WSMR Surface Automated Meteorology System (SAMS) data list (text box).

2-plot graphic: (#24: Not answer 2.1 2-plot graphic.)

n/a **50% (5)** - Two area maps.

90% (9) - Time stamp of wind data.

90% (9) - The height of output winds (Left plot header).

90% (9) - The wind model streamlines (Left plot).

90% (9) - The color-gradient wind velocities (Left plot).

n/a **60% (6)** - A "No Plume" notice (Right plot). [If not relevant, put N/A on line.]

n/a **60% (6)** - A plume gradient description (Right plot).

2.2 Evaluating the Wind Field Model output: (Questions 2.2.1 and 2.2.2)

2.2.1 On the **1-plot (Google Earth) output...**

1-Plot - Finding compass north: (select one)

90% (9)-Was easy.

10% (1)-Was sort of easy. Why? **18:** Blended in w/text box. Suggest relocate to right of plot map.

___ Was difficult. Here's why _____

___ Was not relevant. Here's why _____

1-Plot - Determining the direction for the airflow: (select one)

100% (10) - Was easy.

___ Was sort of easy. Here's why _____

___ Was difficult. Here's why _____

___ Was not relevant. Here's why _____

1-Plot - Determining the speed of the airflow: (select one)

80% (8)-Was easy.

10% (1)-Was sort of easy. Here's why **11:** Had to reference previous picture with red arrow

10% (1)-Was difficult. Here's why **18:** No reference.

___ Was not relevant. Here's why _____

2.2.2. On the **2-plot (Wind and Plume) output...** **[24: Not answer question.]**

2-Plot, Wind Field Plot (left side) - Finding compass north: (select one)

70% (7)-Was easy.

10% (1)-Was sort of easy. Here's why **10:** I know that north is always up

10% (1)-Was difficult. Here's why **18:** No "N" indicator

___ Was not relevant. Here's why _____

2-Plot, Wind Field Plot (left side) - Determining the airflow direction: (select one)

90% (9)-Was easy.

___ Was sort of easy. Here's why _____

___ Was difficult. Here's why _____

___ Was not relevant. Here's why _____

2-Plot, Wind Field Plot (left side) - Determining the speed of the airflow: (select one)

70% (7)-Was easy.

20% (2)-Was sort of easy. Here's why

10: Had to mark a known speed off the right plot then measure on the left plot.

15: Flipping back to measure the red arrow to get a speed.

___ Was difficult. Here's why _____

___ Was not relevant. Here's why _____

L-REACT™ SYSTEM EVALUATION: CASE II - System Functionality

Case II: The 1-Plot and 2-Plot Evaluation, Plume: (20 minutes)

- STATUS: Wind Field Model (5m resolution) and Pre-determined Plume.
- SCENARIO: Bldg 1622 – large image (1) and zoomed-in images (3).

Evaluator #: **3, 8, 10, 11, 13, 14, 15, 16, 18, 24** [10 total]

Evaluation Date/Time: _____ MT

1. Access to L-REACT™ System Output: (#8 and 24: Not answer 1.1 and 1.2 questions.)

1.1. Describe your experience with the DMZ network connection (L-REACT™ output access):

70% (7)-The DMZ connection ran *without* any interruptions.

10% (1)-The DMZ Connection ran *with* interruptions. (please describe) _____

_____ Other: _____

1.2 Frequency of output updates:

60% (6)-The frequency of output updates was sufficient.

10: With use of the F-5 key every now and then.

20% (2)-The frequency of output updates needs to be more often.

_____ The frequency of output updates can be less often.

_____ Other _____

2. The L-REACT™ System Output:

2.1 During the evaluation period, which of the following was seen on your output display?

(Select all that apply): **(#16: Difficult to read ink answers, may have impacted 2-plot.)**

1-plot graphic:

100% (10) - An area of interest (AOI) map (Google Earth Map).

100% (10) - The date and time stamp.

70% (7) - The height of the output winds. **10:** I missed the red arrow on the first screen did not see it on the second zoomed in screen.

90% (9) - The wind field model wind arrows (blue).

90% (9) - The wind field model streamlines (yellow).

70% (7) - The measured wind arrows (red).

100% (10) - A plume overlay.

100% (10) - A plume gradient description of the gradients used.

90% (9) - The WSMR Surface Automated Meteorology System (SAMS) data list (text box).

2-plot graphic:

90% (9) - Two area maps.

90% (9) - Time stamp of wind data.

90% (9) - The height of output winds (Left plot header).

90% (9) - The wind model streamlines (Left plot).

90% (9) - The color-gradient wind velocities (Left plot).

90% (9) - A plume overlay (Right plot).

90% (9) - A plume gradient description (Right plot).

2.2 Evaluating the Wind Field Model output: (Questions 2.2.1 and 2.2.2)

2.2.1 On the **1-plot (Google Earth) output...**

1-Plot - Finding compass north: (select one)

90% (9) - Was easy.

10% (1) - Was sort of easy. Here's why **18:** Location of indicator

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

1-Plot - Determining the direction for the airflow: (select one)

90% (9) - Was easy.

10% (1) - Was sort of easy. Here's why

10: Blue arrows were very small, had to use yellow stream arrows to tell direction.

_____ Was difficult. Here's why _____

10% (1) - Was not relevant. Here's why **NOTE, #14:** "was easy" & "not relevant".

1-Plot - Determining the speed of the airflow: (select one)

70% (7) - Was easy.

10% (1) - Was sort of easy. Here's why **10:** By looking at the station & the speed there.

20% (2) - Was difficult. Here's why **18:** No scale

24: The colors indicating the concentrations blend into the background. The lines are extremely thin. (Plume concentrations)

_____ Was not relevant. Here's why _____

2.2.2. On the **2-plot (Wind and Plume) output...**

2-Plot, Wind Field Plot (left side) - Finding compass north: (select one)

80% (8) - Was easy.

10% (1) - Was sort of easy. Here's why **10:** Knowing that North is always up.

10% (1) - Was difficult. Here's why **18:** No indicator

_____ Was not relevant. Here's why _____

2-Plot, Wind Field Plot (left side) - Determining the airflow direction: (select one)

100% (10) - Was easy.

_____ Was sort of easy. Here's why _____

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

2-Plot, Wind Field Plot (left side) - Determining the speed of the airflow: (select one)

90% (9) - Was easy.

10% (1) - Was sort of easy. Here's why **10:** By going off the station & speed there.

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

2.3 Evaluating the Plume Model:

2.3.1 Did you start the ALOHA Model for this exercise? **Yes-1 No-7** (Circle one)

If **no**, please **go to Question 2.3.2**.

10: Done by ARL Staff.

If **yes**, please continue.

2.3.1.1 Was the ALOHA start up user-friendly? **Yes-1 No** (Circle one)

2.3.1.2 Was gathering the plume model input difficult? Yes. **No-1** Sort of. (Circle one)

Comments: _____

2.3.1.3 Was entering the plume model input difficult? Yes. **No-1**. Sort of. (Circle one)

Comments: **11:** Did not input any data

15: Did not do any input

2.3.2. On the **2-plot (Wind and Plume) output...** (**#8 did not answer 2.3.2**)

2-Plot, Plume Plot (right side) - Finding compass north: (select one)

80% (8) - Was easy.

_____ Was sort of easy. Here's why _____

10% (1) - Was difficult. Here's why **18:** No indicator

_____ Was not relevant. Here's why _____

2-Plot, Plume Plot (right side) - Determining hazardous areas generated by the plume: (select one)

80% (8) - Was easy.

_____ Was sort of easy. Here's why _____

10% (1) - Was difficult. Here's why **18:** No distance scale to reference

_____ Was not relevant. Here's why _____

2-Plot, Plume Plot (right side)-Determining the most/least hazardous areas: (select one)

80% (8) - Was easy.

10% (1) - Was sort of easy. Here's why **18:** Lines very thin, better when you filled in the red area.

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

L-REACT™ SYSTEM EVALUATION: CASE III - System Functionality

Case III: No Plume/Plume Scenarios, with multiple locations: (30 minutes)

- STATUS: Wind Field Model (5m resolution) with No Plume & Plume scenarios.
- SCENARIOS: 1622-No plume & Plume; Plume at user-selected site within Post.

Evaluator #: 3, 8, 10, 11, 13, 14, 15, 16, 18, 24 [10 total]

Evaluation Date/Time: _____ MT

1. Access to L-REACT™ System Output: (#8 and 24: Not answer 1.1 and 1.2 questions.)

1.1. Describe your experience with the DMZ network connection (L-REACT™ output access):

80% (8) - The DMZ connection ran *without* any interruptions.

_____ The DMZ Connection ran *with* interruptions. (please describe) _____

Other: _____

1.2 Frequency of output updates:

50% (5) - The frequency of output updates was sufficient.

30% (3) - The frequency of output updates needs to be more often.

10: Might need quicker updates in dealing with a plume.

_____ The frequency of output updates can be less often.

Other _____

2. The L-REACT™ System Output:

2.1 During the evaluation period, which of the following was seen on your output display?

(Select all that apply):

1-plot graphic:

100% (10)- An area of interest (AOI) map (Google Earth Map).

90% (9) - The date and time stamp.

80% (8) - The height of the output winds.

90% (9) - The wind field model wind arrows (blue).

90% (9) - The wind field model streamlines (yellow).

70% (7) - The measured wind arrows (red). **18: Barely.**

80% (8) - A “No Plume” notice [May only be present during initial part of test sequence].

70% (7) - A plume overlay.

70% (7) - A plume gradient description of the gradients used.

90% (9) - The WSMR Surface Automated Meteorology System (SAMS) data list (text box).

2-plot graphic:

90% (9) - Two area maps.

100% (10)- Time stamp of wind data.

100% (10)- The height of output winds (Left plot header).

100% (10)- The wind model streamlines (Left plot).

100% (10)- The color-gradient wind velocities (Left plot).

_____ 60% (6) - A “No Plume” notice [May only be present during initial part of test sequence].

_____ 80% (8) - A plume overlay (Right plot).

_____ 80% (8) - A plume gradient description (Right plot).

2.2 Evaluating the Wind Field Model output: (Questions 2.2.1 and 2.2.2)

2.2.1 On the **1-plot (Google Earth) output...**

1-Plot - Finding compass north: (select one)

90% (9) - Was easy.

10% (1) - Was sort of easy. Here's why **18: Same.**

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

1-Plot - Determining the direction for the airflow: (select one)

100% (10) - Was easy.

_____ Was sort of easy. Here's why _____

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

1-Plot - Determining the speed of the airflow: (select one)

90% (9) - Was easy.

10% (1) - Was sort of easy. Here's why **18: No scale.**

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

2.2.2. On the **2-plot (Wind and Plume) output...**

2-Plot, Wind Field Plot (left side) - Finding compass north: (select one)

80% (8) - Was easy.

10% (1) - Was sort of easy. Here's why **10: Known North**

10% (1) - Was difficult. Here's why **18: No Indicator**

_____ Was not relevant. Here's why _____

2-Plot, Wind Field Plot (left side) - Determining the airflow direction: (select one)

100% (10) - Was easy.

_____ Was sort of easy. Here's why _____

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

2-Plot, Wind Field Plot (left side) - Determining the speed of the airflow: (select one)

90% (9) - Was easy.

10% (1) - Was sort of easy. Here's why **10: Using color chart at bottom.**

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

2.3 Evaluating the Plume Model:

2.3.1 Did you start the ALOHA Model for this exercise? **Yes-1 No-8** (Circle one)

If **no**, please **go to Question 2.3.2**.

10: Input done by ARL

If **yes**, please continue.

2.3.1.1 Was the ALOHA start up user-friendly? **Yes-1 No** (Circle one)

2.3.1.2 Was gathering the plume model input difficult? Yes. **No-1** Sort of. (Circle one)

Comments: _____

2.3.1.3 Was entering the plume model input difficult? Yes. No. Sort of. (Circle one)

Comments: **15:** Did not do this

2.3.2. On the **2-plot (Wind and Plume) output...** (**#8 and 13 did not answer 2.3.2**)

2-Plot, Plume Plot (right side) - Finding compass north: (select one)

#8, 13 and 16: Didn't answer this part of question 2.3.2.

60% (6) - Was easy.

_____ Was sort of easy. Here's why _____

10% (1) - Was difficult. Here's why **18:** No indicator

_____ Was not relevant. Here's why _____

2-Plot, Plume Plot (right side) - Determining hazardous areas generated by the plume: (select one) **#8 and 13:** Didn't answer question 2.3.2.

70% (7) - Was easy.

10% (1) - Was sort of easy. Here's why **18:** Would help to fill most hazardous w/color.

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

2-Plot, Plume Plot (right side)-Determining the most/least hazardous areas: (select one)

#8 and 13: Didn't answer question 2.3.2.

70% (7) - Was easy.

10% (1) - Was sort of easy. Here's why **18:** Should fill area with AEGL-3 with red.

_____ Was difficult. Here's why _____

_____ Was not relevant. Here's why _____

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Appendix B. Administrative Questionnaire–Evaluator Results

The *Administrative Questionnaire* focused on administrative (“big picture”) questions and applications. The first two categories evaluated were the instructions for accessing the L-REACT™ System, and the output of the L-REACT™ System as seen through the evaluator’s professional requirements. A short prose (written) section allowed them to describe their overall impression of the L-REACT™ System, where they thought the L-REACT™ product future vision should be, and to make marketing suggestions. The questionnaire concluded by soliciting “Final Comments.”

There were nine *Administrative Questionnaires* filled out and returned; therefore, all the statistics were based on a total of nine submissions. (Evaluator #24 did not fill out this questionnaire form.) Where an evaluator skipped or missed a question, a note was placed after the question, but the tally was still based on nine total submissions.

Note: If the tallies had been based on the actual number of evaluators who filled out the question, the tallies would have been higher in magnitude.

L-REACT™ SYSTEM EVALUATION: Administrative Questions

Evaluator #: 3, 8, 10, 11, 13, 14, 15, 16, 18 [9 total] -- #24 did not fill in this form.

Evaluation Date/Time: _____ MT

1. Accessing L-REACT™ Output: The SOP for accessing L-REACT™ output was:

100% (9) - Easy to follow.

_____ Easy to follow, but I'd recommend the following improvement(s): _____

_____ Difficult to follow. Comment: _____

2. Application:

2.1 Briefly describe your application for the L-REACT™ System output (ie, Fire/Rescue applications, Dispatch applications, etc) :

3: Was Sufficient, worked quick.

8: Ops Center and CBRNE.

10: For all of the above plus for emergency use such as plume data.

11: IOC

13: Force protection/personnel notification/evacuation

14: CBRNE applications for displaying plume modeling for decision makers.

15: IOC/EOC

16: Step by step procedures easy to follow

18: Emergency MST which encompasses Fire/Police/Dispatch and providing info for decision makers.

Would L-REACT™ help you to do your work? **Yes-89% (8)** No (Circle one).

2.2 Which L-REACT™ output display information was useful for your application (check line next to all selections that apply; please do NOT circle the "+" until answering question 2.3):

1-plot graphic: (#18 circled the "+")

100% (9) - + An area of interest (AOI) map (Google Earth Map).

100% (9) - + The data time stamp.

100% (9) - + The height of output winds presented.

100% (9) - + The wind field model wind arrows (blue).

100% (9) - + The wind field model streamlines (yellow).

100% (9) - + The measured wind arrows (red).

89% (8) - + A "No Plume" notice.

100% (9) - + A plume overlay.

100% (9) - + A plume gradient description of the gradients used.

100% (9) - + The Surface Automated Meteorology System (SAMS) data list (text box).

2-plot graphic:

100% (9) + Two area maps.

100% (9) + Time stamp of wind data.

100% (9) + The height of output winds (Left plot header).

100% (9) + The wind model streamlines (Left plot).

100% (9) + The color-gradient wind speeds (Left plot).

89% (8) + A "No Plume" notice.

100% (9) + A plume overlay (Right plot).

100% (9) + A plume gradient description (Right plot).

2.3 Please select the information listed in question 2.2 that was ‘**most useful**’, by circling the “+” next to the 1-plot & 2-plot line descriptions (multiple selections are ok).

78% (7) - If ALL the information was “most useful” then check this line only.

2.4 Comparing graphical outputs (check the statement that best summarizes your observation, and provide comments): (**#16 did not answer 2.4**)

89% (8) Both the 1-plot and 2-plot displays were equally useful. Comments: _____

3: Nice to see the different colors; hard to tell which colors were, looked like 2 yellows.

8: 1P displays all wind speed info and 2 plot displays the plume much more clearly.

10: Plot 1 was more useful than Plot 2 when there was no plume. But when there was a plume, it was good to have the smaller Google picture in the plume box on Plot 2; and having the option to go to Plot 1 for an expanded view.

14: They allowed for comparison in order to double check original information.

15: Both have different uses and give useful information

18: Critical for current decision making and future planning.

___ The 1-plot output was more useful than the 2-plot because: _____

___ The 2-plot output was more useful than the 1-plot because: _____

2.5 Which would be better for a Government Range (such as WSMR Post), in your opinion:

(**#11 did not select an option for 2.5, but did give a comment**)

56% (5) Multiple organizations have their own dedicated L-REAC™ Systems, or

33% (3) One organization having a dedicated system with multiple organizations seeing the output.

Briefly explain why:

3: Maybe 2 or 3 organizations, in the case that 1 organization went down, no electricity, etc.

8: It would be best for different organizations to have a common point of reference.

10: It would be good to have at least another organization with the system in case the initial L-REAC System is down or destroyed.

11: Can conceptualize the situation fast.

13: Each organization would be able to adapt for specific mission requirements.

14: This would allow for one-source information dissemination to multiple agencies and avoid confusion and distortion of information.

15: Everyone would have different uses.

16: Better uniformity and control of data

18: WSMR IOC operates 24/7 and having on hand availability is important. No need for ARL operators to arrive.

3. OVERALL IMPRESSION:

3.1 What did you like about the system?

- 3: Real time data and visual with buildings and surrounding area.
- 8: Clear & concise. Displays the most pertinent information.
- 10: Easy to use & understand. It helped with the initial overview done by Gail a week prior.
- 11: Great tool with potential
- 13: The capabilities for real world use as a force protection tool.
- 14: It gives real time information and can also produce a plume (if necessary).
- 15: Very easy to understand and read winds
- 16: Clear and concise output and (user friendly)
- 18: Everything, wind flow, speed, current data, toxic plume data

3.2 What were the greatest strengths?

- 3: wind speed and direction. The probability of the plume direction. Safe points.
- 8: It gives enough information so that if someone outside of the organization came to assist, they should be able to assess the situation relatively quickly.
- 10: The ability to add a plume
- 11: Ease of Use
- 13: The ability to determine hazards plume areas for personnel evacuation purposes.
- 14: Ease of use
- 15: The prediction of the plumes
- 16: The amount of different data elements
- 18: Wind speed, direction and flow

3.3 Is the system providing timely information? Yes-**89%** (8). No. **Sort of-11%** (1). (Circle one)

Comments: _____

- 3: Good to have live data when presented questions from the IOC
- 10: Yes; but during an emergency it would be nice to have update quicker when there was a plume involved.
- 13: Would eventually like to see the system running at real time.
- 14: But I think that we could lessen the update times (if possible)
- 18: Yes

3.4 Is the system providing enough / too many details?

Comments: _____ Enough-**100%** (9) / Too many-**22%** (2) - #8 and 10 is yes/no _____

3: No, as in “no comments to add”.

8: Perhaps the type of chemical and the N-hour could be included.

10: Yes; it might be more helpful if there were more known (RED) arrows in the area.

11: Enough detail for now → I use it and a large map to view immediate then potential effects

15: Not at all (as in ‘there are not too many details’).

13: From my perspective the system has the required details.

14: It is providing what is needed for decision makers to get timely and up-to-date data to deal with the crisis at hand.

16: Enough details.

18: Enough details; no comments.

3.5 Is the flexibility (zoom and pan) in the visualization useful?

Yes-**66%** (6). No-**11%** (1). Sort of-**22%** (2). (Circle one) Comments: _____

3: Focuses in the area of interest.

8: This makes it easier to be sure where on WSMR the incident is located for those unfamiliar.

10: We were not able to zoom in & out during the cases; but the ability to zoom in& out is very helpful.

11: Did not use the function

15: We did not do this

18: Yes, very useful in the emergency mgt arena.

4. **FUTURE VISION:** What improvements to L-REAC™ would you recommend?

3: Phone applications, web access if evacuated off post.

8: Add N-hour and the type of chemicals released.

10: The ability to cover a wider area & zoom in to your area of interest like on Google Earth. Off main cantonment areas like the F.B.R. for use during a radiological plume.

11: More locations providing real-time data (red arrow); APP creation for smart phones

13: My future vision for LREAC would be a system with real time display to incorporate multiple Plume data.

16: Would like to see graduation to hand-held that soldier could use in the field

18: 1) Ability to search for multiple chemical presence

2) Continuous/autonomous system monitoring/operational

3) Monitor multiple locations

5. MARKETING: Would you recommend this system be purchased? Yes-89% (8).

If so, why?

3: yes. Useful tool in determining any wind plume threats.

8: It has virtually every bit of information first responders need.

10: It would be useful with local & county dispatch/fire & EOC's.

11: Yes

13: Yes, this tool would be helpful for emergency response and building evacuations all over post.

14: Yes, It provides real-time meteorological information to the end user allowing him/her to make timely and important decisions

16: Yes, it can save lives!

18: Yes, this tools ability to determine wind flow around structures is very useful for fire fighters and EM. Selling the product would be great, too bad those that need it most would most likely not afford it.

6. Any Final Comments:

10: Good & easy system to use. Is this the system used by the weather people on TV that show wind maps of the area; or can they be tied in together.

11: Keep the visuals (GUI) clean

14: Keep up the great work.

15: I think the IOC could use a bigger map for the wall, so that when things get hopping, we don't have a crowd behind a computer. Also, it would help show the bigger picture.

16: Great demonstration.

18: Incredible what comes out of burning crap! Also, would like one day a week for a month or so to train operators by having L-REAC on-line and processing data requests from the IOC. A Wednesday is preferable.

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List of Symbols, Abbreviations, and Acronyms

ADLO	Associate Director for Laboratory Operations
AEGL	acute exposure guideline level
AGL	above ground level
AOI	area(s) of interest
ARL	U. S. Army Research Laboratory
CBRNE	Chemical, Biological, Radiological, Nuclear Effects
CISD	Computational & Information Sciences Directorate
DoD	Department of Defense
DPTMS	Directorate of Plans, Training, Mobilization and Security
EM	Emergency Management
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
EUD	End User Display
FBR / F.B.R.	Fast Burst Reactor
Fire Dept	Fire and Rescue Department
FY11	fiscal year 2011
FY12	fiscal year 2012
GEMS	Gains in the Education of Mathematics & Science
GUI	Graphical User Interface
<i>html</i>	hypertext markup language
IC	Incident Command
IOC	Installation Operations Center
km	kilometers
L-REAC™	Local-Rapid Evaluation of Atmospheric Conditions System

m	meters
mgt/MST	management
min	minute
NOAA	National Oceanic and Atmospheric Administration
Ops	Operations
OS	operating system
PC	personal computer
PoC	Proof of Concept
QC	Quality Control
SAMS	Surface Automated Meteorological System
SIP	Shelter-in-Place
SLAD	Survivability/Lethality Analysis Directorate
W03US	<i>White Sands Missile Range 2003 Urban Study</i>
W05US	<i>White Sands Missile Range 2005 Urban Study</i>
W07US	<i>White Sands Missile Range 2007 Urban Study</i>
WSMR	White Sands Missile Range

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