Strategic Mine Planning

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<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Characterisation</td>
<td>• Measure &amp; quantify the Grade Engineering® responses of the orebody</td>
</tr>
<tr>
<td></td>
<td>• Conducted through combination of physical testing &amp; data analytics</td>
</tr>
<tr>
<td>2. Geometallurgy &amp;</td>
<td>• Understand geological controls on Grade Engineering® responses</td>
</tr>
<tr>
<td>Spatial Analysis</td>
<td>• Spatially map responses defining Grade Engineering® domains</td>
</tr>
<tr>
<td>3. Process Design &amp;</td>
<td>• Define Grade Engineering® “circuit”, equipment design &amp; specifications</td>
</tr>
<tr>
<td>Simulation</td>
<td>• Quantify process simulation responses across mining value chain</td>
</tr>
<tr>
<td>4. Strategic Mine</td>
<td>• Develop strategic mine plan incorporating Grade Engineering®</td>
</tr>
<tr>
<td>Planning</td>
<td>• Define impact on equipment, layout, material movement, mine development</td>
</tr>
<tr>
<td>5. Project Evaluation</td>
<td>• Quantify the economic impact utilising Scenario Analysis</td>
</tr>
<tr>
<td></td>
<td>• Define implementation options and viability</td>
</tr>
<tr>
<td>6. Pilot/Production</td>
<td>• Technical validation at production scale of Grade Engineering® technology</td>
</tr>
<tr>
<td>Trials</td>
<td>• Detailed testing, validation, reconciliation process</td>
</tr>
</tbody>
</table>
MINE PLANNING STAGES AND INDIVIDUAL TARGETS

**Long Term Mine Planning**
- 5 to 100 Years
- Project Overall Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Metal Production (Commitment)
- Life of Mine (Years?)

**Medium Term Mine Planning**
- 1 to 5 Years
- Refines the LTMP
- Follows the LTMP
- NPV is the target

**Short Term Mine Planning**
- Weekly, monthly up to 1 Year
- Tries to achieve LTMP Targets
- TPH to Mill
- Head Grades to Mill
- Cost Reduction
- Annual Cash Flow
The Main Target of LTMP is to achieve the economic and strategic targets of the Company / Shareholders:

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Metal Production (Commitment)
- Life of Mine (Years?)

One of the Main Targets of LTMP is to convert Ore Resources into Ore Reserves.

“An ‘Ore Reserve’ is the economically mineable part of a Measured and/or Indicated Mineral Resource.” JORC 2014
STRATEGIC MINE PLANNING: STRATEGIC

**Importance of Strategic Mine Planning?**


2. Calculate the annual cut-off grades for the life of the mine for all processes.

3. Model and find optimum timing and size for secondary processes (leaching).

4. Model and select the optimum time for plant expansions, maintenance and close of mine.

5. Model and Optimise multiple scenarios with different Plant Sizes and Metal prices.

6. Maximises NPV and estimates; optimum time, resource region and quantity/size of new technology application to a specific project.

Incorporates and plans at a global level.
## STRATEGIC MINE PLANNING COMMON ACTIVITIES

1. Mining Method Selection  
2. Cost Modelling and Equipment Selection  
3. Resource Evaluation  
4. Definition of Reserves and Final Pit  
5. Definition of Economic Sequence  
6. Phase Design (Ramps and Operability)  
7. Production Schedule and NPV Optimisation  
   7.1 LOM Cut-off Grades Optimisation

### Resource Evaluation and Economic Block Model

- Final Pit Optimisation
- Economic Sequence
- Production Schedule Optimisation

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**CRC ORE** Optimising Resource Extraction
STRATEGIC MINE PLANNING + GE ACTIVITIES

1. Cost Modelling including GE.
2. Estimation of economically exploitable resources through GE.
3. Definition of new Reserves and Final Pit through GE.
4. Phase Design (Ramps and Operability) incorporating GE.
5. Production Schedule and NPV Optimisation through GE.
   5.1 Find optimum GE plant size and operating mode.
   5.2 LOM Cut-off grades optimisation through GE.
STRATEGIC MINE PLANNING: GE OPTIMISATION STEPS

Grade Engineering Techniques

1. Pre-feasibility/Strategic Planning
2. Different blast strategies for grade by size
3. Sensor-based bulk sorting
4. Sensor-based stream sorting
5. Course grade separation

GE Cost Model

GE Resource Evaluation
GE Final Pit Optimization
Push Back Opt/Dsg
GE Production Schedule Optimization

Project Strategic Targets (NPV)
### COST MODELLING EXAMPLE: CAPEX & OPEX

#### MINZONE PARAMETER UNITS TOTAL

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>UNITS</th>
<th>SEC</th>
<th>PRI</th>
<th>TOTAL</th>
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<tr>
<td><strong>Mining</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ore to Mill Mining Cost</td>
<td>CmineMILL $/t</td>
<td>2.63</td>
<td>2.68</td>
<td>2.65</td>
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<tr>
<td>tonnnes mined</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Ore to LCH Mining Cost</td>
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<td><strong>Dump Leaching</strong></td>
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<td>Leaching Cost</td>
<td>CromLCH $/t</td>
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<tr>
<td>tonnnes leached</td>
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<tr>
<td>SXEW Cost</td>
<td>CSXEW $/lb</td>
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<td>0.00</td>
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<td><strong>Dump Leaching Cost</strong></td>
<td>Clch $/t</td>
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<td><strong>Milling</strong></td>
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<td>Mill Throughput Rate</td>
<td>TPHMILL t/hr</td>
<td>3,523</td>
<td>2,437</td>
<td>3,026</td>
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<td>tonnnes milled</td>
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<tr>
<td>Mill Availability</td>
<td>AvMILL %</td>
<td>93.0%</td>
<td>93.0%</td>
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<td>13.51</td>
<td>14.31</td>
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## COST MODELLING EXAMPLE: SELLING COSTS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>UNITS</th>
<th>MINZONE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEC</td>
<td>PRI</td>
<td>TOTAL</td>
</tr>
<tr>
<td>Cu Concentrate Selling</td>
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<td></td>
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<tr>
<td>Concentrate Cu Grade</td>
<td>ConCu</td>
<td>%</td>
<td>33.4%</td>
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<tr>
<td>Concentrate As Grade</td>
<td>ConAs</td>
<td>ppm</td>
<td>1,839</td>
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<tr>
<td>Concentrate Ag Grade</td>
<td>ConAg</td>
<td>g/t</td>
<td>51</td>
</tr>
<tr>
<td>Cu Concentrate Tonnage</td>
<td>TconCu</td>
<td>dmt</td>
<td>22,515</td>
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<tr>
<td>Transport &amp; Port Cost</td>
<td>CtrcCu</td>
<td>$/wmt</td>
<td>26.0</td>
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<tr>
<td>Ocean Freigh Cost</td>
<td>CofcCu</td>
<td>$/wmt</td>
<td>54.0</td>
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<tr>
<td>Insurance Cost</td>
<td>CinsCu</td>
<td>$/wmt</td>
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</tr>
<tr>
<td>Umpire, Surveying, Asseying</td>
<td>CusaCu</td>
<td>$/dmt</td>
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<tr>
<td>As Penalty</td>
<td>PenAs</td>
<td>$/dmt</td>
<td>0.00</td>
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<tr>
<td>Concentrate Humidity</td>
<td>HumCu</td>
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<td>9.0%</td>
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<tr>
<td>Concentrate Losses</td>
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<td>Cu Payable Factor</td>
<td>PFCu</td>
<td>%</td>
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<td>Cu Smelter Charge</td>
<td>TCCu</td>
<td>$/dmt</td>
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<tr>
<td>Cu Refining Charge</td>
<td>RCCu</td>
<td>$/lb</td>
<td>0.105</td>
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<tr>
<td>Sales Cu Price</td>
<td>PCu</td>
<td>$/lb</td>
<td>2.87</td>
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<tr>
<td>Cu Price Particip. Factor</td>
<td>PPCu</td>
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<td>Cu Conc. Selling Cost</td>
<td>SellConCu</td>
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<td>Cu Cathode Selling</td>
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<td>Transport &amp; Port Cost</td>
<td>CTRP</td>
<td>$/lb</td>
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<td>Ocean Freigh Cost</td>
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<td>$/lb</td>
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<td>AAA Cathode Quality Premium</td>
<td>QPCu</td>
<td>$/lb</td>
<td>0.000</td>
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<tr>
<td>Sales Cu Price</td>
<td>PCu</td>
<td>$/lb</td>
<td>2.87</td>
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<td>Cu Cathode Selling Cost</td>
<td>SellCuH</td>
<td>$/lb</td>
<td>0.05</td>
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## COST MODELLING EXAMPLE: GE CAPEX & OPEX

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Unit Cost</th>
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<tbody>
<tr>
<td>Screening – Grade by Size Cost</td>
<td>$/t. processed</td>
<td>-0.31</td>
</tr>
<tr>
<td>Undersize Material Cost</td>
<td>$/t. processed</td>
<td>0.03</td>
</tr>
<tr>
<td>Oversize Material Cost</td>
<td>$/t. processed</td>
<td>-0.60</td>
</tr>
<tr>
<td>Differential Blasting Cost</td>
<td>$/t. processed</td>
<td>-0.10</td>
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</table>

<table>
<thead>
<tr>
<th>‘Mass Pull’ to Undersize</th>
<th>Grade by Size ($/t)</th>
<th>Differential Blasting ($/t)</th>
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<tbody>
<tr>
<td>20%</td>
<td>0.784</td>
<td>0.884</td>
</tr>
<tr>
<td>30%</td>
<td>0.721</td>
<td>0.821</td>
</tr>
<tr>
<td>40%</td>
<td>0.658</td>
<td>0.758</td>
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<tr>
<td>50%</td>
<td>0.595</td>
<td>0.695</td>
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<tr>
<td>60%</td>
<td>0.532</td>
<td>0.632</td>
</tr>
<tr>
<td>70%</td>
<td>0.469</td>
<td>0.569</td>
</tr>
<tr>
<td>80%</td>
<td>0.406</td>
<td>0.506</td>
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</table>

<table>
<thead>
<tr>
<th>GE Plant (Ktpd)</th>
<th>GE Plant (Ktpa)</th>
<th>Installed CAPEX</th>
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</thead>
<tbody>
<tr>
<td>55</td>
<td>20,000</td>
<td>$183,137</td>
</tr>
<tr>
<td>68</td>
<td>25,000</td>
<td>$195,990</td>
</tr>
<tr>
<td>82</td>
<td>30,000</td>
<td>$209,477</td>
</tr>
<tr>
<td>96</td>
<td>35,000</td>
<td>$213,427</td>
</tr>
<tr>
<td>110</td>
<td>40,000</td>
<td>$220,769</td>
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<tr>
<td>123</td>
<td>45,000</td>
<td>$227,455</td>
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</table>
GE RESOURCE EVALUATION: ECONOMIC BLOCK MODELLING

Geological Parameters

Metallurgical Parameters

GE Geometallurgical Attributes:
- Grade Variability
- Separation Properties per GE Technique

GE Economic Variables
- Ranking Responses
- Pre-C Operating Costs
- Unit Value per Block $/t
- Optimum Economic Destination
- Optimum GE tech and operating mode
- MCAF, PCAF

CRC ORE 13
Calculating the Maximum $/t per block and Economic Destination.

**Conventional Direct Feed:**
- Mill - $/t
- Leach - $/t
- Waste - $/t

**Direct Feed to Grade Engineering:**
- Grade by Size (GS) - $/t
- Differential Blasting (DB) - $/t
- Sensor Based Sorting (SBS) - $/t

**Direct Feed vs Grade Engineering Feed:**
- Mill - $/t
- Sensor Based Sorting (SBS) - $/t
GE RESOURCE EVALUATION: RANKING RESPONSE & MASS PULL

Selects Highest Economic Value: $/t

20% @ 0.95 + 80% @ 0.39 = 0.5
30% @ 0.80 + 70% @ 0.35 = 0.5
50% @ 0.70 + 50% @ 0.30 = 0.5
70% @ 0.60 + 30% @ 0.28 = 0.5

CRC ORE 15
GE RESOURCE EVALUATION: BLOCK VALUE & DESTINATION

Best Economic Destination

GE Economic Optimum Combination

Mine

CU @ 0.5

Process Plant

Leaching Pads

Stock Pile

Waste Dump

Grade Engineering Plant

GE Technique

Mine Circuit:

- Concentrate
- Leaching
- Tailings
- Residue
- Other

Process Plant:

- HG Stream
- LG Stream

Best Economic Destination:

- LG Stream
- HG Stream
Ken Lane Value and Cut-Off Grade Equations

\[ V_m = (P - k)xy\bar{g} - xh - m - \frac{(f+F)}{M} \]
\[ V_h = (P - k)xy\bar{g} - xh - m - \frac{(f+F)x}{H} \]
\[ V_k = (P - k)xy\bar{g} - xh - m - \frac{(f+F)xy\bar{g}}{K} \]

\[ COG_m = \frac{h}{(P - K)y} \]
\[ COG_h = \frac{(h + \frac{(f+F)}{H})}{(P - k)y} \]
\[ COG_k = \frac{h}{\left( P - k - \frac{(f+F)}{K} \right)y} \]
VALUE CURVES AND CUT-OFF GRADES FOR GRADE ENGINEERING

Cut-Off Grades

<table>
<thead>
<tr>
<th>Cut-Off Grades</th>
<th>Cu%</th>
<th>Cu%</th>
<th>Cu%</th>
<th>Cu%</th>
<th>Cu%</th>
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</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.15</td>
<td>0.24</td>
<td>0.36</td>
<td>0.50</td>
<td>0.62</td>
</tr>
<tr>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
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</table>
GE RESOURCE EVALUATION: ECONOMIC BLOCK MODEL

GE % ECONOMIC AMENABILITY OF THE DEPOSIT
GE RESOURCE EVALUATION: BEST BLOCK VALUE
GE RESOURCE EVALUATION: FINAL PIT OPTIMISATION

Grade Engineered Final Pit

GE Economic Block Model

Grade Engineering
- GE Parameters
- Pre-C Independent Processing Destination
- Pre-C $/t
- Pre-C Recoveries
- Ranking Responses
GE RESOURCE EVALUATION: FINAL PIT OPTIMISATION

BASE CASE - CONSTRAINED

GRADE BY SIZE - CONSTRAINED

DIFFERENTIAL BLASTING CONSTRAINED

BASE CASE - UNCONSTRAINED

GRADE BY SIZE - UNCONSTRAINED

DIFFERENTIAL BLASTING UNCONSTRAINED

73% Value, 340% Material Movement Compared to BC Constrained.

1% Value, 2% Material Movements

4% Value, 5% Material Movements

2% Value, 3% Material Movements Compared to BC Unconstrained.

4.5% Value, 6% Material Movements Compared to BC Unconstrained.
GE RESOURCE EVALUATION: PUSHBACK SEQUENCING & DESIGN

Push Backs - Base Case

Push Backs – Grade Engineering
PUSHBACK SEQUENCING & DESIGN: EXAMPLE

GRADE BY SIZE - CONSTRAINED

1% Value, 2% Material Movements

DIFFERENTIAL BLASTING CONSTRAINED

4% Value, 5% Material Movements
PRODUCTION SCHEDULE AND NPV OPTIMISATION

Natural Deportion
Differential Blasting
Sensor Based Sorting
Results:

- 20% of Total Material Movement goes to GE Plant.
- 14% of Mill Feed comes from Grade Engineering Plant.
Results:

- 14% of Mill Feed comes from Grade Engineering Plant.
- Produced 121 CuKt, and 1 MoKt more of metal in concentrate than the Base Case.
- However, the GE MP produced 39 CuKt less in metal cathode.
Grade Engineering Plant - Capacity: 35 Mtpa

Results:

✓ **Feed** Average Grade: 0.37 Cu%
✓ **Upgraded to Mill** at 0.61 Cu% - 29% of GE Material
✓ **Marginal to Dump Leach** at 0.32 Cu% - 48% of GE Material
✓ **Downgraded to Waste Dump** at 0.19 Cu% - 23% of GE Material
GE PRODUCTION SCHEDULE OPTIMISATION: MASS PULL PLAN (GS)

Comments:

✓ Grade by Size Only
✓ **GS 20% Mass Pull** is the Main Mass Pull Across the LOM
✓ Mass Pull Increases throughout the LOM
Comments:

- Sensor Based Sorting Only
- **GS 30% Mass Pull** is the Main Mass Pull Across the LOM
- Mass Pull Increases throughout the LOM
GE PRODUCTION SCHEDULE OPTIMISATION: NPV VS METAL PRICE

When Cu Prices Drop GE adds resilience to a Mining project.
STRATEGIC MINE PLANNING: CONCLUSIONS

☑ GE Full Mine Planning Optimisation aids to reach and improve Strategic Goals.
☑ NPV Improvement of 3% to 15% achieved through GE fully optimised mine plans
☑ Head Grade Improvement from 3% to 15%, per year and for LOM.
☑ Improvement in Metal in Cu concentrate
☑ Improvement in Metal in Mo concentrate
☑ Reduction in Metal in Cu cathode
☑ When Cu Prices Drop GE adds resilience to the project.

Grade Engineering Amenability

- Every Deposit is Different
- Every Deposit will have different heterogeneity, grade variability.
- Every Project will be amenable to different Grade Engineering Techniques and at different scales.
Invent
integrate
implement
introduce

Strategic Mine Planning

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Strategic Mine Planning

CRCORE
Optimising Resource Extraction