Follow Up Grant ASTI14-81: Early-Warning System Prototype Tests for Real-Time Safety Intervention and Optimum Ventilation Control Assistance

Initial Grant ASTI14-03: Early-Warning Safety Hazard Predictor for Preventive Ventilation Management

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Focus of the proposed follow-on work: The main focus is to make the innovative EWS safety system tested and proven at partner mines, as well as making it attractive and available to mines by the completion of the proposed tasks. These need software reliability tests and the support partnership of reputable OEM suppliers as partners. The new and innovative components are: (1) the time is expanded in the future from the real-time monitoring signals by forecasting in accelerated, simulation-time from the data to predict any likely event in the near future that may compromise safety; and (2) the space from the AMS locations is expanded into the entire mine layout to forecasts in space, in order to evaluate safety at any critical working area, even at a place where no monitoring station is installed. All these tasks need high-performance numerical simulation at the mine site continuously parallel with the mining operations. We propose an Information Technology (IT) approach, considering the significant focus on 'big data', 'internet of things' as well as machine learning (ML), neural networks (NN) and artificial intelligence (AI) in mining word-wide.

We propose to implement and progress the conceptual EWS procedures used in the AFSTI14-03 project to the prototype phase for commercialization with industrial partners. The prototype software is planned to be developed and tested to deal with real mine data in metal and coal mines. The EWS software is planned to be completed by the integration of the high-performance MULTIFLUX solver into Ventsim and Ventfire for using as the DMVM from Ventsim's Graphical User Interface (GUI). The setup configuration of the prototype EWS will be accessible for the user from Ventsim's GUI. The AMS layout of the mine is designed to be mapped using Ventsim's LiveView tool in the GUI for the tests of the EWS in mines.

The experimental validation work of the prototype EWS will be carried out at a metal and a coal mine. Three mines expressed interest in partnership collaboration letters, all well equipped for the EWS application with elaborate AMS, but only two will be selected for cost reduction. The gob model element of the EWS will be validated first against experimental results conducted by NIOSH under agreed cooperation for coal mine applications in MULTIFLUX programed as a Continuous Dynamic Correlator (CDC).

The EWS will be implemented for easy marketing with input from Original Equipment Manufacturers (OEM) and suppliers, three of them with expressed interests in partnership letters. Key cooperation is planned with Chasm (the Ventsim developer) and Howden to reach its world-wide market that includes hundreds of coal and metal mines.

To increase the success of introducing a commercial version of the EWS, new output components are included in addition to simple safety warnings. Specifically, support information outputs are added for optimized ventilation control for miner's health and cost reduction benefits, enhancing the primary role for overseeing mine safety in coal and metal mines alike.

Expected research outcome: The outcome of the proposed research project is a fully-tested, operation prototype of an EWS, ready for offering to commercial applications in metal or coal mines. Systems for accessing and evaluating against maximum, threshold values of the AMS data are widely used in the US and in the world for compliance evaluation for safety and health in subsurface coal and metal mines. The EWS will be an add-on to the AMS already used in mines with perhaps a few more sensors necessary for the minimum hardware configuration for operating the EWS software.

We propose to go beyond the present practice of evaluating only past conditions at a limited numbers of monitored locations. We proposed to create, test, verify, and offer for marketing with OEM partners the EWS that will allow forecasting evaluation of real-time AMS signals for the recognition of the development of dangerous conditions *everywhere in a mine* for *past, present and near-future time* in order to assist management for preventive interventions. In addition, the EWS will provide continuous output information to optimize ventilation operation for safety, health and cost benefits.

Specific Aims of Proposed Research:

(1) Health and Safety Interventions

Testing, verifying and marketing the EWS method for AMS data interpretation is proposed, very relevant to i*ntervention and prevention.* Preventive intervention management is the main goals of installing and running continuously and real-time the EWS in underground mines. The EWS is applicable to both metal and coal mines. It it is proposed to use past and present AMS data and predict future AMS expectations. The interpolation of AMS data for all relevant mining locations by a built-in, dynamic mine ventilation model (DMVM) is to predict future outcome even at unmonitored locations which do not have AMS sensors. The proposed EWS prototype software and hardware will identify potential problems in their evolution in various hazard scenarios during mining operations in a *timely manner* to provide advance time for an intervention before an accident would have happened.

(3) Safety and Health Management

Using the EWS in its full capacity is proposed for safety and health management while observing additional cost benefits. The EWS is proposed to continuously mine the AMS data stream and enhance it using the model-based, forward-in-time output information to watch health-effecting atmospheric conditions at any critical (and not just past and monitored) location and time in a mine. It is aimed at providing support data to safety and health management to operate a mine according to Optimized Ventilation Control (OVC) by optimizing safety, health, and cost benefits. As a subset of OVC, a mine may use the EWS for supporting data for Ventilation on Demand (VOD) control if desired, always keeping the operation on the safe side of the dynamically changing air parameters with time.