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Mitigating risk with real-time, sensor-driven plume dispersion modeling

November 2022

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Introduction

Across the U.S., 17% of the population live near a toxic release facility, ranging from 6.5% in Hawaii up to 37.3% in Wisconsin. That means 56 million Americans live close to a facility that uses or manufactures one or more of the 770 chemicals recognized by the U.S. Environmental Protection Agency (EPA) to have negative health implications. (Stacker 2022) Of this broad range of chemicals, 258 chemicals are especially hazardous, including ammonia, chlorine and bromine.

In sufficient quantities stockpiled, processed or manufactured at a facility, a Risk Management Program must be filed with the EPA. (EPA 2022). In addition to chemical plants and storage facilities, hazardous materials are also transported by tanker truck or railcar, presenting risks to communities.

Chemical releases can occur through a tank rupture, a pipe burst, a puddle or a direct source. A sufficient volume of hazardous material released at a facility or in the community can present a dramatic and immediate risk to businesses, the public and responders. Managing these events requires an informed and immediate response, a communications strategy and effective teamwork. When lives are on the line, seconds matter, and having real-time access to data for an informed and quick response is crucial.

Rapid risk assessment

For chemical releases at a facility or due to transportation of hazardous materials, responders need to quickly understand all details surrounding the incident, and its potential impact, to manage a quick and effective response. Rapid risk assessments include reaching answers for several key questions, including:

- What type of chemical release is it?
- Where did the release originate and what is the release rate?
- Is there a gas cloud? Where is it headed? And how fast?
- What life safety protective actions should be taken for those who are, or will be affected?
- Whom should be notified or warned?
- Where are my people and what action do they need to take?
- Are neighbor facilities or communities likely to be impacted?
- Do evacuation or shelter-in-place orders need to be made?

The first steps involve understanding the nature of the chemical release, initially driven by data from the field — a traffic accident involving a tanker truck, odor complaints from the public or even gas detection readings from the monitoring system at a facility. From there, further assessment validates this data and helps to inform response commanders to make a plan of attack to manage the release and its impact on nearby employees, members of the public and downwind receptors.

New innovations in gas plume dispersion monitoring

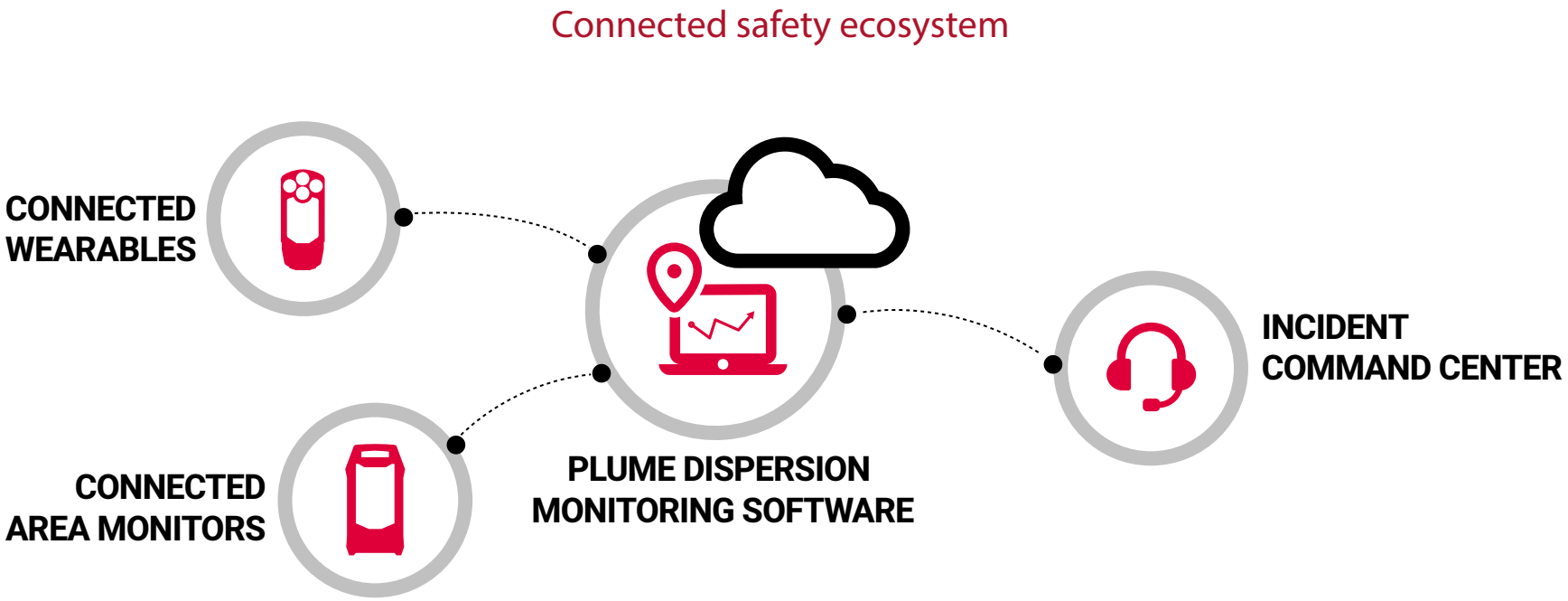
A new era of technology has arrived to empower early event assessment plus workflows for the incident commander and response teams. A combination of cloud-connected gas monitoring equipment and cloud-hosted dispersion modeling software automates the process of visualizing the overall release, plus how to effectively manage it through setting out staging areas, roadblocks and protective boundaries. Understanding where responders are deployed and the location of mobile assets contributes to the controls in place to manage an effective response, knowing real-world field conditions.

Sensor-driven source location and plume dispersion modeling are terms that describes the use of real-time environmental data from gas and meteorological sensors — combined with advanced algorithms — to automate the source location of releases, modeling the downwind gas concentrations that affect receptors, facilities and the public, and supporting the protective and mitigating decisions required to manage the event.

Starting with cloud-connected gas detection, we'll further explore how sensor-driven plume dispersion capabilities automates situational awareness and equips the response teams with the tools needed to efficiently and comprehensively manage a response.

Cloud-connected gas detection

Hazmat response operations require quick access to a live view of an incident's conditions and responders' locations to ensure informed decisions can be made. However, conventional 'disconnected' gas detectors only provide a snapshot of real-time readings to the user directly monitoring the instrument. These devices fail to continuously share this information to others involved in the response, and manually coordinating readings from response team members requires valuable time and opens the door to human error. Additionally, since any data is just from a moment in time, decisions regarding the response are made based on outdated information as conditions can rapidly change.



The shift toward cloud-connected personal and area gas monitoring instruments eliminates the old pain points of conventional gas detectors. Not only is the maintenance of this equipment streamlined through automated reporting — critically — these monitors continuously stream situational information associated with each responder and portable area monitors that are dropped in place or moved to a new location.

Cloud-connected monitors ensure that up-to-date location-enabled environmental gas readings are available, powered by built-in cellular or satellite data communication. This data is stored in the cloud and automatically flows into cloud-hosted gas plume dispersion monitoring software, accessible from any smartphone, tablet or computer.

While dramatically increasing the information flow into the incident command team, cloud-connected gas monitoring equipment is no more complex than traditional detection instruments. Personal and area gas monitors feature a user-friendly interface, and when turned on, each device automatically connects to the cloud within seconds, has a battery life to outlast any incident and is designed to withstand the harshest environments.

CASE STUDY

Learn how an urban fire department in the U.S. used connected safety technology to respond to a dangerous ammonia leak with speed and precision.

Read full story: **Real-Time Awareness Boosts Hazmat Team Response.**

CASE STUDY

Learn how connected gas detectors helped contain a dangerous fuel spill in a southern U.S. city.

Read full story: **Fire Department Uses Gas Detectors to Save Lives.**

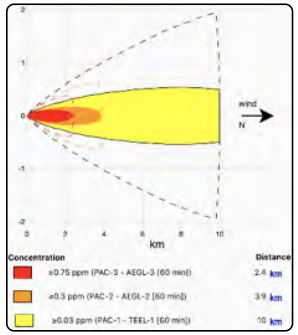
Traditional gas plume dispersion modeling

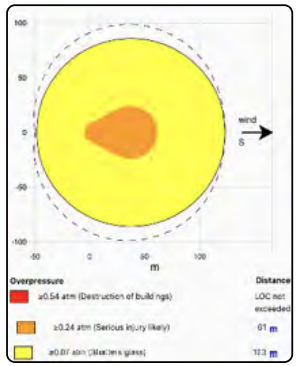
Gas plume dispersion software is a computer-based tool used to predict the path and concentration of airborne contaminants and toxic gases following a release. Users enter details about actual or possible chemical releases and the program calculates potential threat zones in the surrounding area. Emergency responders then use these predictions to make informed emergency management decisions like whether surrounding communities should shelter in place or need to evacuate.

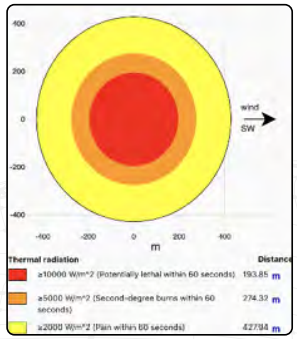
What is a gas plume? Unanticipated chemical releases, whether due to accidents or natural events, can create a gas plume with the potential to spread quickly and impact people and communities.

A common plume modeling software application is the Areal Locations of Hazardous Atmospheres (ALOHA®) model. Jointly developed by the National Oceanic and Atmospheric Administration (NOAA) and the EPA, ALOHA is a tool used to predict the location of hazardous areas in the event of a chemical release. Often used for planning purposes, the parameters of a release must be entered manually, which can be time consuming and error-prone. Additionally during live events, the required information often isn't available at the onset, forcing users to rely on their best estimate.

The biggest drawback of static models — such as responding to an incident from a tank spill — to visualize the plume, the user needs to know a lot of factors like the type, size, pressure and location of the tank, the inventory, size of the opening, where it is located on the vessel, etc. During a real-world event, this information can be very difficult to assess. Often, responders need to wait until the incident is resolved and do a forensic review after the fact. And this doesn't account for changes in atmospheric conditions, where wind speed, direction or stability changes. As release and environmental details change, including as a result of mitigative action, inputs to the modelling software must be continually assessed and updated manually.







Real-time, sensor-driven gas plume modeling system

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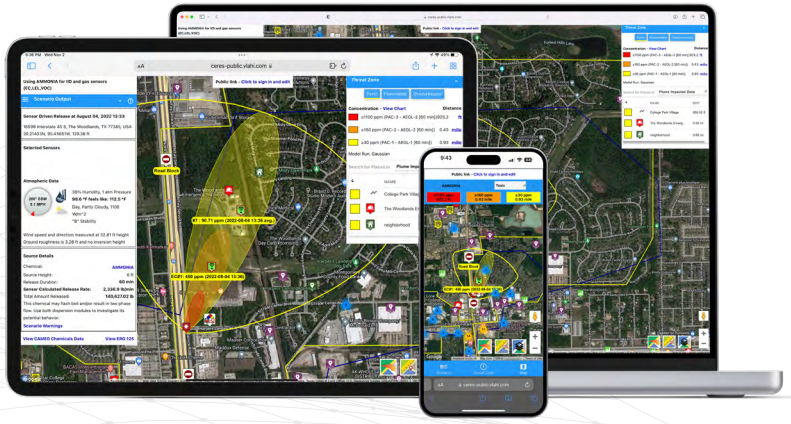
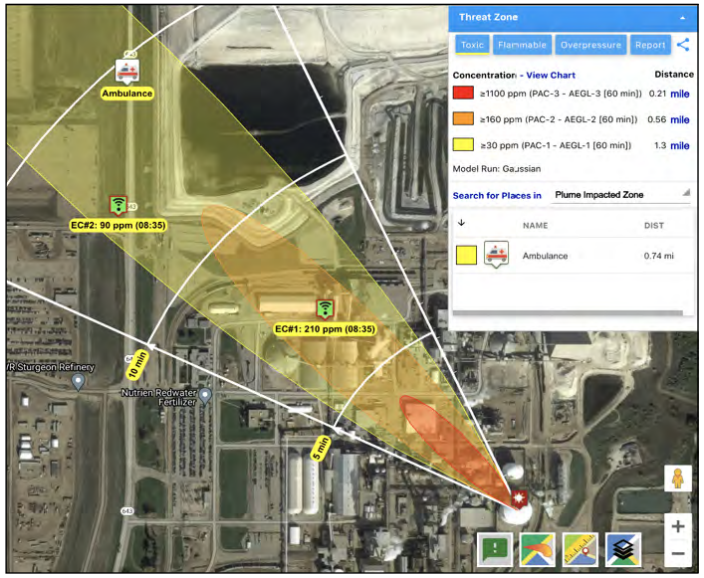
VLAHI CERES

Blackline Safety partnered with Vlahi Systems to integrate the real-time, location-stamped gas sensor data from its cloud-connected G7 personal and area gas detectors with live weather data flowing into Vlahi's CERES plume modelling software.



Sensor-driven plume dispersion software

The latest innovation in sensor-driven plume dispersion software is its availability through a cloud-hosted platform, often referred to as software-as-a-service (SaaS). This SaaS application becomes easily accessible from internet-connected smart devices, for chemical release event modeling, threat assessment, situational awareness, and protective action decision support. This sensor-driven plume dispersion SaaS software can include live meteorology, government-vetted models and government-sourced emergency response guides, plus special sensor driven algorithms for release source location identification and release rate estimation. All this infrastructure enables teams to prepare for, respond to, and analyze chemical release, fire or explosion events – anywhere – any time – on any device.

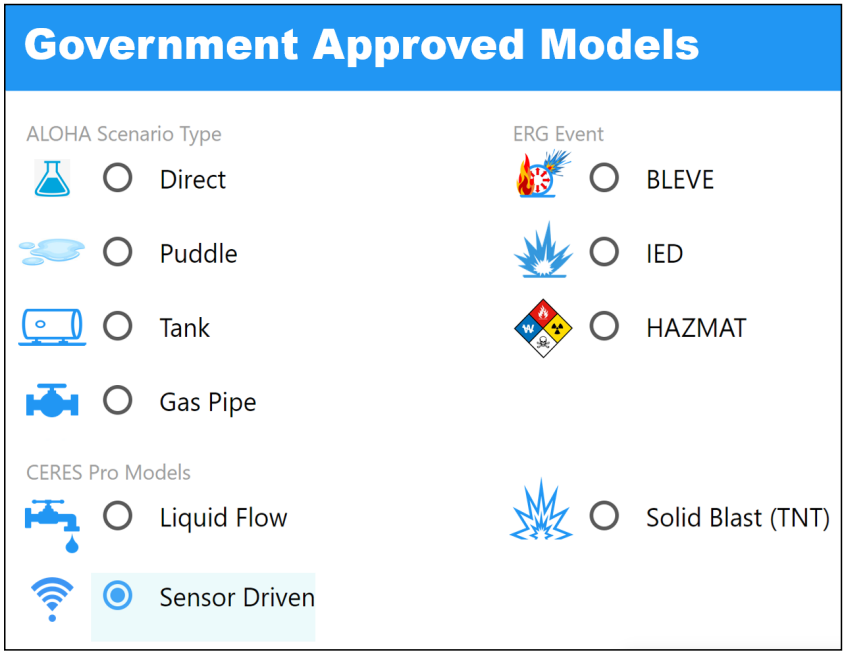


This cloud-hosted plume dispersion software can also incorporate real-time live meteorological data, gas concentration and radiation data from deployed sensors from a wide range of manufacturers, live traffic conditions and fixed or GPS-enabled devices (including phones and fleet tracking tools). All data is displayed live on a map of the area of interest along with sensitive receptors including schools, hospitals, churches, fire and police stations etc., to provide improved awareness.

Models and response guides

Using US government-approved dispersion models, cloud-hosted sensor-driven plume dispersion software models toxic gas clouds, flammable gas clouds, BLEVEs (Boiling Liquid Expanding Vapor Explosions), jet fires, pool fires, tank-top fires, flare stacks, vapor cloud and solid explosions. It also incorporates and plots ERG, PERG, BLEVE, and IED protective action guidance distances.

Responders can input the chemical release details — location, type of threat, size of the containment, failure mode or size of the leak — and generate threat zone estimates for various types of hazards. This includes toxic, thermal, flammable and overpressure scenarios.



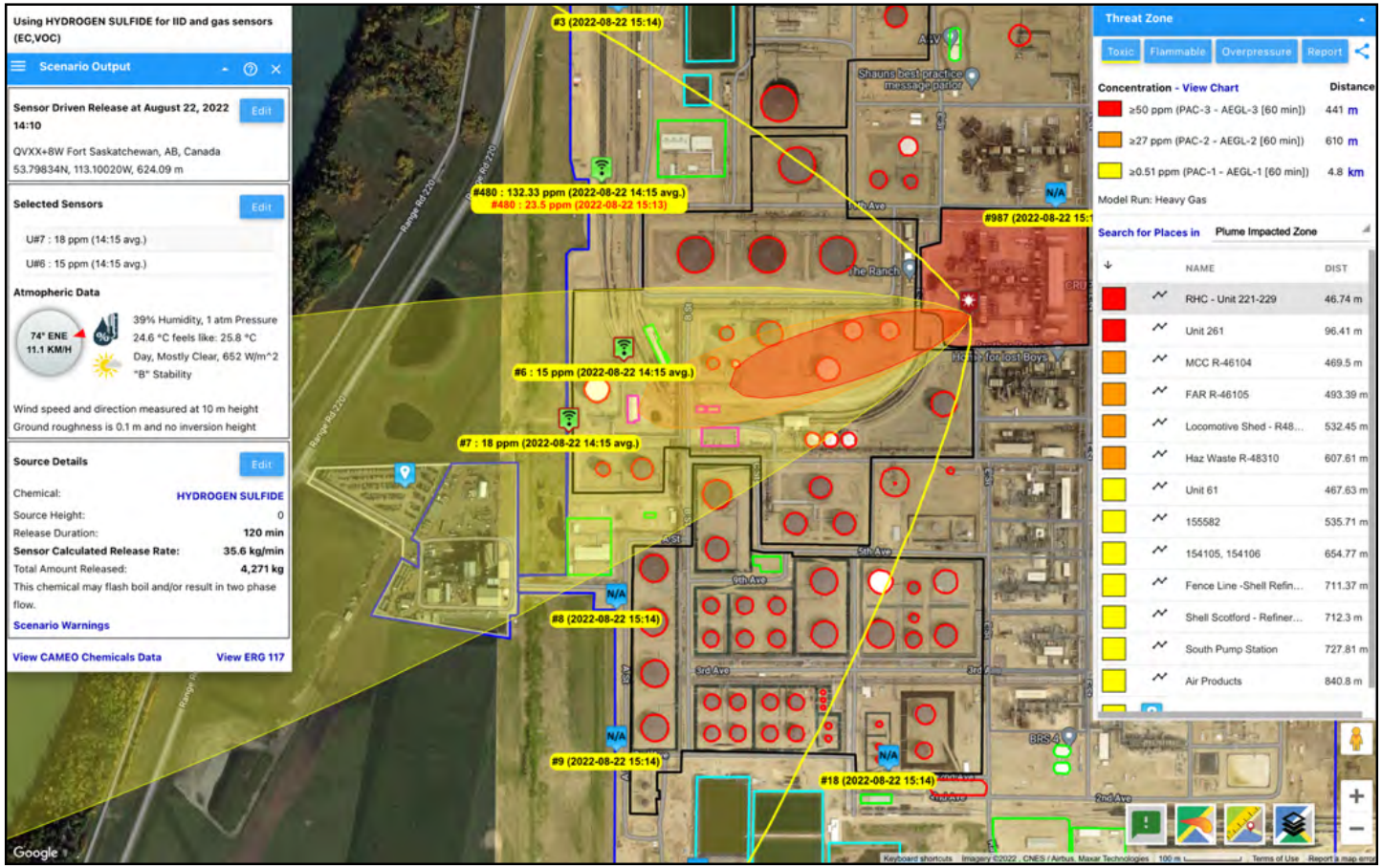
Responders can plot threat zones on an interactive map, such as Google Maps, and the impacted receptors list is generated live, along with time to impact, severity and expected impact duration. All scenario activity with impact assessments and live data would be recorded and available for post-event reporting and analysis.

The new generation of plume dispersion software can enable people to import local Tier II, RMP, SEVESO, COMAH, E2 and regulated site information and launch automatically generated and / or manual predefined scenarios using the chemical inventory data from these imported databases or custom defined vessel dimensions and transportation vehicles.

Live gas sensor Data

Because many release details may be difficult or impossible to determine at the onset of an event, sensor-driven plume dispersion software can generate threat zones based on live gas sensor data. This approach has the added benefit of evaluating the real time impact of mitigative actions — including leak seal, foam application and vapor suppression —that cannot be quantified by traditional modeling methods.

When gas concentrations are detected by mobile or fixed sensors, if the source location is unknown, users can run a source location identification model to help identify the source of the detected release. Once the location is identified, the incident respone team can model and plot the gas plume using the map-based sensor driven plume (SDP) model that uses algorithms to determine downwind gas concentrations based on real-world sensor information.



Snapshot of CERES' Sensor Driven Plume (SDP) model with live data

SDP averages live gas sensor values over time and, using connected meteorological data, runs a convergence routine until the plume concentrations match the sensor measured values. The system displays the affected area on a map along with the estimated time of arrival and concentration impacting each receptor location. The information helps to better inform responders about event severity and extent, and support decisions related to shelter in place from the ERG 2020 and Pipeline Emergency Response Guide.

Snapshot of plume dispersion modeling software with live data including Risk Management Plan Tier 2 data (based on USCPA and OSHA standards)

Plume dispersion monitoring software can also update its model as winds shift and monitored conditions change, notifying the user to rerun and update the analysis. This gives the emergency management organization the most accurate information about the incident and helping them coordinate and adjust the scale and scope of the response.

CASE STUDY

Sensor Driven-Plume Scenario with CERES HAZMAT Team (SaaS, Cloud Based Monitoring, Modeling and Response System with Sensors Driven Plume capability), Data Acquisition System connected to the local met station (installed on the HAZMAT truck) and 20+ Area and Personal Gas Monitors integrated.

Texas Fire Department Training Session - Sensor Driven Plume Scenario.

Summary

Gain control over chemical release incidents

As a result of combining real-time data and plume modeling, Hazmat response teams can know with confidence if an area is safe, or to sound the alarm when gas levels have exceeded an unsafe threshold. In addition, response leaders can immediately monitor changes in gas concentrations and shifts in weather patterns to visualize the scenario as it unfolds allowing the identification of at-risk areas faster than ever before.

By knowing how far and fast toxic plumes travel, first responders can quickly identify the shortest and safest response paths and easily assess potential impact. Being able to share up-to-the-minute reports with all stakeholders and teams heightens the ability to rapidly assess health risks and make life-saving decisions.

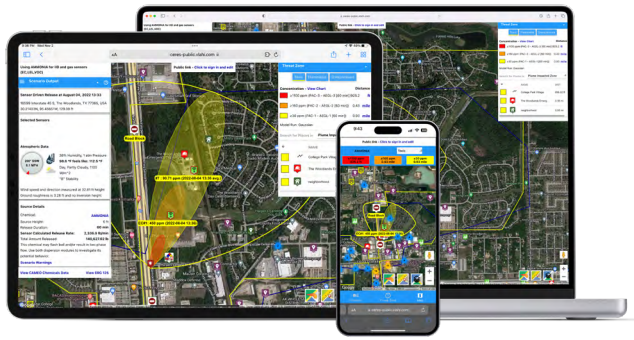
When the health and safety of first responders and communities are on the line, the more you know, the better. Combining connected gas detectors with sensor driven source location and predictive plume modeling, provides the most accurate information available to make confident, informed decisions during Hazmat responses.

About Blackline Safety

Blackline Safety is a technology leader driving innovation in the industrial workforce through IoT (Internet of Things). With connected safety devices and predictive analytics, Blackline Safety enables companies to drive towards zero safety incidents and improved operational performance. Blackline Safety provides wearable devices, personal and area gas monitoring, cloud-connected software and data analytics to meet demanding safety challenges and enhance overall productivity for organizations with coverage in more than 100 countries. Armed with cellular and satellite connectivity, Blackline Safety provides a lifeline to tens of thousands of people, having reported over 185 billion data-points and initiated over five million emergency alerts. For more information, visit BlacklineSafety.com and connect with us on Facebook, Twitter, LinkedIn and Instagram.

About Vlahi Systems

Vlahi Systems, is a Houston-based technology company with a mission to deliver the most cost effective and feature-rich emergency response solutions to planners, responders, chemical plants, government organizations and the transportation industry. The team behind the company is well versed in the design and development of real-time, chemical hazard analysis and decision support technology. Currently used by over 9,000+ users globally (including ICL-Group, Nutrien, Chemiepark Linz, CANUTEC, PIESAT, FIIAPP, Michigan MABAS, CST (WMD) Teams, CBRNE Teams, and numerous municipal Fire Department HAZMAT teams) across more than 100 countries, CERES delivers an industry-leading user experience for planning, responding to, and analyzing chemical, fire and explosion events — anytime, anywhere and on any device, before, during or after a chemical incident. For more information, visit www.vlahi.com.



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Contact us today to speak with a consultant about connected safety solutions for fire and hazmat.

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