Mine Reconciliation and Optimisation for Enhanced Mine Performance

Chris Bray, Minex Conference 2009
What is Mine Reconciliation?

- Comparison of estimated tonnage, grade and metal with actual measurements
- Aims to measure the performance of the operation
- Supports the calculation of the mineral asset
- Validates the Mineral resource and Ore Reserve Estimate
- Provides key performance indicators for short and long term control
- Highlights improvement opportunities
- Allows for proactive short-term forecasting by providing reliable calibrations to critical estimates
• All these areas need to be understood and applied
• Sufficient answers for the questions provided are required during the mine reconciliation process
• Relevant systems need to be implemented and maintained to produce suitably accurate results
Six Sigma is a business management strategy that provides a logical approach to understanding and improving the mining operation through a set of quality management methods.

Systems such as the Six Sigma provide a structured approach to defining the bottlenecks and limiting factors within a wide range of operational activities. The systems aim to determine solutions for problems within the organisation and ensure they stay in place.
Details

• Established by Welsh Miners, named after the old Latin word for Wales
• Managed by Herbert Hoover who later went on to become the US President
• Gwalia Mine has produced in excess of 4 Moz or 125 tonnes of Gold
**Brief History of the Gwalia Gold Mine**

- 1897 to 1963 - Underground mining of the Sons of Gwalia gold deposit with shaft access to depths of 1.08 km
- 1984 to 1999 – Mined as an open pit
- 1998 to 2003 – Remnant underground mining of upper levels using hanging wall decline access
- 2007 to present – Mine decline development recommenced and is now below 1.1 km.
• Stope planning is primarily carried out by the Mine Planning Engineer in Consultation with the relevant specialists. Communication and involvement of all significant parties is essential to reduce the likelihood of failure.

• Stope Planning is an iterative process where a safe, cost effective and practical solution to mining a particular section of the orebody must be determined while working within the regulatory framework of the mining law in the area.

• Where a safe, practical or cost effective solution cannot be achieved or agreed upon by all parties, then the mining area should be placed on hold until conditions become favorable.
Suitable plans and sections of the relevant mining area are required to be produced.

Plans should be clear and contain as much applicable information as possible.

Any information that is not relevant should be left out to prevent distraction.

All parties should be guided through the plans to ensure they understand the approach and are familiar with the mining area and issues.

Standards and conventions for presentations should be developed and improved on with time.
The specific challenges for working in the area should be understood by all parties. Past experience in dealing with these conditions will assist greatly in the planning process.
Stope Planning Procedure – Areas to be covered

- Geology – Based on study and previous experience
- Stope Design Criteria – Based on study and previous experience
- Development – Minimum necessary to satisfy statutory, production, ventilation, equipment and safety requirements
- Ventilation – Suitable plan for fresh air intake and exhaust based on equipment and manpower
- Production – Practical consideration and realistic targets
- Drill and Blast – Practical and realistic approach using past experiences
- Ore Reserve – Best estimate of modifying factors based on design and experience (Ore Losses and Dilution)
- Geotechnical – Based on study and previous experience
- Financial – Analysis based on technical study and historical performance
• Communication between the Mining Engineer, Geotechnical Engineer and Production Supervisor is required to develop the optimal approach to mining
• The Mine Planning Engineer collates the information and presents plans and schematics that can be discussed further before approval
Sections views of the block and geological model can be used to justify ore body boundaries with respect to drill hole intersections and results of assay composites. Also used to justify diluting grades and volumes.
Basic cashflow analysis is based on the applicable cost, revenue, consumption and recovery information available at the time which is applied to the proposed design. This provides an estimate of the expected return and profitability based on all the required activities and processes to produce the final product.
• The CMS is extended into the void using a staff which must be stabilized in the safe area.
• There is a risk that the instrument may be damaged by falling rocks
• Cost of equipment can be more than compensated by the increased control of mining activities
• The CMS allows an increased level of accuracy when comparing design with actual excavation
• The information obtained allows for improved design and safer operating conditions
• The impact of production decisions can be monitored for effectiveness
• A section view of the actual versus design stope allows the engineers make better informed production decisions

• In this case we can observe:
  
  • Areas of overbreak in the hangingwall;
  • Additional ore lying on the footwall; and
  • Influence of historical stopes on current production activities
• This section view shows the interaction of adjacent mining areas which would not have otherwise been known.

• This interaction had serious safety and economic consequences which may not have been identified in a timely manner without the appropriate engineering tools and software.

• Indicate where the stope has broken through into the adjacent drive (safety) and where the backfilled stope had broken through leading to excess dilution.
Greater accuracy for the Stope Reconciliation process allows improved decision making with respect to the economic of the project.

A suitable system for recording this information is required to improve future mine planning.

Benchmarking of the Key Performance Indicators allows greater control of expenditure and identifies areas of improvement.
Financial analysis should be completed, where possible, on all working areas of the mine.

All relevant parties should be included to determine which decisions worked well and where there was room for improvement.

Benchmarking of the mines performance is especially important in marginal operations and provides the management with the necessary information to make effective and timely decisions.

### Key Learning Outcomes

- Only the slot drive required cable bolting. 6m cables would have been adequate;
- Shoulders would have been better supported with herringbone cables drilled at 30 degrees;
- Downhole rings through delaminated ground should have been “just-in-time” drilled; and
- Long Cut used to break 375 PW SG6 into the void was too long. Should have taken a short cut first.
Mine Reconciliation and Optimisation

- Greater accuracy of mine reconciliation will improve the ability of a company to optimise the mining operation;
- Optimisation software is dependant upon the accuracy of input parameters such as costs, modifying factors and operating constraints. The Planning Engineer is relied upon to set up practically achievable scenarios;
- Mine optimisation exercises are usually the basis for long term mine planning;
- Goals of the client are taken into account for the purposes of the operation however the user supplied parameters will ultimately determine whether the goals are achievable;
- The optimisation process must be transparent and repeatable before being accepted by the company. It is important that all aspect of the optimisation are tested and interrogated to ensure the input data is reliable and the results are achievable;
- For investment purposes it is essential that the optimisation process uses internationally recognised techniques for information gathering and process testwork; and
- It is important that all information used is well organised for reference and future optimisation work.
Open Pit Optimisation

- Blocks are based on a mineable unit
- Geotechnical parameters
- Open Pit vs Underground Mining
- Waste Storage Facilities
- Costs of mining, processing and selling the commodity
- Metal recovery
- Blending, processing and mining constraints
- Physical barriers to mining
- Revenue obtained from metal content of block
Underground Optimisation

- Definition of Mineable Stopes
- Sequence of Mineable Stopes
- Mineable Shape Optimizer
- Taking in account orebody geometry, practical mining constraints and cutoff grade or value
- Backfill vs Pillar Analysis
Recommendations

- The described measures for mine reconciliation and optimisation can be adapted to a wide range of mining operations and methods;
- Organisation, communication, flexibility, ongoing training and file management is essential for successful mine reconciliation and optimisation;
- A reliable and suitably accurate reporting system for the mine must be developed in order to capture the relevant information;
- Technical Staff must be provided with the tools for the job (Computers, software, vehicle) in order to be dynamic for the operating conditions;
- There are always many unknowns in both open pit and underground mining. The more useful and timely the information available to the Mining Specialists, the lower the number of assumptions required and better the information and results provided to management;
- In a production environment you never gain time, only lose it. It is important to implement the required changes to optimise the mining operation when time and finances permit;
- It is important to Benchmark your operation against other similar mines in order to determine what the potentials and what systems and technologies are available to assist; and
- Mining is not rocket science but requires a good systematic approaches and communication between all relevant parties to ensure mistakes are not repeated and inefficient practices are discarded.
These comments about business and operational control are especially applicable to mine reconciliation and optimisation.

Understanding, quantifying, controlling and correctly reporting the results is an integral part of successfully monitoring the performance of the mining operation.