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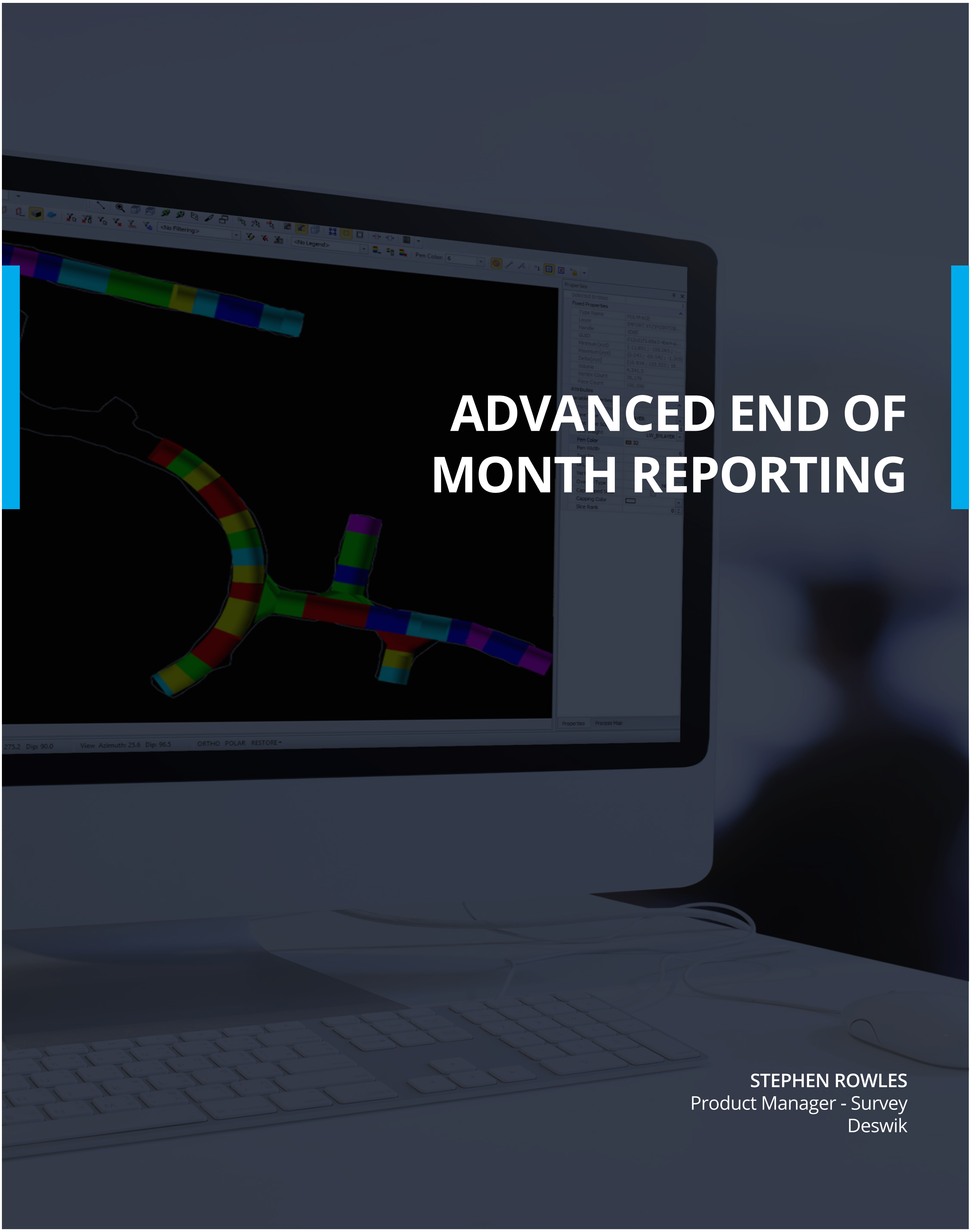

ADVANCED END OF MONTH REPORTING

STEPHEN ROWLES
Product Manager - Survey
Deswik

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ADVANCED END OF MONTH REPORTING

As mining operations seek greater conformance to plan and margins become increasingly tight, end of month (EOM) reporting needs to keep pace with these increasing requirements. However, to obtain this information, it would dramatically increase the workload on the departments that deliver this information. What is needed is a highly detailed, usable report that reduces the time taken to generate the EOM data.

Purpose

The purpose of this document is to provide the mining industry an option for greater analysis of EOM data. Although not every output from this paper may be useful or practical for your operation, it is the author's desire that it will promote discussions about how to improve the deliverables from survey EOM reports. At the same time making the overall workload on the survey department less time consuming.

Key Deswik functions built within the project

To streamline the EOM process and automate as many of the manual steps as possible, several important functions in Deswik are used within the EOM project and the EOM process map.

These key functions can be broken down into two groups, those that are setup before the EOM process begins, and ones that are used on the data as it is created.

Functions used during project preparation:

- Global Constants
- Parameter Tables
- Formula
- Dashboards
- Document Settings

Functions used during the workflow:

- Modify | Attributes | Set from Nearest
- Draw | Solids | Tunnels by Rule
- Conglomeration

Global Constants

Global constants allow the user to set values which can be used throughout the project. The primary use is within the *Formula Builder*, but a lesser known use is in *Block Text* and *Titleblock Text*.

Below, in Figure 1, the constants for this project are rock density for both ore and waste (if a block model is available then it can be used in the reconciliation tool instead of these values), cycle times/fuel burn from the portal, diesel cost, and the moisture content. Moisture content is a variable that has historically not commonly been included in EOM reports, despite having a significant impact on the haulage. In this paper, an assumed value of 10% moisture has been factored in to account for the water used to wash down the fired material. The moisture content value can be altered to allow further data accuracy e.g. where a heading has a positive or negative grade to account for water flowing away from the fired material.

Global Constants

Name	Group	Description	Type	Value
SG				
ORE	SG	ORE SG	Double	2.8
WASTE	SG	WASTE SG	Double	3.2
TKM				
TO ROM	TKM	PORTAL TO ROM	Double	0.5
TO WD	TKM	PORTAL TO WD	Double	0.75
TRUCKING				
CYCLE TIME TO ROM	TRUCKING	TIME TO ROM	Double	10.2
CYCLE TIME TO WD	TRUCKING	TIME TO WD	Double	9.7
DIESEL COST	TRUCKING	$ PER L	Double	1.32
FUEL BURN TO ROM	TRUCKING	FUEL TO ROM	Double	9.4
FUEL BURN TO WD	TRUCKING	FUEL TO WD	Double	8.6
MOISTURE	TRUCKING	MOISTURE CONTENT	Double	0.1
TH663i	TRUCKING	TH663i CAPACITY	Double	63

OK Cancel

Figure 1 - Global constants used within the project.

Parameter tables

The parameter tables in this project are critical to ensuring the formulae work correctly during the workflows. Each of the parameter tables have been created in CSV format so that they can be imported with any updated data as the mine progresses. They have been grouped into three main tables.

PROFILES

The largest of the parameter tables is the one covering the ground support requirements for each heading profile. For every profile (including stripping), the number of bolts, mesh etc. have been assigned for each development round. By generating a report on the ground support that should have been installed based on design, it provides a method for analyzing where extra ground support has been used.

Name	Description	5.0m W x 5.0m H ARCH	5.5m W x 5.5m H ARCH	5.5m W x 5.8m H ARCH	6.0m W x 6.0m H ARCH	6.0m W x 6.0m H STRIP	5.0m W x 5.0m H STRIP	5.5m W x 5.8m H STRIP
XSA	In m2	23.2	27.8	29.5	30.6	0	0	0
GS	GS Code	GS - A	GS - B	GS - C	GS - D	0	0	0
FRICTION BOLTS	Per firing	36	34	30	32	12	12	12
RESIN BOLTS	Per firing	0	6	12	16	0	4	4
MESH	Per firing	9	9	12	12	6	8	8
CABLES	Per firing	0	0	0	0	8	6	8

Figure 2 - Parameter table for the volume and ground support installed depending on the profile (including new drive turnouts).

STRIPPING

While some elements of the stripping are taken into account using the *Tunnel by Variable Section* function, the ground support still needs to be allocated based on the stripping within the heading. While the back stripping for fans and load points are designed within a set location, the position of cuddies within the drive usually have some flexibility for their position. Although the cut-by-cut analysis will show up as higher overbreak, the actual volumes will be correct as the design volume is added from the input fields to correct the volumes reported.

Name	Description	SINGLE CUDDY	DOUBLE CUDDY	SP LOADING	SINGLE FAN	DOUBLE FAN
VOLUME	m2 of strip	12	29	0	0	0
CABLES	Per strip	0	3	0	4	6
MESH	Per strip	3	6	4	5	9
FRICTION BOLTS	Per strip	4	8	6	6	10
RESIN BOLTS	Per strip	0	0	0	3	6

Figure 3 - Parameter table for the volume and ground support installed depending on the stripping.

LOAD POINTS

Load points are used for the TKM related calculations and have data taken from the Landform and Haulage (LHS) module. As new load points are developed, they can be loaded into the trucking parameter table using the Import from *csv function. To update the attribute list, the active load points from the *.csv file are copied into the table and added onto the INPUT DATA/CL layer attribute list.

Name	Description	2030 SP	2050 SP	2055 SP	2070 SP
Distance to Portal		2.918	2.815	2.82	2.673
Cycle Time to Portal		25	24	24	23
Fuel Burn to Portal		53	50.8	48.8	48.2

Figure 4 - Parameter table for the trucking values depending on the load point.

Modify | Attributes | Set from Nearest

This command is critical for transferring data between layers using the nearest entity to the source. It is further refined by using the same grouping attributes used in the reconciliation tool to avoid incorrect data being copied. The layers are specified for each iteration of the command (it is run six times during the workflow) along with the attributes to be copied. Document Settings allow this command to be run without the need for any user input once the layers and attributes have been configured. This keeps all the outputs on a single layer.

Formula

The formula uses the Global Constants and Parameter Tables to generate over 50 calculated attributes for the EOM report. By transferring attributes and data from the various source layers and calculating the results on the CL layer, data analysis becomes easier to view and export.

The formulae have been grouped together into three distinct sets:

» Reporting
» Geotech
» Trucking

Tunnels by Rule & by Selection

Due to a pre-determined number of profiles approved for the mine; this attribute is used to generate the design solids automatically. Where the profiles have already been generated, they can be imported; if not, they can be generated within the project. As this layer is dynamic, the user only needs to refresh the layer to generate the design solids. This command has been automated within the process map by using *Document Settings*.

This function will only generate design solids for drives that do not have variable sections assigned to them. Cuddies for fan starters etc., are typically mined within a certain range of the design so their volume needs to be added manually and the variance adjusted accordingly.

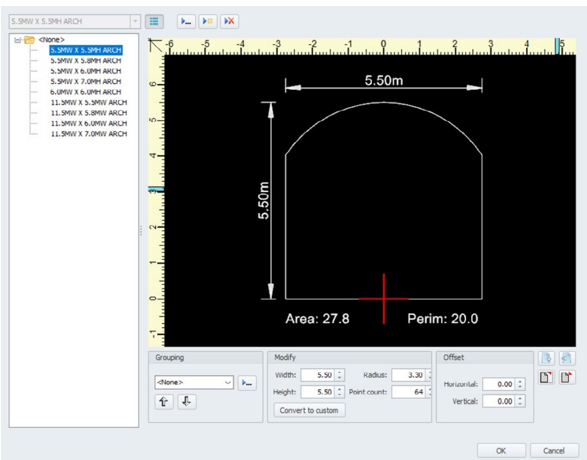


Figure 5 - Cross sections used to generate design solids.

To create the variable section design solids, the vertices are copied from the design CL layer. **Draw | Tunnels | By Selection** is used and the profile assigned to each vertex on the centerline, this is shown in Figure 8. Ideally these variable section solids will have been created within Deswik.IS so the user who is generating these EOM reports would only need to cut the design solids in a similar manner as the as-built solid. However, it is important to demonstrate the steps to create these solids if the user is only presented with a CL and the associated *Polyline Vertex Attributes*.

Dashboards

A feature in Deswik from 2019.3, data can be presented using a variety of graphs, tables and other reports. These are stored within the Deswik.CAD project, if the data is to be exported to other platforms, then a *.csv export is best. A Microsoft© PowerBI© project has been created which references the *.csv export. This can then be made available for anyone with access to Power BI© and can be synchronized to a phone or tablet for 'on the fly' access to the EOM report.

Document Settings

This saves time by loading the settings for a function to be run in a process map using *Document Settings*, rather than manually selecting the options.

Conglomeration

This tool is used predominantly in the coal sector to group coal horizons together for the purposes of design and scheduling, it has been described as a lighter version of the Deswik.Agg (Coal Seam Aggregation) module.

Within this workflow it is used to group together fired rounds which display a trending of overbreak between 10-20%, 20-25% and over 25%. Using a series of formulae, it will exclude individual rounds of overbreak, instead only looking for two or more continuous rounds of overbreak as per the overbreak parameters.

Workflow within the Process Map

The process map presents the user with a clearly defined workflow to execute the EOM report.

The information icon next to each button explains the commands that will be performed. It is possible to link these to procedures or videos of the steps so new users can watch and check they are following the correct steps.

The squares to the right act as a traffic light system; if the button has been executed without errors it turns green, if errors have been found then it turns red.

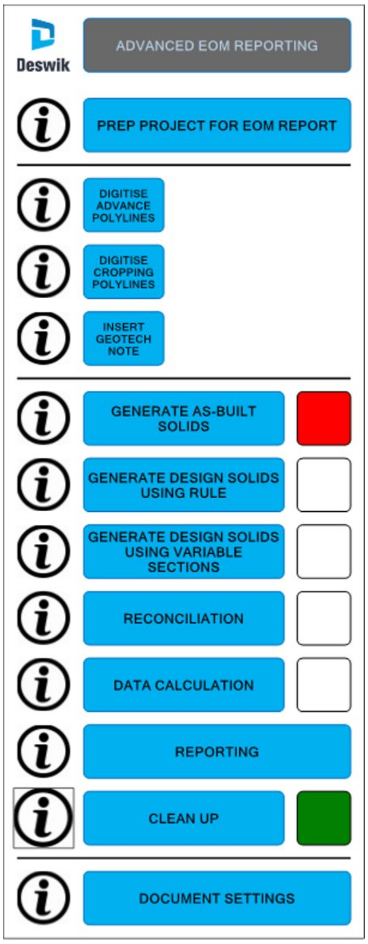


Figure 6 - Process Map used for the EOM workflow.

Updating the External References

The EOM project is created with *External References* to the survey and design projects. The first function of the process map is to update these references, so the user has the most up to date information.

User inputs to EOM project

Two polylines are digitized for each active heading in the reporting month; filtering by the *Area* and *Level* attributes makes the work simpler.

One polyline is created to represent the months advance and once created, the layer will prompt them to enter the relevant information for this heading.

The second polyline is generated to crop the surveyed solid and requires the *Area* and *Material Type* attribute to be applied. The *Material Type* is required if the same drive name is used across different financial categories (CAPEX, OPEX), if the drive name is unique then this attribute would not be required.

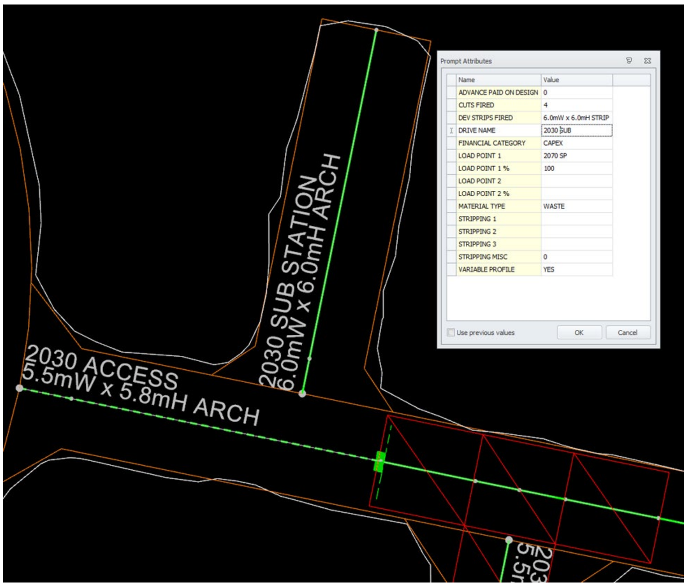


Figure 7 - The attributes that are prompted for when a new advance is digitized on the CL layer.

Generating the solids

After the CL and CROPPING polylines have been generated for each heading, the AS-BUILT solid is created. The command **Modify | Crop | Entities Bulk** uses a grouping attribute (DRIVE NAME) so the solids are cropped by each level using the boundary polyline. Attributes are transferred between layers and then the design solids which have not been created using the *Tunnel by Variable Section* are refreshed on the DESIGN layer.

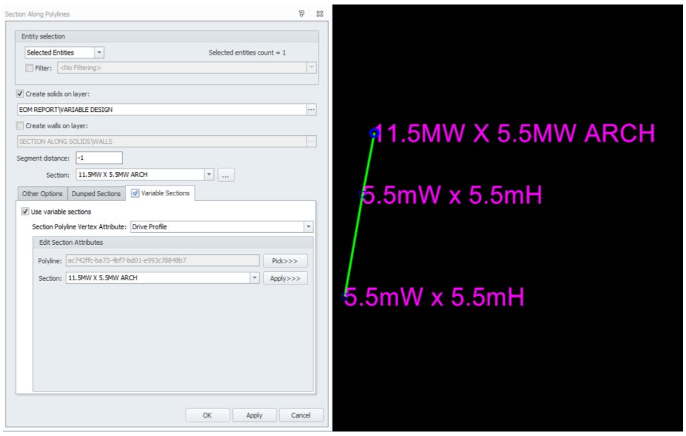


Figure 8 - The interactive form to create solids using variable sections.

Reconciliation

By employing the grouping attribute DRIVE NAME, the reconciliation can be performed for all development headings at once. The grouping attribute is used on the centerline tab which means each heading will be reconciled cut by cut using a specified length. In this paper 4m per firing has been used. If a more detailed analysis of the development was needed, an individual distance per firing can be entered, however this would involve reconciling each heading on its own and would add to the time taken to generate the EOM report.

For a more detailed analysis, the cross-sections of each firing can be plotted with the associated tables so the areas of overbreak/ underbreak can be visualized.

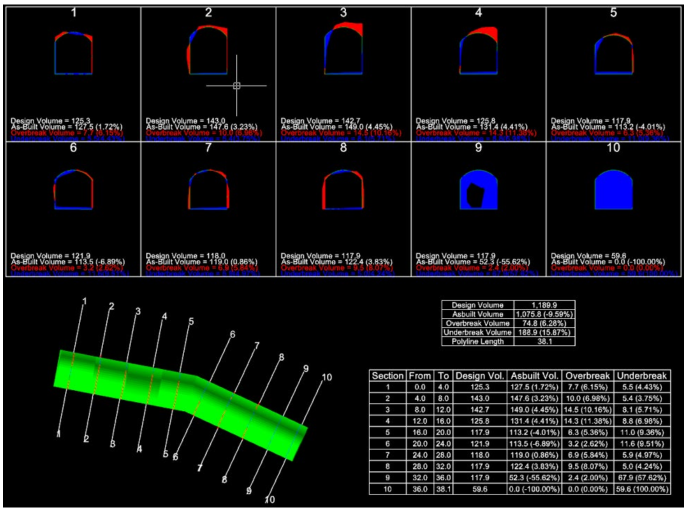


Figure 9 - Outputs from the reconciliation tool showing each firings compliance to plan.

If a block model is available, then this can be referenced with the appropriate fields from the model and reconcile each cut of the headings.

Data Calculation

To calculate the results for the EOM report, attributes are copied from multiple layers to the CL layer. This is accomplished using **Modify | Attributes | Set from Nearest** multiple times to transfer attributes from the output layers back to the CL layer which contains all the attributes shown here.

Once all the attributes have been collated on the CL layer, the following formulae groups can be run:

GEOTECH – These attributes use the **Parameter Table** values based on the drive profile assigned to each heading. The consumables are based on the amount of cables, mesh, and bolts used for each firing.

REPORT – These attributes re-calculate many of the reconciliation tool outputs to account for design stripping and any development paid on design.

TRUCKING – The trucking parameter table contains the distance, fuel burn and cycle time from each load point.

These values are used to determine the difference between the actual and design values for the fuel burn, number of trucks and cycle time.

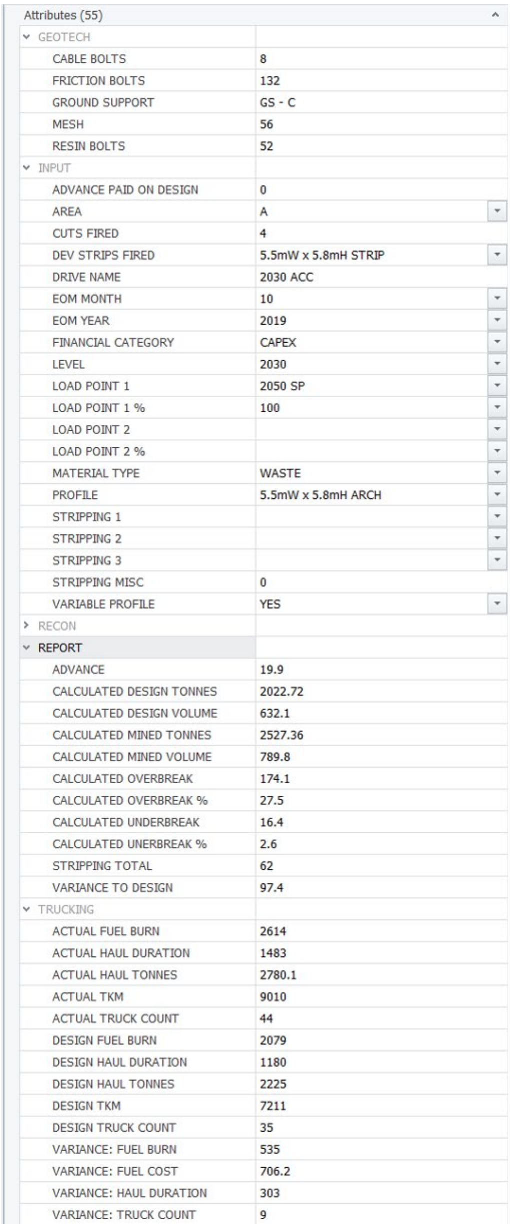


Figure 10 - Attributes generated from the DATA CALCULATION button. This represents all the attributes for each heading in the EOM report.

Conglomeration is run to group together sequential firings of overbreak based on set ranges. The formulae run prior to the conglomeration command groups together sequential firings of overbreak by those percentage ranges. The "Overbreak" legend has been applied to show these ranges.

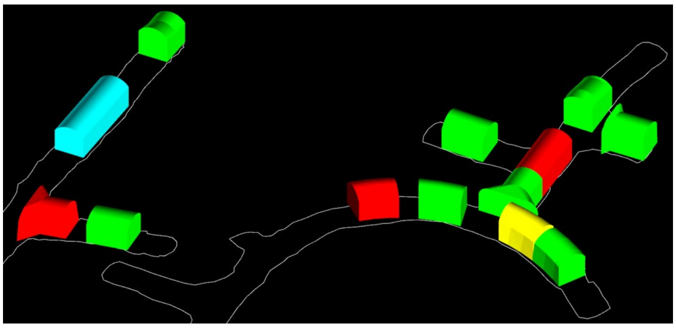


Figure 11 - Results from the CONGLOMERATION functions to group the overbreak together where there are successive cuts of overbreak.

The final functions copy several outputs from the EOM calculations to the MEASURE DATA layer so that it keeps a record for the entire mine's EOM activity. This provides a single layer source for all the EOM data in the mine.

Reporting

A sub-layer within the process map opens to give the user a choice of how the data for the EOM report is to be exported, either as a *.csv, a dashboard within Deswik or a Deswik.CAD project. The exporter takes the current months data and saves it as its own project. This can be reviewed should any of the reports be questioned at a later date. As part of the clean-up in this process map, all the month specific data except for the CL data are deleted to maintain a sensible project size.

Outputs and analysis of the data

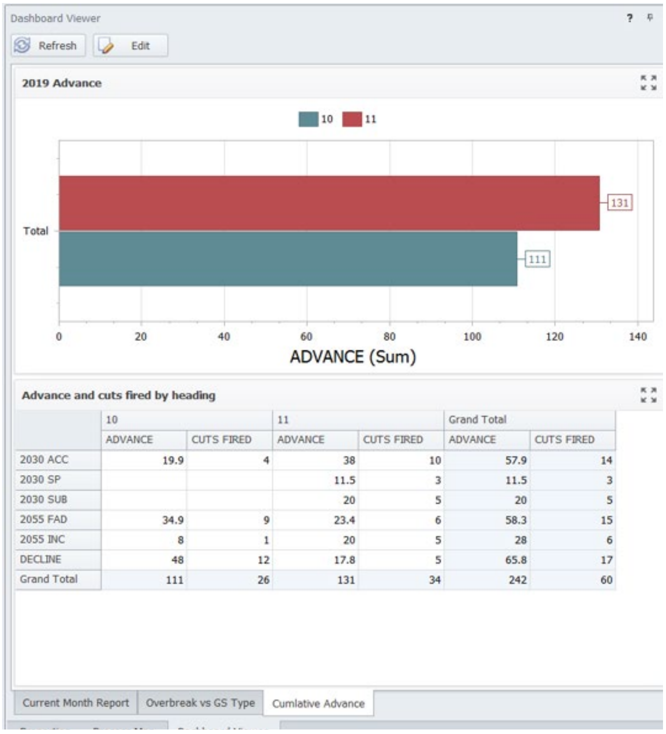
With all the data on a single layer, this is then used by a variety of departments to analyze, interpret and disseminate the information to assist in improving mining practices at site.

Survey

While the data generated from this workflow is to be used by other members of the mining team, it also needs to make the surveyors EOM work easier. The purpose of this process map is to streamline the work by the surveyors each month.

The workflow makes the EOM report as simple as possible, by using layer presets and filters, each level is loaded into the model space. The speed of the report being generated is especially important for client/contractor operations where billing cycles may have short turnaround times and submitting the report on the day of the EOM is critical.

The *Dashboard* is docked into the CAD layout and customized as per the reporting requirements. The example below shows the advance for each month as a graph and a more detailed table showing the breakdown of advance and cuts fired by each heading.



	10		11		Grand Total	
	ADVANCE	CUTS FIRED	ADVANCE	CUTS FIRED	ADVANCE	CUTS FIRED
2030 ACC	19.9	4	38	10	57.9	14
2030 SP			11.5	3	11.5	3
2030 SUB			20	5	20	5
2055 FAD	34.9	9	23.4	6	58.3	15
2055 INC	8	1	20	5	28	6
DECLINE	48	12	17.8	5	65.8	17
Grand Total	111	26	131	34	242	60

Figure 12 - Dashboard graphic of the EOM data.

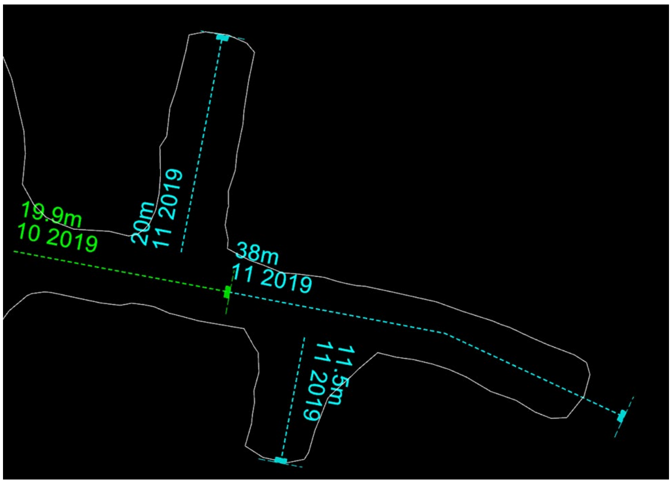


Figure 13 - Final output on the MASTER DATA\ADVANCE layer with the annotations visible.

A legend is used for each month, which makes visual presentation easier. There are three annotation layers created.

1. The monthly advance for the heading
2. The month and the year
3. The marker at the end of each months advance to make it easier to visualize the advance.

At the completion of the EOM report, the current month centerlines and individual drive sections are transferred to the MASTER parent layer and exported to the month specific CAD project.

This allows any queries about EOM report metrics to be placed on dashboards for a more permanent report or use an interactive filter to answer any ad-hoc queries.

Geotech Outputs

The outputs from the conglomeration function are shown in Figure 14 with the legend applied. The overbreak can be filtered by the ground support type, so that if there is one ground support standard with a greater correlation to overbreak it can be further investigated. Although correlation does not mean causation, it provides a good place to start investigating. If the survey team are picking up the additional installed ground support (cables, pull rings etc.) then they can be incorporated into the assessment as well. If the development interacts with the same fault further down the mine, then the results from the EOM analysis can be factored in and perhaps a different support profile, explosives or drill pattern can be used.

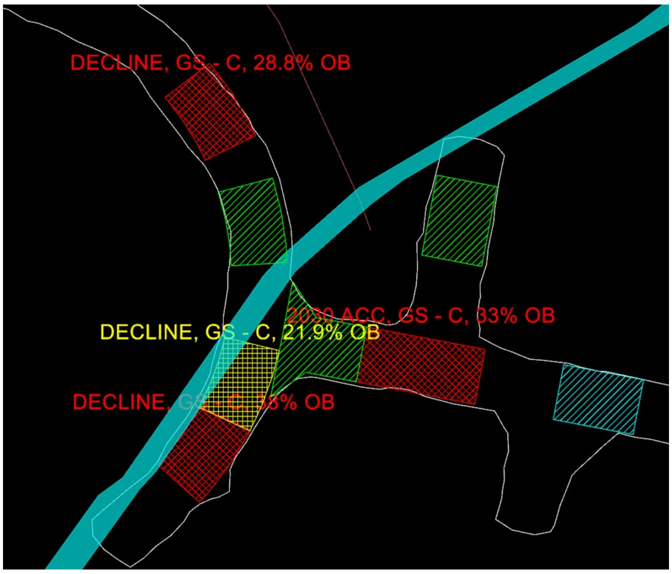


Figure 14 - Conglomerated overbreak annotated with the ground support type and average overbreak. The fault structures have been sliced at the elevation of the access.

The INSERT GEOTECT NOTE button in the process map also allows the user to insert a block into the project which represents a geotechnical note, such as photos of the ground, rock noise report etc. Using the URL option in Deswik, the block links to the report/image so any user can view the linked file/folder. Figure 15 shows the additional installed ground support and the pull rings have been colored by their status. Red = Failed, Orange = Not tested, Green = Passed. The pass/fail status of the installed ground support is purely hypothetical for the purposes of demonstration. This allows the user to check if there is any correlation between the failed ground support and the proximity to the fault structures.

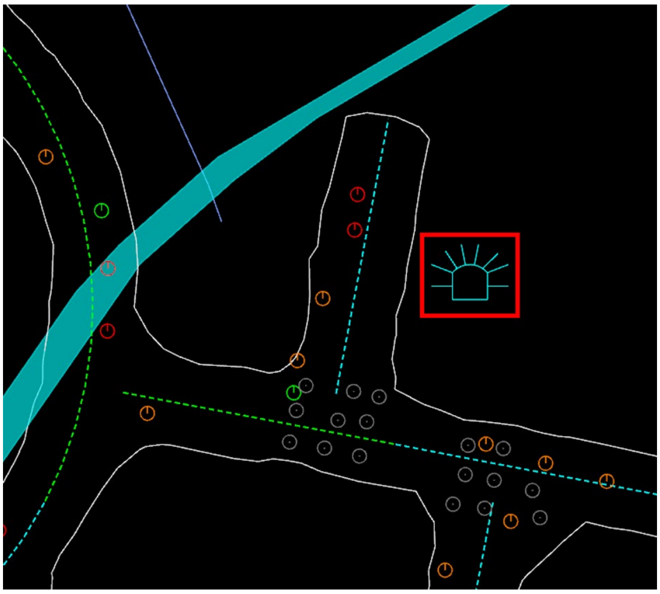


Figure 15 - Additional ground support with the legend applied, the Geotech block has been added and if clicked on will use the URL applied in the Variable Properties.

Trucking Outputs

This is a purely hypothetical but potentially realistic scenario where the truck counts, variance etc., all indicate that there was a high compliance to plan. However, when the Deswik EOM figures are compared to the claim it shows that there was a distinct difference between the calculated truck loads and the claimed loads. Further investigation shows that a portion of the main access's backs was under broken which causes the vent bag to be hung low. This results in the trucks that are loaded to capacity ripping the vent bag continuously. To solve this, the operators are not loading the trucks to capacity to alleviate the work to repair the vent bag. By capturing the costs of each truck load, the user can assess the ongoing cost in truck utilization, fuel etc., associated with not restoring the backs to design height.

Using the *Dashboard* function, Figure 16 shows some simple analysis of the total fuel cost and haul duration for the two months that have EOM data for them. While the fuel variance is a total for the month, the haul duration variance is broken down into each heading for a more detailed view of the variance.

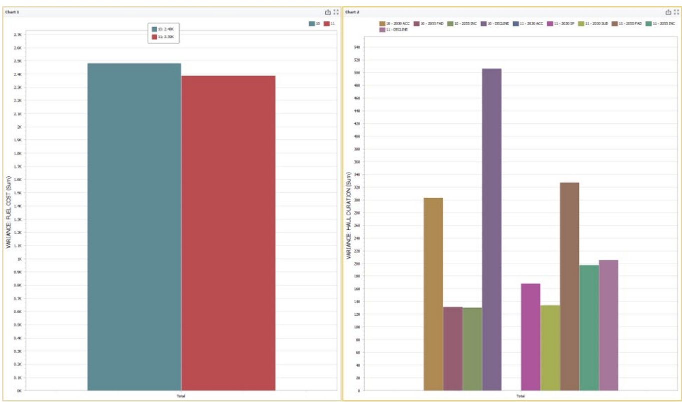


Figure 16 - Additional dashboards reporting on trucking EOM metrics.

In previous EOM reports, if load points have been factored in, then usually only one load point has been included in the TKM calculations. By having the option to incorporate two load points (or more if the report needs it), the TKM calculations will become more accurate when reconciled against the claim.

Reconciliation Outputs for operators

The reconciliation tool in Deswik can be run by individually selecting each development drive using the as-built, design and advance polyline to perform the reconciliation. However, this can be a time-consuming task for operations that have many active headings each month. By using the *Drive Name* attribute, the inputs are grouped into one iteration of the reconciliation tool. The grouping attribute must be the same between the three input entities (a quick check with the *Interactive Filter* can find any issues) but means the entire EOM reconciliation is performed once. If the user is manually assigning the cut length for each firing then this approach will not work, it will just apply one *Fill Length* for all the advance polylines.

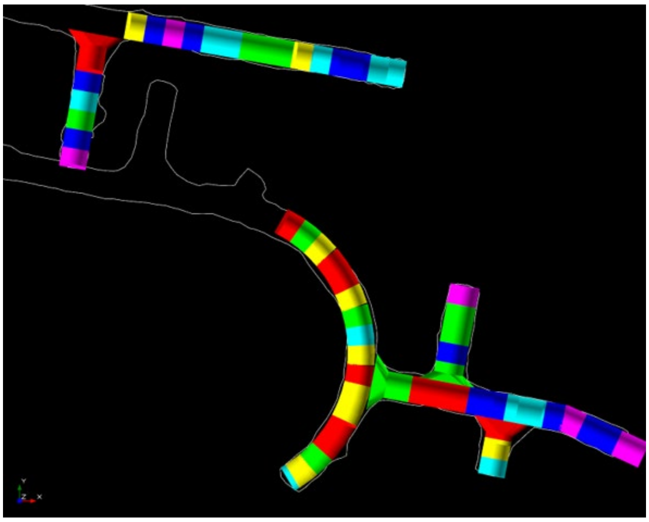


Figure 17 - Individual firings colored by overbreak percentage.

Reporting on installed ground support against a planned amount enables the user of the data to inspect variance by each heading. This helps to highlight non-compliance and allows for refinement of costings for current and future contracts. By highlighting and potentially reducing non-compliance to plan and the associated costs of non-compliance, savings can be made in a variety of places and mitigate risk with cost overruns. If maintenance schedules are based on hourly utilization (every 250 hours etc.), spending less time hauling overbreak which may not be paid for by the client, will increase the revenue per truck hour.

Social license to operate and being a responsible miner

With increased public awareness on the contributors to climate change, all industries are subject to scrutiny with metal mines not exempted. Cost reductions are clearly a desired outcome from an efficient mine plan, reduction in carbon emissions is another. By capturing the direct costs and consumption of fuel against compliance to plan, operations can show the cost of non-compliance to plan. If changes are made to improve compliance, a monetary value can be shown on these changes and presented to the industry and/or market.

While the measured changes are very small for each month, extrapolating this out to a mining region could yield significant positive changes for the industry and create a substantial impact on carbon emissions. There is not only the initial reduction on diesel consumption by the haulage fleet, but with greater constraint on the installed ground support etc., the operation may require less raw materials and emissions from the delivery of those materials.

Conclusion

By changing the reporting outputs to focus more on the compliance to plan, key indicators can be analyzed by respective departments to improve mining efficiency.

While finding a magic 10% improvement may be beyond reality, identifying several 1%'ers to help with compliance to plan, the direct cost savings can add up to a considerable overall improvement. It also allows the company a way to promote an effort towards sustainability, cost savings and a potential reduction in carbon emissions.

This workflow isn't designed to be a 'one size fits' all solution to operations but rather promote discussion about improvements to the EOM process and compliance to plan.

Acknowledgements

The author wishes to thank the Deswik employees who gave advice on how to achieve some of the functions within this workflow, special mention goes to Luke Waller and Benjamin Williams for their splendid ideas for elements of the reporting. Thanks also goes to Holly Allday from Pybar Mining Services who helped frame the outputs from the reports towards the contract miner aspect.

Disclaimer

The data used in this paper is from the 4.11 Survey for UG Metals training document. The profile sizes, ground support requirements/names and the trucking distances are purely arbitrary however they reflect the author's experience of standard mining practices in order to provide more realistic outputs.

Deswik.com