FROM SENSING TO MAKING SENSE

Systems Engineering Approach To Designing A Low Swap Multi-class Chemical Vapor Detector To Address Warfighter Needs In The Early Development Phase

Jessica Milke Teledyne FLIR Detection, Inc. **Katie Kunkel** Teledyne FLIR Detection, Inc. **Mark Fisher** Teledyne FLIR Detection, Inc. **Kyle Hawes** Teledyne FLIR Detection, Inc. **Hartmut Brands** Teledyne FLIR Detection, Inc. **Sammi Mike** Teledyne FLIR Detection, Inc. **Casey Flynn** Teledyne FLIR Detection, Inc. **Jeffrey Verity** Teledyne FLIR Detection, Inc.

The General and Specialized forces require a singular device capable of rapidly detecting a broad range of chemical classes at hazardous levels in a low size, weight, and power (SWaP) form factor that is unobtrusive and mission flexible. Teledyne FLIR's solution (TDY FLIR) under the Compact Vapor Chemical Agent Detector (CVCAD) Program offers an all-in-one solution integrating mature, commercial sensors with developmental sensors that alert in the presence of Chemical Warfare Agents (CWAs), Toxic Industrial Chemicals (TICs), Lower Explosive Limits (LELs), and oxygen enriched and deficient levels. The content presented herein describes TDY FLIR's sensor capabilities, exploratory algorithm approaches, and engineering trade-offs made in the early development phases to achieve the end goal of a compact, reliable detector while the Program requirements are being developed in parallel.

TDY FLIR has successfully produced an alpha prototype that operates multiple MEMs (micro-electromechanical systems) type sensors each uniquely designed to detect either LELs, TICs, CWAs, or oxygen in an initial form factor that currently measures approximately 38 in3. Conductance measurements from metal oxide sensors as well as electrochemical and thermodynamic measurements from additional sensors enable the device to continuously monitor the output of over 16 separate channels of chemical sensor data as well as environmental conditions to provide hazardous vapor alarms intended to have increased reliability and minimal false alarm rates due to sensor redundancy and orthogonality. Phase I and Phase II third party and internal testing shows that due to the unique chemical selectivity and functionality of each of the sensors, differentiation can be achieved among the CVCAD chemical classes of interest. Current efforts are focused on algorithm optimization, specifically, comparing various machine learning techniques with less complex human driven decision trees to achieve the most rapid and accurate classification possible for a feature rich, but low volume data set due to limited access to live agents and highly toxic TICs.

In addition to selecting the sensing components, TDY FLIR has used feedback from early end user events and Government functional specifications to implement specific mechanical and electrical design features to increase the probability of meeting future CVCAD Program requirements. For example, to minimize power dissipation, multiple DC-DC converters were implemented to ensure each sensing component works at optimal power consumption. Further, the prototype uses multiple central processing units to divide the load of sensor data collection from system functionality. Among other engineering trade-offs described herein, a certified intrinsically safe replaceable battery (consumable) was selected over non-certified rechargeable options and aluminum was chosen as the housing material due to its best-in-class EMI performance.

In the next Program Phase, down-selection in the number of sensors, specifically the metal oxide sensors, will be considered as a means of reducing the size, complexity, and power consumption of the system if analyte discrimination can be maintained and development will be aligned with the maturation of Program requirements.

Defense Threat Reduction Agency, JPM CBRN Sensors , NevadaNano Tech Systems