With prices falling and costs rising...

Australia has some of the world’s largest coal reserves, but is struggling with maintaining mining profit margins....

... which is in large part due to the falling productivity of the mining industry.
...improving productivity is the talk of the town

“In the broader mining industry, the opportunity cost of not producing a unit of production during this high price period meant that most miners took a “volume over cost” approach; the benefits of being able to produce more outweighed the increased costs that resulted”

Marius Kloppers, CEO BHP Billiton

*Presentation to Brisbane Mining Club, 17 October 2012*

“We are right at the bottom (of the cost curve), in the lowest quartile. That is incredibly important. That means no matter what happens in the business, we will be profitable”

“‘I have referred to it as an assembly line’

Sam Walsh, Rio Tinto Iron Ore Chief Executive

*Australian Financial Review, 12 October 2012*

“We are operating in lean mode. People constantly say ‘don’t you have extra capacity between mine rail and port?’ Well, we actually don’t. If we had excess capacity we are wasting investment”
Three industry focus areas of productivity

### What

**Labour**
Output generated per hour of work undertaken. It is measured in dollars of gross value added (GVA) per hour.

**Investment Capital**
Real output($) per unit of capital services($).

**Operating Asset**
Real output($) per resource.

### Why

**Labour**
Skills shortages have been driving rising labour costs.

**Investment Capital**
Increase investment in profitable assets.

**Operating Asset**
Increase margin

### How

**Labour**
- Identifying sources of talent
- Disciplined workforce planning
- Develop EVPs with a focus beyond monetary incentives.

**Investment Capital**
- Ensure internal rigour in the CAPEX review process
- Get the parameters for financial modelling right
- Get the level of investment right

**Operating Asset**
- Maintenance
- Reliability
- Asset utilisation
- Operational cycle times
- Operations planning and control
Low productivity in one stage of the value chain filters through to the subsequent stages

Core Activities
- Exploration
  - Program Planning
  - Drilling Efficiency
  - Remote Logistics
- Extraction
  - Pit Optimisation
  - Extraction Methodology
  - Fleet Productivity & Fit
- Processing
  - Plant Optimisation
  - Maintenance Strategy & Execution
  - Capacity Planning
- Logistics
  - Intermodal Optimisation
  - Procedural Review
  - Capacity Analysis
- Support Services
  - Benchmarking
  - Process Mapping
  - Resource Allocation

Discreet Activity Solutions
- Cross Activity Solutions
  - Outsourcing
  - Warehouse & Logistics Optimisation
  - Supply Chain Optimisation
  - Shared Services Analysis & Implementation
  - Process Bottleneck & Constraint Analysis
  - Cost Reduction
  - Application Implementation
We will focus on two main areas: extraction and processing

**Extraction**
- Drill
- Blast
- Load
- Haul

**Processing**
- Crushing
- Grinding
- Sizing
- Separation
- Concentration
- Disposal

- Reduce size to allow liberation of the material. (Comminution)
- Separate wanted and unwanted material
- Concentrate wanted material into a transportable form
- Dispose of the unwanted material (tailings).
Focus area 1: Extraction

- Exploration
- Extraction
- Processing
- Logistics
- Support Services
Having a blast
Having a better blast
# Getting one stage wrong leads to inefficiencies in the following stages of the extraction process

## Process

<table>
<thead>
<tr>
<th>Drill</th>
<th>Blast</th>
<th>Load</th>
<th>Haul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare ground for blasting</td>
<td>Break the ground</td>
<td>Load broken ground into trucks</td>
<td>Haul ore and waste</td>
</tr>
</tbody>
</table>

Issues can add 10 to 25% to downstream costs through:

- Damage to fleet, ore body, mine plan
- Inefficient processing
- Waste of explosive
- Re-work

There needs to be sufficient stock of broken ground to:

- Deliver preferred material blend to processing plant
- Achieve sizing within specification
- Ensure effective cycle time and utilisation of fleet

Inefficient loading can consume large amounts of capital and drive the operation up the cost curve.

Critical success factors:

- Loading efficiency - matching haul truck size with loader size
- Operational efficiency - matching fleet disposition and mine plan
- Avoiding queuing at the loader or dump/crusher
- Avoiding double-dipping from inefficient loading practices
- Reducing tyre impacts from road conditions
- Reliability from schedule and plan compliance
**Mobile Fleet**

![Image of mobile fleet equipment at a mining site]
Improving equipment utilisation increases productivity

- **Total time** (8760 hours)
- **Scheduled time** (Loading %) - Loss
  - Scheduled non-operating time (holidays, etc)
- **Available time** - Loss
  - Non-available time (planned maintenance, servicing, etc and unplanned maintenance down time)
- **Operating time** - Loss
  - Non-operating time within available time (training, shift changes, etc)
- **Effective operating time**
  - Loss 1
  - Loss 2
- **Actual effective production time** - Loss
  - Quality losses

1. Lost production *rate* due to operational matters (e.g., queuing due to unlevel production flow)
2. Lost production *rate* due to maintenance matters (e.g., equipment partially broken)
Identify latent capacity by using value driver trees to verify Performance Drivers against operational constraints...

Influencers

Objective

Operational Effectiveness

Operational factors

Performance Drivers

- Planning and coordination issues
- Equipment scheduling & placement
- Operating protocols (formal & informal)

- Metallurgical & geological interpretation
- Grade control & mill feed variability
- Mine sequencing and scheduling
- Short term versus long term objectives

- Variations in cycle time
- Cause-effect analysis
- Operating protocols

- Maintenance/Operations communications
- Operating protocols
- Plan compliance

- Capacity planning and execution
- Match of fleet/plant to process

- Maintenance effectiveness
- De-rating due to maintenance
- MTTR and MTBF

- Operator training & awareness
- Operator competency
- Early problem identification

- Strategic Sourcing
- Supplier performance
- Service performance to business

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November 2012

Slide 13
...and Asset Management definitions and restrictions

Influencers

Objective

Asset Effectiveness

Operational factors

Equipment Availability

Influencers

Capital Cost

Maintenance Cost

Operating Cost

Preventive & Predictive Mtce

Maintenance Cost

Planned Corrective Mtce

Life-Cycle Cost

Reliability (MTBF)

Breakdowns

Performance Drivers

Operational factors

Effective preventive/predictive mainten.

• Effective Preventive/Predictive Maintenance
  • Equipment ownership and operator care
  • Root-cause and reliability analysis
  • Availability of skilled workforce

• Supplier performance
  • Supply & materials performance
  • Facilities and resources effectiveness
  • Supply cycle time performance

• Maint, planning & scheduling performance
  • Availability of skilled workforce
  • Equipment design & usage

• Effective maintenance management
  • Communications with ops and planning

• Effective Preventive/Predictive Maintenance
  • Equipment ownership and operator care
  • Root-cause and reliability analysis
  • Availability of skilled workforce

• Effective preventive/predictive mainten.
  • Mainten. Planning and scheduling
  • Ops/Mainten. communications

• Effective preventive/predictive mainten.
  • Ops/Mainten. responsiveness and learning

Effective Preventive/Predictive Mtce

Maintenance Cost

Planned Corrective Mtce

Unplanned Corrective Mtce

Maintainability (MTTR)

Reliability (MTBF)

Logistics

Administration

Capital Cost

Blast

Drill

Load

Haul

November 2012

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Slide 14
What is the impact of poor haul truck cycle time performance?

Actual site averages...

Wait at shovel: 1 minute
Load: 2 minutes
Travel loaded: 0.8 minutes
Dump: 0.6 minutes
Return to shovel: 0.8 minutes

Potential latent capacity:

Wait at shovel: 2.5 minutes
Load: 0.8 minutes
Travel loaded: 0.6 minutes
Dump: 0.6 minutes
Return to shovel: 0.8 minutes

Total potential 3.9 mins = ?? haul trucks
Existing fleet: 22 ...means ??

Opportunity

Capital saving = ?
Maint & Ops saving = ?

Leading practice targets (240 t trucks)
Example: This approach can unlock significant cost benefits as indicated by initial analysis of limited data from an operating mine...

Observations (fleet of 22 haul trucks)

**Operations**
- Utilisation 71% (or equivalent to 16 haul trucks)
- Effective operating time 52% (or equivalent to 11 haul trucks)

**Maintenance**
- Availability 90% (leading practice 92%)

But the assets are not being stressed by operations as shown by:
- Asset Utilisation 71% (85%)
- Operational Effectiveness 52% (70%)

And we are concerned about Maintenance performance:
- Unplanned maintenance 51% (20%)
- Scheduled maintenance 49% (80%)

### Caveats
- Data definitions to be confirmed
- Only Q1 data available
- No Constraint analysis performed
- No Fleet matching performed
- Geological and mine planning not incorporated

<table>
<thead>
<tr>
<th></th>
<th>Equivalent haul trucks locked up</th>
<th>% of fleet</th>
<th>Est. Value ($M p.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Opex</td>
</tr>
<tr>
<td>Asset Utilisation</td>
<td>6.3</td>
<td>29%</td>
<td>16</td>
</tr>
<tr>
<td>Operational Effectiveness</td>
<td>8.4</td>
<td>38%</td>
<td>21</td>
</tr>
</tbody>
</table>
Focus area 2: Processing

Exploration → Extraction → Processing → Logistics → Support Services
The basic steps of mineral processing

**Objectives**
- Remove waste products mixed with the commodity during mining to reduce the overall tonnage to be shipped to the market
- Produce a concentrate from the mined ore to reduce downstream transport costs
- Produce a final product for shipping to the customer

*Improves productivity of shipping and logistics*
There are opportunities for improvements throughout the process

Typical CHPP Facility

<table>
<thead>
<tr>
<th>Waste to reduce</th>
<th>Problems / Causes</th>
</tr>
</thead>
</table>
| Motion          | • Inefficient truck paths  
                 | • People moving  
                 | • Shovels making too many passes |
| Waiting         | • Information or materials not complete or ready to go  
                 | • Idle equipment and resources |
| Over-production | • Large batches  
                 | • Making for the sake of it  
                 | • Ignoring CHPP constraints  
                 | • Ignoring customer demands |
| Processing      | • Adding more value than the customer wants  
                 | • Unnecessary process steps |
| Defects         | • Incorrect action, out of standard  
                 | • Requires remediation and costly rework |
| Inventory       | • High material stockpiles  
                 | • Excessive space requirements |
| Transportation  | • Unnecessary movement and stockpile shifting  
                 | • Extra handling |
| Unused Creativity | • Limited tools or authority available to employees to carry out basic tasks  
                     | • Lost ideas or knowledge |
Through coal handling & preparation the optimal product mix can be developed

- Each pile of raw coal can be separated into groups according to density
- As these groups are added together, an “Yield-Ash” curve is formed
- Every coal has a unique Yield-Ash curve
- Ideally, we desire a low ash, high yield product
- The “elbow” of the curve is usually the optimum operating point
Coal Handling & Preparation
What will we do to make it better?

What is the value of just 1 TPH of additional coal recovery?
Coal handling & preparation
Coal quality - trivia

Heating Value

• How many BTU’s are in one match head?
  1 BTU

• How many BTU’s are in a 50g lump of Thermal Coal?
  1425 BTU’s

• How long could a 100 watt light bulb run from the energy in a 50g lump of coal?
  4.2 Hours
Unlocking the benefits from improved extraction and processing
Combining improvements to the extraction and processing stages can unlock substantial benefits...

Observations (fleet of 22 haul trucks)

Operations
Utilisation 71% (Best practice: 85%)
Effective operating time 52% (Best practice 70%)

Maintenance
Availability 90% (Best practice: 92%)

We are concerned about Maintenance performance:
Unplanned maintenance 51% (20%)
Scheduled maintenance 49% (80%)

Equivalent haul trucks locked up % of fleet Opex Capex (unutilised)
Asset Utilisation 6.3 29% 16 20
Operational Effectiveness 8.4 38% 21 28

If only 50% of opportunity is accessible
Asset Utilisation 8 10
Operational Effectiveness 10 14

Example of setting cycle time for customer or constraint demand

• A coal mine has a rail capacity constraint of 2.38mtpa.
• Cycle time = 1,440 minutes / 6,849 tonnes (customer/ constraint demand)
• The mine needs to produce one tonne of blended product (1:2) every 12.6 seconds.
• CHPP capacity only needs to be 320tph at 85% yield.
• The CHPP could receive a 320t load from CF-B once every three hours, and a load from CF-A once every 1.5 hours.
We have used our knowledge and experience to help our clients realise substantial cost savings

50% increase in BCMs with half the CAPEX requested, identified >70% latent capacity

Board approved 50% of the proposed CAPEX but required the original mine plan to be fulfilled, which called for an increase of 50% in BCMs moved. The mine management team was required to meet the increased production within 18 months. Following an analysis of the operations, latent capacity of 77% was identified in haul truck cycle time and maintenance practices – target was achieved with capacity left over.

Saved $250m capital & generated $300m additional revenue

An Australian mining company wanted a major rail capital expansion proposal ($250m to increase capacity by 10-15%) tested for value – as a result of our work, the capital was not spent and we developed means to release increased rail capacity of 60-80% from the existing infrastructure; when tested, the system ran at the high rate and delivered an additional spot revenue over 3 months of approximately $300 million.

Iron Ore

- Focus on improving mechanical unplanned downtime and meantime between failure
- Project resulted in a 7% uplift in the availability of the shovels and a 40% increase in the mean time before failure

Identified >50% latent capacity in existing mobile fleet

At a time of high commodity prices and increased demand, the client wanted to test the effectiveness of current operations – we identified spare capacity of over 50% in haul truck fleets at a number of mine sites.

Gold

- Start up operation was underperforming in comparison to estimates put forward in the DFS and the client needed additional margin from across all other assets to support
- More than 100 initiatives totalling >A$90m were approved by the steering team and $70m delivered within four months
Thank you!
Want to learn more about how you can beat the cost curve?

1. **Contact**

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2. **Available resources**
Thank you.

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