NEXT GENERATION CB HAZARD PREDICTION AND CONSEQUENCE ASSESSMENT WITH MULTI-ECHELON DECISION SUPPORT APPLICATIONS

Development Of An Autonomous Inhalation Robot For Chem/bio (air-cb) For Real-world Estimation Of Aerosolized Threats

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Adversaries continually engineer new chemical and biological threats, necessitating early detection and assessment for the safety of soldiers and civilians. Given that many threats are aerosol-transmitted, predicting their impact within the respiratory tract is paramount. However, assessing this impact of aerosolized threats first requires knowledge of aerosol deposition within the respiratory tract, which remains highly challenging to predict due to complex interactions between the human physiology, breathing, aerosol properties, and exposure conditions.

Here, we introduce the Total Inhalable Deposition in an Actuated Lung (TIDAL) platform, a novel in vitro experimental tool that can simulate aerosol deposition within the human respiratory tract. Leveraging capabilities unique to additive manufacturing, TIDAL is comprised of a patient-derived upper airway connected to five human lung lobe compartments that are populated with innovative internal structures and actuated with independent motor control to generate realistic breathing profiles and mimic spatial aerosol collection. Our team has demonstrated physiologically relevant inhalation-exhalation maneuvers over a range of human breathing scenarios (i.e. sitting, exercise) and validated regional aerosol deposition measurements of model aerosols to published clinical benchmarks. Through a collaboration with DEVCOM CBC, we are continuing rigorous validation of the measured deposition and tailoring TIDAL for exposure scenarios and defense applications as an Autonomous Inhalation Robot for Chem/Bio (AIR-CB) assessment tool.

Aligned with the DTRA JSTO's mission, AIR-CB aims to enhance aerosol exposure testing, with long-term impacts to improve assessments for protective measures, evaluate countermeasures, and develop warfighter-specific respiratory medications. Establishing TIDAL as AIR-CB contributes to assessing and countering threats, with potential applications in both laboratory and field settings. The TIDAL system is also readily extensible, enabling future physiological features, as well as integrated testing of organ-on-a-chip-like systems. The TIDAL platform represents a significant advancement in aerosol threat assessment, with implications for military preparedness and public health. Its development promises to enhance defense capabilities, ensuring the safety of personnel against evolving aerosolized threats.

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