

A New Generation of Web-Based Applications for Mine Design

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ABSTRACT

As mining reserves continue to be developed in deeper and more complex geological and geometric conditions, there has been an increased demand for underground mine designs to better reflect site-specific conditions, measurements, and observations with respect to ground control safety and stability. Current ground control design software are limited to a given device and data files generated can only contain a single design. However, with the growth of cloud computing and increases in internet access, even underground where permissible, web-based software applications allow for in-the-field calculations, as well as collaborations, from multiple users. webGroundControl (webGC) utilizes a multiple-tier architecture, building upon existing NIOSH ground control design software, more specifically ARBS, ALPS, and ARMPS. By providing operators the ability to access ground control design programs from any device, given an internet connection, webGC allows for on demand calculations to ensure underground pillar and roof stabilities with respect to current site-specific parameters, geometries, and geology. Through the development of new features, which aid in design analyses, as well as project collaborations, webGC provides the modern engineer with a more versatile ground control design tool for the improvement of underground health and safety.

With the completion of the ARBS, ALPS, and ARMPS modules, this paper introduces potential users within the mining industry to the navigation and operation of the webGC application, as well as its ability to facilitate collaborations between operational personnel and planning engineers. The purpose of this paper is to raise interest in the web-based application before its official launch in Summer 2018.

INTRODUCTION

Over the past two years, a new web-based software package called webGroundControl (webGC) has been under development. Taking advantage of current internet technologies, webGC builds upon existing National Institute of Occupational Health and Safety (NIOSH) ground control design software to provide users with instantaneous access to mine plans through a web browser. Through the use of a web-based platform and multiple-tier architecture, webGC allows for on-demand design calculations and

analyses, streamlines communications between mine personnel, and provides cross-platform compatibility over multiple devices (PC, tablet, smartphone, etc.) and operating systems (Windows, Android, iOS, etc.). Given the advancements in cloud computing, as well as increases in internet connectivity on the surface and even underground, webGC users will be able to access the application anywhere and at any time.

For the past 20 years, NIOSH has provided the mining industry with several stand-alone Windows applications, distributed free through the NIOSH website, for the safe design of underground coal mines with respect to ground control (NIOSH, 2005). NIOSH programs, such as Analysis of Longwall Pillar Stability (ALPS), Analysis of Retreat Mining Stability (ARMPS), Analysis of Multiple Seam Stability (AMSS), and Analysis of Roof Bolt Stability (ARBS), are essential to mine design and plan approval for longwall, room-and-pillar, and multiple seam mining operations with respect to pillar stability, geological formations, and support requirements. Each of these stand-alone applications requires an individual or workgroup computer equipped with a Microsoft Windows operating system on which all program data will reside (Figure 1a). This often becomes a hindrance when trying to update one's design with respect to new site-specific parameters observed in the field or when trying to collaborate with other engineers or operational personnel. However, through the adoption of modern technologies and a multiple-tier architecture (Figure 1b), webGC allows users to access NIOSH analysis and design applications (currently ARBS, ALPS, and ARMPS) through a web browser, as well as easily share project information with multiple users, increasing cooperation and design transparency.

While previous publications (Agioutantis and Newman, 2016; Newman, Agioutantis, and Schaefer, 2017a; Newman, Agioutantis, and Schaefer, 2017b) discussed the concept, framework, and development of webGC, the intention of this paper is to familiarize potential users within the mining industry with application navigation and operations and the ability of webGC to facilitate collaboration between operations personnel and planning engineers. With the development of mining reserves at deeper depths and in more complex geological and geometric conditions, as well as increases in internet accessibility, the shared platform structure of webGC will ensure more transparent design

determine the project under which their analysis will be stored. A project should be defined with respect to a mining location or operation. Users can access the Project Administration page by either selecting “Select Project (Mine)” from the user dashboard or “Projects” located in the menu bar along the top of the page. Upon accessing the Project Administration page (Figure 5), users are able to define (Add Project), select, or delete mining operations to which their ARBS, ALPS, or ARMPS analyses will apply.

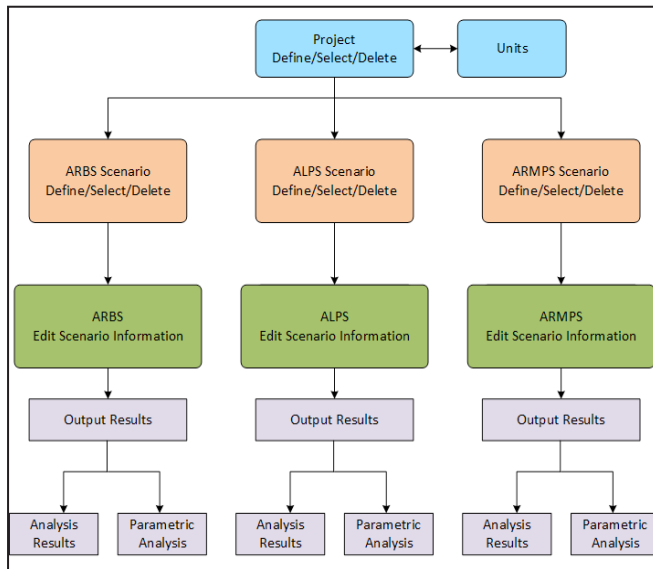


Figure 3. Navigational flow chart for webGroundControl.

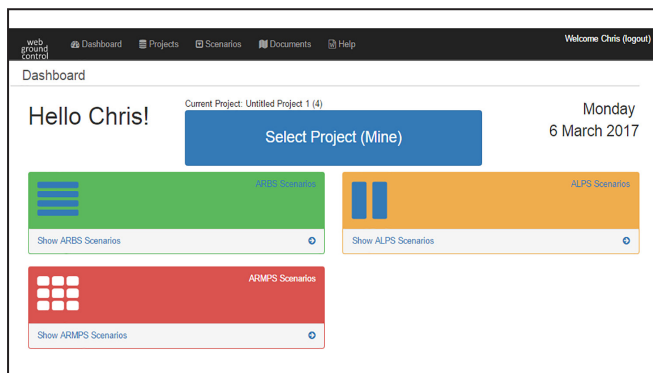


Figure 4. User dashboard.

Name	Select	UnSelect	Description	Units	Delete	Created by	Id
Mine Project A	UnSelect		Company, Complex, Operation, etc.	English	Delete	Chris	5
Mine Project B	Select		Company, Complex, Operation, etc.	Metric	Delete	Chris	6
Mine Project C	Select		Company, Complex, Operation, etc.	English	Delete	Chris	7

Figure 5. Project administration.

The units (English or Metric) for a project can only be set when the project is defined. When set, project units cannot change and all project scenarios will follow the same unit convention. This is by design to ensure data integrity. Once a project has been selected, users will be directed back to the main dashboard where they can

then select a webGC module (ARBS, ALPS, or ARMPS) with respect to the required ground control analysis.

By selecting a given module, for example ALPS, users will be directed to a Scenario Administration page (Figure 6) with respect to user selection. Here, users can define a new scenario (Add ALPS Scenario), as well as edit or delete a previously defined scenarios. As shown in Figure 7, modules within webGC may contain multiple analysis types. With respect to the ALPS module, one can perform basic pillar stability analyses (ALPS Analysis) or pillar design analyses (ALPS Design), which provides the minimum pillar dimensions for a user-defined pillar stability. If the user decides to create a new or edit an existing Scenario, they will be directed to the Edit Scenario Information page based on the previously selected webGC module and scenario type.

Id	Scenario Name	Scenario Description	Created on	Modified on	Delete Scenario	Active Scenario
6	ALPS Analysis 1	Mine Complex A, Operation B, Longwall Gateroad C	6 March 2017	6 March 2017	Delete	Active
7	ALPS Analysis 2	Mine Complex X, Operation Y, Longwall Gateroad Z	6 March 2017	6 March 2017	Delete	Active

Id	Scenario Name	Scenario Description	Created on	Modified on	Delete Scenario	Active Scenario
1	ALPS Design 1	Mine Complex A, Operation B, Longwall Gateroad C	6 March 2017	6 March 2017	Delete	Active
2	ALPS Design 2	Mine Complex X, Operation Y, Longwall Gateroad Z	6 March 2017	6 March 2017	Delete	Active

Figure 6. ALPS scenario administration page.

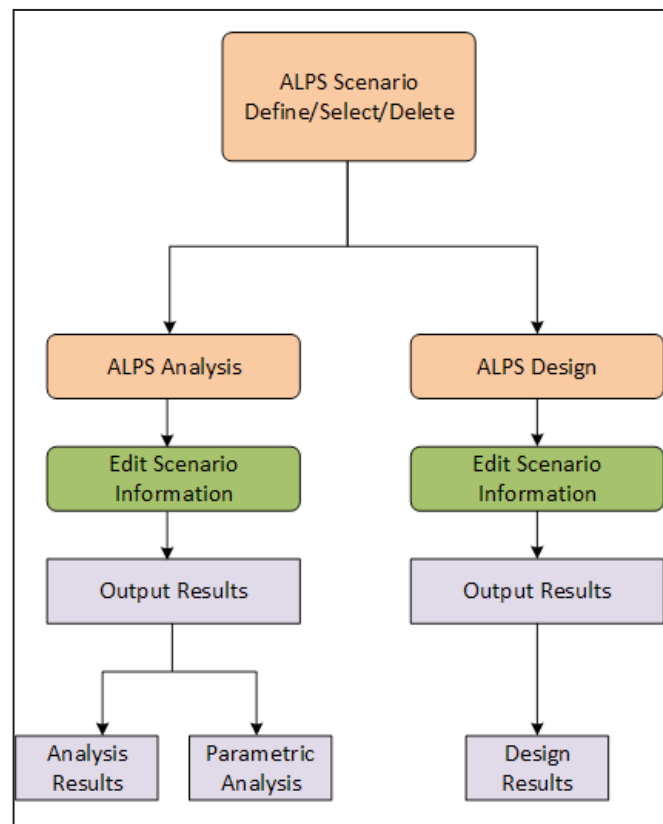


Figure 7. Navigational flow chart for ALPS.

Within the Edit Scenario Information interface, the user can make edit and save modifications to the input parameter form for the given module scenario. As shown in Figure 8, each input parameter form has been developed as a series of HTML groups and tables with input parameters organized with respect to parameter group tabs, such as Panel Specifications. By selecting the associated parameter textbox or drop-down menu, users modify input parameters with respect to site-specific conditions, measurements, or observations. Using the Cancel, Save, and Apply action buttons at the top of each parameter group, users can do one of the following: (1) Scratch all parameter modifications and return to the Scenario Administration page. (2) Save parameter modifications and return to the Scenario Administration page. (3) Submit a parameter modification and remain in the current Edit Scenario Information page.

Figure 8. ALPS Analysis edit scenario information user-application interface.

At the bottom of each Edit Scenario Information page, users are provided with basic output results for the current scenario analysis (shown as Classic ALPS and ALPS(R) in Figure 8), as well as several result utilities. By selecting the Show Report action button, users are able to view a full report for the scenario analysis that includes input parameters, stability factors, loading conditions, etc., organized as a series of HTML tables (see Figure 9). By selecting the adjacent Print to PDF action button, users are able to convert the full report to a PDF format to save to their local device or print. Users also have the ability to perform a parametric analysis for the current scenario by employing the Chart action button and associated drop-down menu. Here, users can select from a series of parametric investigations with respect to mining geometries (depth, entry height, entry spacing, etc.). Upon selecting the appropriate parametric investigation from the drop-down list and then selecting Chart, for example ALPS vs Height as shown in Figure 8, users will be directed to a graphing interface (Figure 10) in which they will be provided with seven scenario results with respect to automatic adjustments to the selected parametric parameter.

Through the use of a multiple-tier architecture, webGC projects and their associated scenarios can be easily accessed, amended, and shared between users. These functions become extremely beneficial

[TOTAL PILLAR SYSTEM LOAD BEARING CAPACITY]	
ALPS Classic	58592607 (lbs) per (ft) of gate entry
ALPS (R)	72927587 (lbs) per (ft) of gate entry
[DESIGN LOADINGS ON PILLAR SYSTEM]	
Development Loading	20736000 (lbs) per (ft) of gate entry
Headgate Loading	30087629 (lbs) per (ft) of gate entry
Bleeder Loading	39439258 (lbs) per (ft) of gate entry
Tailgate Loading	54565170 (lbs) per (ft) of gate entry
Isolated Loading	60535023 (lbs) per (ft) of gate entry
[INDIVIDUAL PILLAR LOADING]	
PILLAR #1	
Development Loading	1223 (psi)
Headgate Loading	2001 (psi)
Bleeder Loading	2779 (psi)

Figure 9. ALPS Analysis results from full report.

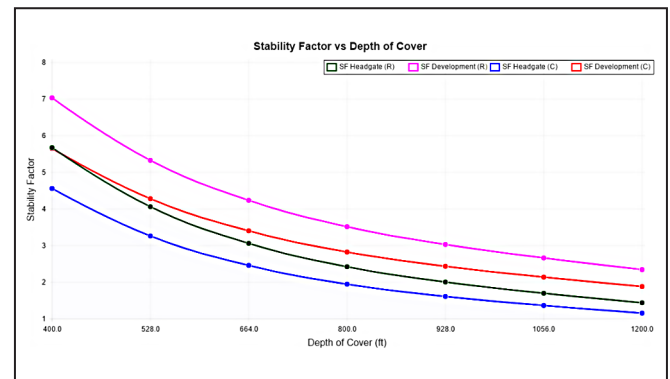


Figure 10. Parametric graphing utility - ALPS stability factor vs depth of cover.

when trying to maintain communications between planning engineers and operational personnel, as well as maintaining design transparency between the mining company and regulatory agencies, such as MSHA, OSMRE, and DEP. A major development within webGC is the ability to attach mine mapping, core logs, roof control plans, and so forth that are relevant to a given ground control design through the Documents utility located on the menu bar. By selecting Documents, users will be directed to the Documents Administration page where they will be able to upload or delete supporting files with respect to the user-selected project. This allows users to always maintain access to pertinent design information when accessing webGC across multiple devices and in multiple locations. Similarly, the ability to share project files within webGC among multiple users not only increases design visibility but also improves communications within design teams.

Within the Project Administration page, the user is able to grant other webGC users viewing or editing rights to a single or multiple projects. Once a fellow user has accepted an invitation to a given project, they will be able to gain access to the respective project and its associated scenarios and documents. With respect to the authentication rights provided to the fellow user, one can either modify or simply view project information. Within a shared project, all scenario modifications or document management will

be stored in an Event Log that is accessible through the Documents Administration page. Building upon the traditional functions of the NIOSH ground control programs, webGC provides the modern engineer with several features and utilities for increased access to design applications, as well as improved project design communications and maintenance. All the conveniences provided by webGC, as well as the operation and input definitions of ARBS, ALPS, and ARMPS have been documented and outlined in a series of help files accessed by selecting Help from the menu bar. Upon selecting Help, users are directed to a help page displaying information on their current location within webGC.

SUMMARY AND CONCLUSIONS

For over 20 years, software developed and distributed by NIOSH has provided the mining industry with a series of tools for the evaluation of underground coal mines with respect to ground control. These programs (specifically ARBS, ALPS, and ARMPS) have become essential in obtaining mine design and plan approvals from regulatory agencies with respect to longwall and room-and-pillar pillar stability, geological formation, and support requirements. By taking advantage of modern internet technologies, webGC builds upon ARBS, ALPS, and ARMPS software providing industry engineers with instantaneous access to ground control designs through a web browser. User accessibility to the webGC platform from any location and across multiple devices allows mine personnel to update designs with respect to varying site-specific parameters, measurements, or observations, allowing ground control analyses to be more representative of actual conditions underground. In utilizing webGC, operators will be able to ensure underground roof and pillar stabilities with respect to current site-specific parameters, geometries, and geology encountered during the course of mining the reserve. The integration of project sharing and document upload within the application allows for an increase in design collaborations between planning engineers, operational personnel, and regulatory agencies while maintaining design transparency.

As of writing this paper, all originally proposed modules (ARBS, ALPS, and ARMPS) have been completed and are currently undergoing the last round of beta testing. Due to development choices made by the design team, the webGC platform can further incorporate other ground control or mine design modules. In fact, work has begun on further developing webGC to incorporate modules for the Analysis of Retreat Mining Pillar Stability-Highwall Mining (ARMPS-HWM) and the Analysis of Horizontal Stress in Mining (AHSM). In packaging webGC for industry distribution, a single signon (SSO) mechanism is under development to further streamline user login and authentications within a company intranet. The expansion of webGC has resulted in pushing the application release to Summer 2018.

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