LOCALIZING CHEMICAL AND BIOLOGICAL THREAT DETECTION

Chemical Aerosol Remote Sensing: The Intelligent Chemical Aerosol Transmission Spectrometer (iCATS)

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Many chemical threats can be delivered as aerosols, including chemical warfare agents (CWAs), toxic industrial chemicals and materials (TICs and TIMs), and pharmaceutical based agents (PBAs), and riot control agents (RCAs). The need to rapidly identify these types of particles is imperative to health and protection of the warfighter and to national security. While the importance of aerosol detection and classification cannot be understated, it is a challenging technical problem particularly in complex environments.

The iCATS standoff detection system is being developed under the IARPA PICARD program. The PICARD program intends to develop fieldable sensing platforms for the rapid chemical classification of aerosol particles in plumes. The development of the iCATS sensor focuses on the challenge of distance from the chemicals of interest, low concentrations, arbitrarily shaped particles, and challenging environments.

The iCATS sensor performs active longwave infrared (LWIR) spectral measurements of chemical aerosol cloud optical extinction using an existing or emplaced scattering surface at up to 10 meters standoff for the Phase 1 prototype. The sensor design extends the tunable laser absorption spectroscopy technique used for gases to chemical aerosol sensing while removing the need for a retroreflector. This approach takes advantage of the method’s high sensitivity and specificity, while adding the necessary flexibility to operate in non-cooperative environments. We use quantum cascade lasers (QCLs) covering the LWIR (800–1250 cm-1) spectral range, operating in pulsed mode to achieve the power level needed to measure a return signal from a diffuse surface. The LWIR atmospheric transmission spectral window for operation has the highest abundance of fundamental chemical absorption features for molecular functional groups such as organophosphates and alcohols. Furthermore, the LWIR requires much less source power to produce the same photon flux as the ultraviolet or shortwave infrared.

The ability to use a “surface of opportunity” to perform measurements enables collection in real-world scenarios where emplacement is not feasible. The costs of using a surface of opportunity are time and added measurement uncertainty from the unknown target spectral shape. The power of the return signal measured by the sensor is a function of the transmitted power, the scattering surface (range, reflectivity, and orientation), and the atmosphere/aerosol medium attenuation. So long as enough energy is returned to enable measurement of the laser pulse, signal accumulation over time (assuming a static scattering surface) provides the SNR needed for aerosol measurement. We deal with the arbitrary spectral shape from existing surfaces by processing sequences of measurements with the expectation that the signature from the aerosol varies over time and that the surface reflectance is constant. Where feasible, emplacement of a target with strong, known infrared reflectivity enables the system to reach the needed SNR in less time and reduces measurement uncertainty compared to using an existing surface.