TO STAND AND PROTECT

AN INFRARED SPECTROMETER SEES HARMFUL VAPORS AT A DISTANCE.

By Thomas C. Gruber, Jr.

When the World Trade Organization met in 1999, the host city, Seattle, was tense. There would be political demonstrations that could turn violent. There would be a response to enforce order. No one could foresee everything. Someone might even release hazardous chemicals.

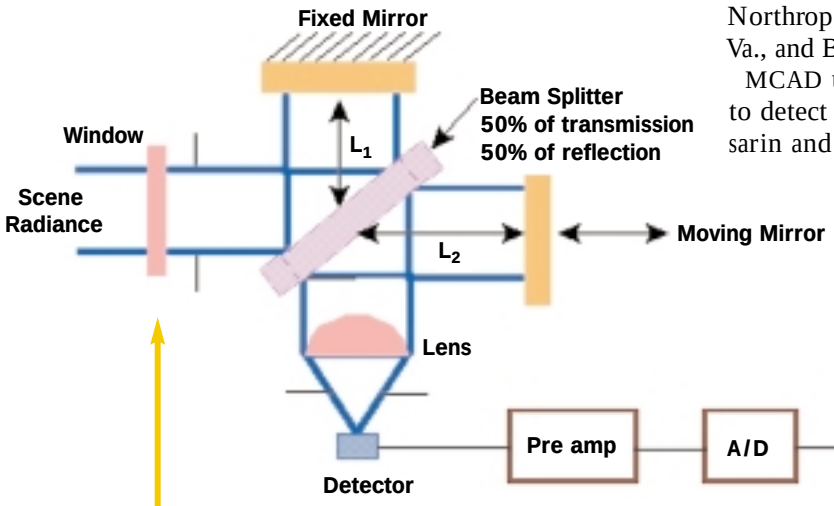
Every day in communities the world over, policemen, paramedics, and firefighters enter sites of accidental or man-made disaster, where they can't be sure that the air is safe to breathe. The armed forces must defend against the possibility of chemical attacks on the battlefield, and at key sites at home and abroad.

It was to serve these needs that MESH Inc. of Oxford, Pa., and several partners created the Mobile Chemical Agent Detector, or MCAD for short. It can be carried by a sport utility vehicle (which is how the Seattle Fire Department used it), by a Marine Humvee, or for that matter, by an unmanned aerial vehicle. The chemical sensing system can warn of dangerous vapors in the air more than five kilometers away.

The idea began about 15 years ago when Larry Grim, an electrical engineer, received a contract to write software for a chemical sensor being developed at Aberdeen Proving Ground in Maryland. Grim and his wife, Sherry, a computer scientist, are the founders of MESH. The letters stand for "Micro Engineering Software and Hardware." The MCAD development team also includes Northrop Grumman in Baltimore, CRE in Alexandria, Va., and Block Engineering of Marlborough, Mass.

MCAD uses Fourier transform infrared spectrometers to detect the spectral fingerprints of deadly agents like sarin and mustard gas. It also has the ability to detect many industrial chemicals, including phosgene, ammonia, and methane. The molecules all leave signature absorption patterns in the thermal infrared wavelengths of 8 to 12 micrometers.

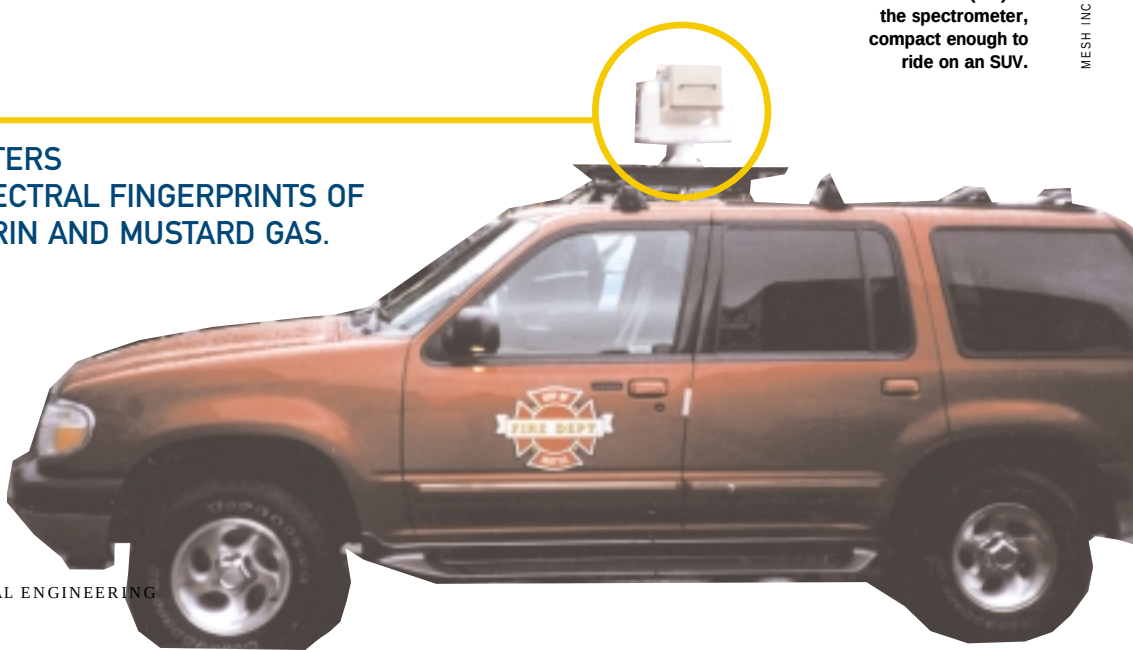
Unlike point sensors, infrared spectrometer-based chemical sensors are called "standoff"



A schematic (left) of the spectrometer, compact enough to ride on an SUV.

MESH INC.

INFRARED SPECTROMETERS DETECT THE SPECTRAL FINGERPRINTS OF DEADLY AGENTS LIKE SARIN AND MUSTARD GAS.



sensors, because they do not need to come in direct contact with the chemical vapor. A single spectrometer-based sensor can monitor an area as large as 80 square kilometers. Many point sensors would be required to cover an area of this size.

The spectrometers, supplied by Block, are the most expensive part of the MCAD system, which at its present manufacturing volume costs several hundred thousand dollars. The IR detector, a semiconductor of mercury, cadmium, and tellurium, must be cooled to 80 K. Its Stirling cycle refrigeration unit is a costly part of the system. MESH has shipped 10 MCAD spectrometers to the U.S. government for testing. Test sites include Larry Grim's starting point at Aberdeen. The company expects the price to come down considerably when MCAD systems are in commercial production.

The spectrometers distinguish between the temperature of a vapor cloud and the effective background temperature. A difference as small as 1 Kelvin degree will yield a net absorption or a net emission in the spectrum due to the vapor cloud's fingerprint. Backgrounds can be sky, mountains, vegetation, or buildings. All of these natural backgrounds emit infrared light that can be used for detecting vapor clouds—that is, in the 8 to 12 μm range.

Light enters the system, where it is divided by a beam splitter. Half the light is reflected by a fixed mirror, half by a moving mirror. A resulting interference pattern, called an interferogram, is detected after the light recombines at the beam splitter. The detection algorithm software processes the interferograms. Chemicals are identified according to their unique absorption/emission patterns in the IR spectrum. MCAD generates 12 detection results a second as it monitors the atmosphere in real time. Results are displayed on a laptop PC. Applications for these sensors range from use by first responders to soldiers on the battlefield. They can also monitor industrial sites.

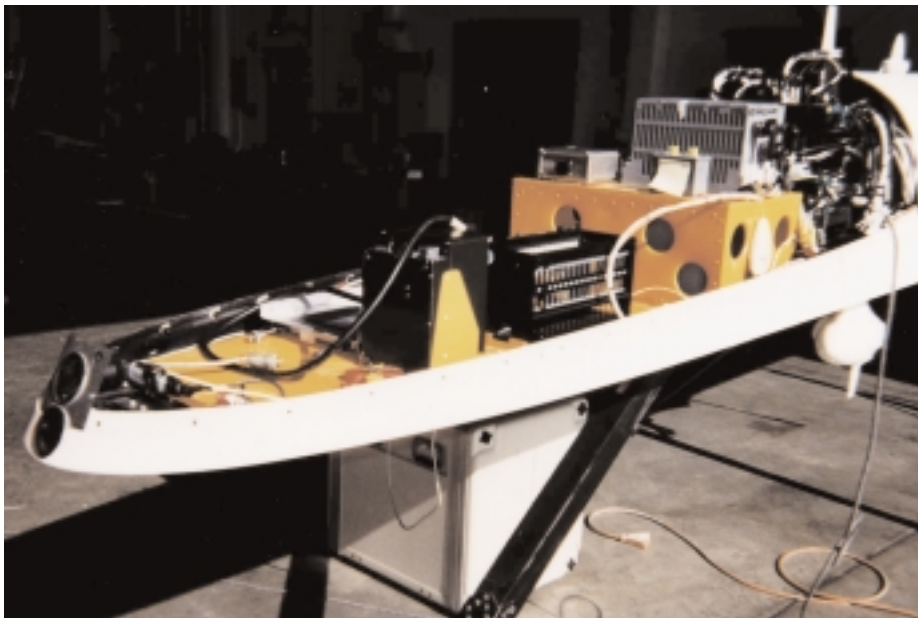
First responders, such as police and firemen, have a need to recognize hazardous vapors before proceeding onto a scene. Standoff chemical sensors can provide a life-saving warning that protective gear is required. The chemical sensor data also provides documentation of substances present.

Soldiers on the battlefield and on military bases have various missions that require chemical sensing, such as contamination avoidance and fixed-site protection. Soldiers in vehicles equipped with chemical sensors can choose routes to avoid contaminated areas. In fixed-site protection, several standoff sensors throughout a base can continuously monitor the entire site.

Industrial sites could use standoff chemical sensors for continuous monitoring. Chemical leaks could be detected and tracked in real time on a map of the area.

In most applications, the sensor is mounted on a pan-and-tilt unit, which can be automatically controlled to scan a desired field of regard. The field can be a full 360 degree azimuth at various elevations. Sensor data from scanning the field of regard can be used to map detection results in real time.

Besides its field test in Seattle, MCAD went to Salt Lake City for the 2002 Winter Olympics. One of its jobs there was to monitor the bobsled run, which was cooled with ammonia.



The MCAD system mounted on an unmanned aircraft. The device takes 12 infrared snapshots a second, from which chemical vapors can be identified by their spectrographic profiles.

An early prototype of the chemical sensor was put together for the Marine Corps Chemical-Biological Incident Response Force in 1997. Mounted on a vehicle, the system was one of the security measures in Washington during President Clinton's second inauguration. Some of the hardware was different from the current generation MCAD, but the algorithm and user interface software were the MESH product.

MESH has developed a stationary version for use at the Dugway Proving Ground in Utah to support chemical sensor field testing. The company calls this one the Chemical Cloud Tracking System. Dugway tests various sensors with releases of harmless substitute gases. The Chemical Cloud Tracking System serves as a referee system for these releases by measuring the vapor cloud size, location, and concentration in real time.

MESH believes that, in our current world where even the unthinkable can happen, devices such as MCAD can address our needs for vigilance. ■

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