“Mine to Market”

Throughput Focused Mining (TFM)

A holistic approach to improving the flow in a complex Mineral Sand Operation

Presented By: Robert Bolton
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Agenda

• Australian Mining Industry
• Iluka South West Operations - Case Study
  − Holistic Review - *What to change?*
  − Holistic View of operation
  − Production simulators workshops
  − Interventions - *What to change to?*
  − Results – Record & Reference
• Argyle Diamonds - Case Study
Operational Management Conflict

- There is a shortage of skilled resources (Metallurgists & Engineers), due to operational consolidation and additional resources projects in WA.
- The operations leader (General Manager) has no tools to assess the leadership skills of his engineers.
- The older ore bodies are creating greater input variation.

New GOAL: Ensure that the short term planning system does not add variability to the process flow [or System]
Australian Mining Industry

- Strong Growth during past 10 years
  - China, India & emerging markets & developed East Asia

- Capital Intensive
  - Highly leveraged to market, operational & financial inputs

- Portfolio Management (Head Office – source of capital & marketing)

- Operating Unit Goals
  - Safety
  - Meeting regulatory requirement
  - Budgeted production targets
  - Increase Life of Mine (LOM)
  - Reduce Unit / Cost

- Benchmarking – Cost Curves
Iron Ore Cost Curves

Supply curve to Chinese market for iron ore fines

Aim to be in first quartile (ie LHS)

Source: Carpentaria Exploration – June 2012.
Mineral Sands Cost Curve

Combines Revenue & unit cost assumptions for R/C curve

Source: Mineral Deposits AGM Nov 2011
Mine to Market – Flow Profile

- Trend move from producer to customer focused
- Modifying product / output to meet end user requirement

**Mining Resources - Typical Operational Flow**

- **Iron Ore** (FeO)
- **Coal Thermal** (C)
- **Coal Coking** (C)
- **Aluminium** (Al)
- **Copper** (Cu)
- **Gold** (Au)
- **Diamonds** (C)
- **Mineral Sands** (Zr, TiO2)

**Source:** R Bolton
**Resource Industry Knowledge**
Iluka (ASX:ILU)

- World’s leading Mineral Sands Miner
- 4 Mines & concentrators, 2 Separation Plants & 2 Synthetic Rutile (SR) plants in the SW
- 1,000 people employed worldwide
South West Operations  May 2002

- Merger of several Mineral Sands operations
- Increasing market for SR Product.
- Capital expansion being planned
- Mining operation becoming more difficult

**Titanium  Mineral Pigments**  **Zircon**
THE LAW
At any point in time,
a chain is only as strong as its weakest link

The Theory of Constraints
Time Line

• TOC Introduction  July 2001

• Holistic Review  - May 2002  -  What to Change?

• Interventions  -  June to August 2002
  – TOC Operations workshop & Follow-up  -  What to Change to?
  – Technical Planning meeting  -  How to Cause the change?
  – 12 week rolling schedule NCSM

• Record SR Production rates – October 2002
Holistic Review 2002 - *What to change?*

- Operational wide planning on a large block model
- Limited short to medium planning (MOS review)
  - *Based on monthly budget & rolled down on a daily basis.*
- Unclear planning horizons
- ADHOC review and follow-up
- Data recording is extensive and updated daily (Protrak)
- Limited planning & scheduling information pass between departments
- CONSTRAINT is likely to be Separation Mill (NCSM)
- Trend of moving from Make to Stock (MTS) to Make to Order (MTO) production system
- Blending of inputs can take place at a number of locations within the site wide process.
The was disagreement over where the CONSTRAINT was. Most thought high unit cost process SR.

Stockpile and storage bins were available as buffers. These were not managed.

Limited communication between functions
Intervention – June to August 2002

- TOC Operations workshop & follow-up training
- Technical Planning meeting
- 12 week rolling schedule NCSM
- 12 week rolling schedule – Mining (4 mines)

AIM: Increase thru-put and increase operational stability.

I.e. Variation in the process is understood then managed.
TOC Operations Workshop

- 2 sessions - 16 attendees – Engineers & Supervisors.

Aim

- Understand the difficulties in scheduling an operation
- Interactive process to understand Constraint Management principles.
- Appreciate the difference between operating and scheduling an operations
- Statistical fluctuations and dependent events.

WHAT HAPPENED?

- Tendency to play – not to plan and manage…
  - First time most of the attendee’s had prepared schedule or plans.
Technical Planning Meeting

• Commenced - Mid June 2002

• Purpose
  – Communicate and resolve Short Term (12 week window) planning issues

• Format
  – participants from Mining, processing and shipping
  – weekly meeting 1 hour duration
  – updated predicted performance during the week
Benefits – Technical Planning Meeting

- **Improved Communication**
  - ownership & resolution of issues increased.

- **Critical Issues raised prior to their impact**
  - *Shipping is aware of what process can deliver number of weeks in the future.*

- **Customer Requirements Communicated**
  - *Customer specific specification are noted as required.*

- **Quality and Logistical issues raised and actioned.**
  - 18 / 26 issues raised were resolved in 1st 3 weeks. All were resolved in 12 weeks.
Benefits – 12 week rolling schedule for NCSM

• Commenced July 2002
  – *Predicted grades for next 2 weeks based on current Mine Tower stock levels*

• SR and CDP have a view of what their future inputs will be. Le can plan for in-purities before they arrive.

• Stockpile management issues being resolved between Mine, Process & Giacci (truck contractor).
  – *All are using the same schedule / Hymn sheet*
12 week Belend has reduced input variability

Predicted vs Actual TiO2 in HMC Feed

- Train 1 Projected
- Train 1 Actual
- Train 2 Projected
- Train 2 Actual
Mine to Market - Interventions

1. Technical Planning meeting (Alignment)

2. Schedule (blend) at the Constraint from Mining.

3. Manage SR plants to meet Customer (shipping) requirements

4. Stockpiles (buffer) information used for scheduling to enhance plant output.
Operational Through-put at record levels – Oct 2002

Benefits to Iluka

- **Record production rate ensured the 2002 targets were met.** This was repeated over next 4 years.

- **Priorities were determined around meeting customer shipments and product flow.**

- **Increased T-put to Iluka due to less out of spec product.**

- **Ability to blend lower grade HMS into SR plant.** This increases the value reserves being mined.

- **Communications changed between key functions to be more business like.**

- **Organisation Development and Structures became more robust.** Roles & responsibilities were resolved post merger.
• Argyle Diamond Mine 1993 - 1995

Argyle’s open-cut mine is the largest diamond producing mine in the world and the only significant pink diamond supplier. Management identified the need to improve understanding of the business from a shareholder value and wealth creation perspective. Specifically, the business needed to establish the economic cut-off point for the mining operation, evaluate extended resource exploitation options, identify and re-locate service related activities and re-evaluate the economics of the entrenched commute options including the 78 employees located in the nearby town of Kunnunurra.

The project involved gathering/interpreting data and translating into the ABC analysis structure, utilising Theory of Constraints resource method, developing ABC business process models, identifying Key Performance and value adding measures -indicating ‘economic health’ and identifying, ranking and evaluating process redesign opportunities. Considerable time was also spent on developing cash flow models with process simulations and sensitivities, documenting business processes and developing an understanding of cost structures and drivers. A key aspect was top establishing knowledge transfer across the business.

The assignment identified and evaluated a number of significant re-engineering opportunities. These included process plant de-bottlenecking, varying the product/waste split, improving mobile fleet utilisation improving fixed plant utilisation, reducing process recycle streams, relocation of ‘indirect value adding’ staff and employing contemporary ‘remote working’ approaches.

These opportunities provided a A$300M increase (30%) in the net present value of the Argyle Project.
“Quote from West Australian 3 October 1995

“The growing financial pressure on the Argyle Diamond Mine has continued to take its toll with the projects partners choosing to throw out the smallest 15 per cent of the production in a bid to boost profits.

Ashton Mining chief executive John Robinson, whose company owns 40 per cent of the project, said yesterday the move would lift annual revenue 10 per cent at Argyle’s key source, the AK1 pipe.

This will cut production of diamonds with smaller profit margins, increase the output of bigger diamonds, more profitable diamonds and reduce the life of the open pit by 10 months.

He said the move was part of the streamlining process under way at the plant and while the total number of carats produced would fall by about 15 %, the higher throughput would lead to lower operating costs.”
Argyle Diamonds – further improvements

• Small Initiative
  – Increased throughput (T) at the constraint. Maximise the return with minimal increase in Operating Expense (OE).

• Subsequent results
  – Re-evaluated other resource bodies - Alluvial. Life of Mine (LOM) was extended
Tips in Complex Resources Projects & Operations

- Conduct Diagnostic / Business review as a pre-requisite to a project.
- Develop a Holistic Operational Flow
  - Understand the logistics flow and variation points
- Understand different planning time spans
- Understand current terminology – use of language. Will be different between process point.
- Measurements points and approach to be agreed early on in project
  Frequent updates (weekly) with Operations leadership
- Understand the meeting styles. This tends to drive the work habits & culture.
- Be safety and environmental aware at all times.
- Adapt the TOC toolkits & solutions to be integral part of the Management Operating System
About Robert Bolton

• Experienced executive, engineer, change agent & Director.

• TOC pioneer in Australia. Sustainable results in resources, construction & financial services.

• Regularly combines ideas & method to solve business problems.

• Applies Good Governance and logistical solutions for common business dilemmas.

• Theme: Business are runs by systems. Systems are developed, run & managed by people.

• Lives in Singapore.
  – Works in Asia Pacific region.

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