

## Development of sustainable performance indicators to assess the benefits of real-time monitoring in mechanised underground mining

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### ABSTRACT:

*This paper presents the development and quantification of a catalogue of Sustainable Performance Indicators (SPIs) for the assessment of the benefits real-time mining can offer in small and complex mechanised underground mining operations. The SPIs investigated in detail include:*

- grade accuracy and error of the resource model,*
- high/low grade ore classification accuracy and error,*
- additional high grade ore identified per unit volume,*
- profit expected per unit volume,*
- ore classification accuracy per unit volume assigned to the stockpiles.*

*A case study utilising the Red Lake gold mine located in Northwestern Ontario, Canada, which is owned by Goldcorp Inc., was designed with the aim to assess the effect of real time sensory data acquisition and resource model update on the SPIs.*

*The methodology broadly comprises of three steps. Firstly, the provided dataset was used to develop a virtual asset model (VAM) representing the true 3D grade distribution in order to simulate the ‘sublevel cave and fill’ mining method and the associated grade data acquisition from the development drillholes and face monitoring, the development and production muck pile, LHD/scooptram and conveyor belt transport, taking into account the sensor parameters. Next, the acquired data was assimilated into the models developed for the purpose of detailed statistical assessment of the SPIs, thereby enabling optimised decision-making during the production of ore in order to meet the grade requirements. Finally, an evaluation of the sensor performance was carried out using three additional levels of sensor error and interpretation bias (10, 20 and 30%).*

*The three models used for the quantification of the SPIs include:*

- resource block model (RBM): which represents the 3D grade distribution in the ore body;*
- grade control model: which enables selective stope production (drilling, charging and blasting) based on the underlying requirements pertaining to e.g. cut-off grade, time and economic constraints; and*
- logistics model: which classifies the ore grades for conveyance and stockpiling, in order to eventually facilitate for the mixing of run of mine ore to meet the grade requirements before milling at the processing plant.*

*The improvement of the SPIs when real time monitored data is used in the update of the models has been verified. It is also shown that the noise in the acquired data, which directly reflects both the accuracy and precision of the sensors, has a measurable effect on the values obtained for the SPIs. However, 10 to 20% noise does not appear to reduce significantly the improvements achieved, while 30% noise has a more profound effect on the SPIs and the quality of improvements achieved through real time data assimilation in the models.*

*The work carried out demonstrates that there is a need for robust sensor technologies that allow for minimum bias in grade estimation and maximum classification accuracy. It is also expected that sensor performance is likely to vary from site to site and possibly within the same ore deposit mined due to local geological conditions (heterogeneity), variations in the underground environment where sensors are installed (affecting sensor performance), the mining method used (affecting the access and availability of real time monitored data) as well as the specifics of the sensor technologies used. Thus, it is suggested that sensor performance needs to be evaluated and quantified for the mine and area considered for sensor installation given the local geological, operational and mining method related characteristics and opportunities for monitoring.*