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A spatial mine-to-plan compliance framework for open-pit iron ore mines

Otto, Theunis Johannes

2019

https://hdl.handle.net/10539/28965

Otto, Theunis Johannes. (2019). A spatial mine-to-plan compliance framework for open- pit iron ore mines. University of the Witwatersrand, https://hdl.handle.net/10539/28965

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ABSTRACT

A major assumption underpinning this PhD thesis work is that the actual financial returns realised by open-pit mines are not only dependent on agreed upon mine plans but, are also dependent on the level of spatial execution of the mine plans. To ensure the sustainable success of a large open-pit mine two major areas need to be effectively managed namely the quality and integrity of the mine planning process and the spatial execution of the “best” mine plan. Existing literature describes improvements in the mine planning process and the development of more robust and optimised mine plans. Despite improvements in the quality and integrity of mine plans, open-pit iron ore mines often struggle to achieve the targets set in these mine plans, especially from a spatial point of view.

Existing literature recognises the value of spatial compliance to a mine plan, but the processes and systems associated with spatial mine-to-plan compliance reconciliation are not adequately addressed. References to practical and integrated approaches for measuring and managing spatial compliance against the approved mine plans are very limited. Where compliance to the mine plan is mentioned, the research has mainly focussed on temporal compliance metrics and have not proposed a comprehensive framework focused on spatial mine-to-plan compliance for open-pit iron ore mines. This thesis took steps towards filling the identified knowledge gaps in existing literature.

The purpose of the thesis was to answer the research question on whether spatial compliance can be improved. This was done through the development, implementation and validation of a spatial mine-to-plan compliance framework for open-pit iron ore mines. The framework defines the components and relationships between the components that determine the level of spatial compliance against the tactical mine plan. This allows measurement and ensure effective management of spatial mine-to-plan execution at open-pit iron ore mines.

The research methodology followed during the execution of this research thesis was to review existing literature with the aim of establishing the extent and depth of current published information. The thesis then conceptualised and developed a spatial mine-to-plan compliance framework. The approach for the measurement and reconciliation of the spatial mine-to-plan compliance at open-pit iron ore mines was defined. This was followed by the development and application of spatial mine-to-plan compliance driver trees (CDTs). Methodologies were defined for determining, quantifying and interpreting the impact of spatial mine-to-plan compliance performance on the achievement of operational targets and mining flexibility. The research

developed the concept of the next best action (NBA) leading to effective decision making. Technology solutions were evaluated and applied to enhance the effectiveness of the framework. Finally, the research was validated through the implementation of the framework at the Kolomela open-pit iron ore mine in South Africa.

The Kolomela spatial mine-to-plan index improved from 74% in 2013 to 99% in 2017, confirming that the adoption of the framework led to a significant improvement in the spatial mine-to-plan compliance to the business plan (BP). Insights gained through the application of the CDT contributed to the improvements. Areas that were planned, but not mined at the time of the assessment were targeted through the NBA methodology and the root causes of adverse spatial mine-to-plan reconciliation performance were addressed. Remotely piloted aircraft systems (RPAS) and high precision global positioning systems (HP-GPS) technologies were implemented, thereby enhancing the effectiveness of the spatial mine-to-plan compliance reconciliation process at Kolomela. This was achieved by utilising the technologies to assist with the visualisation of the actual areas mined in relation to the areas planned for mining.

The results obtained during the validation illustrated the positive relationship between achieving targeted spatial mine-to-plan reconciliation results and the achievement of budgeted total exposed ore (EO) levels. This confirmed the critical role that spatial mine-to-plan compliance performance plays to ensure the sustainability of the mining operation in the longer-term through maintaining the planned level of mining flexibility. This is achieved by generating the budgeted EO levels which are a proxy for mining flexibility.

This thesis contributes to knowledge as a reference based on empirical research validated at Kolomela. The research represents applied knowledge with a significant value contribution that has potential to fundamentally improve open-pit iron ore mining reconciliation practices. The thesis contributes to knowledge in three key areas. Firstly, it developed an integrated spatial mine-to-plan compliance framework for application at open-pit iron ore mines. The framework defined various metrics including a spatial mine-to-plan index. Secondly, it developed and applied spatial mine-to-plan CDTs that provide the ability to drill-down into selected spatial areas within the larger iron ore mine and enable understanding of the root causes of deviations. Lastly, it employed technology solutions (RPAS and HP-GPS) in a novel way to enhance the effectiveness of the spatial mine-to-plan compliance framework.