

Grant Number: AFCRFP20-130

Title: Demonstration of An Intrinsically Safe Drone Propulsion System for Underground Coal Mining Applications

Organization: New Mexico Institute of Mining and Technology

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Partnerships: Americase Inc, White Sand Research and Developers, White Sands Research and Developers, LLC, Sandia National Laboratories, Deserado Mine, Blue Mountain Energy

Focus Area: Mine Escape, Rescue & Training: Rescue Strategies and Technologies

Synopsis

Project Goal: The mining industry has shown an increased interest in the use of drone technology. The application of drones has been mostly limited to surface mining. Utilizing drones in underground mines is challenging because harsh underground environments pose many obstacles to a flying vehicle. Confined space, reduced visibility, air velocity, dust concentration, and the lack of wireless communication systems make it extremely difficult for an operator to fly a drone underground. Particularly, the application of drone in underground coal mines is limited due to the lack of an available permissible platform. An intrinsically safe machine is usually much heavier than its non-intrinsically safe counterpart. Increasing the weight of a drone drastically decreases its efficiency. Therefore, the two main challenges in designing an intrinsically safe drone for indoor applications are (1) to demonstrate the permissibility and intrinsic safety of the vehicle and (2) to design a propulsion system that provides sufficient lifting power and reasonable flight time. To date, it has been a difficult task to design a permissible drone platform with practical size and flight characteristics. However, it is this team's opinion that this is feasible and that demonstration of the feasibility for an intrinsically safe drone can conclusively enhance the application of drones in underground coal mines.

Research Approach: In this proposed work, the investigators will leverage resources from interdisciplinary collaboration, including Mechanical, Electrical, and Mining Engineering, to conduct collaborative research to design and demonstrate an intrinsically safe drone propulsion system for underground coal mining applications. The team includes three research universities (New Mexico Institute of Mining and Technology (NMT), Univ. of Texas Arlington (UTA), and Univ. of New Mexico (UNM)), technology developers/licensors, and partners from government and private sectors.

The proposed project is designed in three phases, led by the PIs collaboratively. In phase one, a comprehensive investigation of the operational properties of various lithium-ion chemistries will be conducted. An optimum battery assembly with a breathable intrinsically protective enclosure will be designed and fabricated. Battery enclosure will enable efficient battery assembly while preventing any spark or flammable material from being released into the environment. The feasibility of the intrinsic safety and permissibility of the electrical components (i.e., motors, circuits, and connections) will be investigated. A comprehensive study on propeller design, spark, and static charges will be conducted. A preliminary drone sizing methodology will be developed to evaluate the size, weight, and other

characteristics of such an intrinsically safe propulsion system. In the end, the design specifications will be submitted to MSHA Approval and Certification Center for validation and approval.

Upon success, in the second phase, the validated design specifications will be used to fabricate the propulsion system. Experimental and numerical analyses, including electrical, heat, spark, battery safety, and propeller safety will be conducted to evaluate the intrinsic safety of the fabricated system. Samples of the propulsion system and designed parts along with a report of intrinsic safety measurements will be submitted to MSHA Approval and Certification Center for review and approval.

Expected Outcome: Upon approval, in the third phase of the project, a final prototype propulsion system will be fabricated. The aerodynamic and stability analyses will be performed computationally and experimentally in order to investigate the specifications of the drone platform. A series of experimental studies will be conducted to evaluate the performance of the system, including endurance, flight range, durability, and payload. The final product and the proof-of-concept demonstration will be provided to MSHA Approval and Certification Center for perspective on its performance.