

**Grant:** AFC518-67

**Title:** Demonstration of a UAV-based Digital Photogrammetry System for Geological Mapping and Geotechnical Characterization of Fractured Rock Masses at Hazardous Underground Sites

**Organization:** Montana Tech

**Principal Investigator:** Mary M. MacLaughlin

**Topic:** Geosensing Instrumentation

**Concept Summary:** The objective of this research is to test the ability of an unmanned aerial vehicle (UAV) in acquiring digital photographs and thermal imagery to collect geological data from an underground opening that is unsafe for people to enter, thereby demonstrating the viability of a new geosensing tool. The project will be deemed successful if a UAV can survive flights within an unsupported underground opening, if high-quality imagery that is sufficiently lit and georeferenced can be captured, if forward looking infrared (FLIR) imagery can be collected and georeferenced, and if the photogrammetry model generated from the imagery and FLIR data can be used to capture and define geological features that define the stability of the opening. The geological data is necessary to determine the potential for ground falls or air blasts to occur in an open stope. Open stopes are typically the largest exposure of unsupported ground in an underground mine, and they have the highest potential for releasing a large volume of failed rock. Geological data is used to determine the extent of unstable material, the strength of the rock, and the orientation of geologic structures that allow sliding to occur. These parameters are used in kinematic analyses and in numerical models to determine the potential for failure. It is uncommon to be able to define and characterize the potential for failure after the stope has been blasted, and failures within the stope typically occur without warning.

UAV's are ideal for capturing this data because they are relatively inexpensive, have the ability to capture high-quality digital and thermal imagery, and because they can be flown without exposing the operators to hazards. UAV's are available off the shelf with both visible-light and thermal cameras, and integrated gimbals that allow for stable imagery to be captured and relayed to the operator. Advances in ultrasonic and visual sensors used for collision avoidance allow for UAV's to be flown inside, where in the past flights would become erratic if the UAV lost its GPS signal. Using the collision avoidance system and the live video feed, the UAV operators can guide the aircraft through an underground opening with little risk of crashing. However, large unsupported underground openings are prone to ground falls, and there is a risk that rock falling within the stope will destroy the UAV.

This proposal plans and budgets for both the proof-of-concept and working prototype phases, where the technology can be tested in the field immediately following the successful demonstration of this concept. This is possible because the project utilizes off the shelf technology, which does not require research and development to use and implement. The proof- of-concept experiments will be conducted on the Montana Tech campus, in buildings and in the underground research facility. The prototype experiments will be conducted at Barrick's Golden Sunlight Mine (GSM).