

## **ABSTRACT**

Ore and metal accounting and reconciliation processes at most South African mines have been a long-standing challenge. Efficiency factors such as the Mine Call Factor (MCF) have been developed and used to monitor the overall mining and metallurgical processes. The MCF at seven AngloGold Ashanti Mines in South Africa averaged at 70% annually from 2010 to 2017. This implies a 30% loss of gold, equivalent to approximately 1.4 billion rand which is material. Metal losses are categorized as either apparent or real. The focus in this thesis is on investigating digital technologies for measuring, monitoring and tracking physical metal content from underground to surface and reporting in real time in a control room on the surface. The fundamental question in the thesis was to determine if digital technologies are suitable for measuring, monitoring and tracking metal content from underground to surface.

In order to test this concept, a literature review was conducted on various topics that embody metal accounting and reconciliation with a key focus on current and new digital technologies and systems for tracking broken ore variables. These include the MCF theory; theory of volume and in process measurements; material monitoring and tracking technology options for broken ore variables; leading mine planning and reconciliation software options; and Microdots technology as a potential solution for ore tracking.

Following the literature review, a conceptual framework for tracking metal content was developed using a typical underground mechanised mining operation as an example. Technology options for tracking metal content and associated variables in a typical production environment at various stages was developed. These are the in-situ

stage; after blast; ore transportation; tipping into ore bins or passes; and stockpiling on the surface.

An implementation plan was developed for measurement, monitoring and tracking of volume and mass, sampling for grade, fragmentation, density and moisture content as well as location-based information. This implementation process is made up of several steps - including identification of the purpose for the measurement, the system used for that particular measurement, development of a site-specific protocol for each of the equipment and a competency standard. A combined digital mining technology (CDMT) approach for metal tracking from underground to surface was then developed. In the CDMT approach, decisions in terms of the best technology or equipment would have to be made in accordance with the mine's standard operating protocol. A SWOT tool was used to identify the best technology for measurement, monitoring and tracking each of the variables. This thesis demonstrates that material tracking is possible through the application of digital technologies during the production aspect of the mine value chain. Technologies such as the RF tags introduced in the past resulted in the prevention of cross tramming of ore to waste and vice versa. The application of several digital technologies to measure, monitor and track metal content has the ability to distinguish between physical and apparent losses, which is a major step forward in understanding metal loss from mine to mill.