



ThroughPut Focused Mining (TFM): Applying ToC to MINING



Robert Bolton
18 April 2018





About the presenter

Robert Bolton is a executive and accomplished engineer who lives in Australia. He has extensive business turnaround and change experience in the Asia Pacific (APAC) region and the UK. He was exposed to the ToC during his MBA in 1990 at Ashridge Management college in the UK. Since 1994 he has implemented ToC based management systems in a number of business sectors including mining, oil & gas, financial markets, banking, software & IT development and startup sectors.

He is a pioneer in Critical Chain Project Management (CCPM). A key theme he adopts is that “Business are run by systems. Systems are developed, run and managed by people” *. Understanding and communication this “recipe” is a key ingredient to business growth.

* Source: Andrew Kay



Slide 2

RB2

Source: A Kay.

Robert Bolton, 18-Apr-18



About this webinar

The global mining industry is a period of transition. Demand is robust and increasing.

In this webinar, Robert will give an overview of the size and value of the mining business. He will explore his experience across 14 mining business units, focusing on the operations where he has applied ToC and supporting systems thinking approach and methods. He's applied different business management systems, change management scenarios and methods to create a stable business environment. He calls this ThroughPut Focused Mining (TFM).

It is Robert's view that if global growth continues its current path, then the demand for minerals and metals product will drive another mini mining boom. The mini boom will stretch existing operations, and the capability of the people in the industry to meet demand. They will need help.

There will be opportunities in the future.

This webinar is a guide "how to talk with the miners".



Agenda

- Background
 - Robert Bolton
 - Mining and resources Industry
- Argyle Diamonds
- Iluka Resources
- Applying ToC thinking & solution
- Future trends & opportunities



Robert Bolton



Civil Engineer (Sydney)
MBA (Ashridge UK)
Company Director (AICD)
Demand Driven Planner (CDDP)

Infrastructure, mining, oil & gas, IT,
Funds Management.

All aspects of Project Management

Expert in Theory of Constraints (ToC),
Pioneer in Critical Chain CCPM
ToC in Mining -
Throughput Focused Mining (TFM)
Fast track construction
Activity Based Costing (ABC)

Sydney Convention Centre



Collector Bypass



Sydney Harbour Tunnel (SHT), Cut & Cover



London Victoria Goldmine





Theory of Constraints Practitioners Alliance

Robert Bolton



Land Rover, Birmingham UK



Argyle Diamonds, WA



Worsley Alumina, WA



JNA Lucent, NSW



Iuka Resources, WA



Chevron FMC, Subsea, China



Breakthrough Project Management

Co-authored with Ian Heptinstall

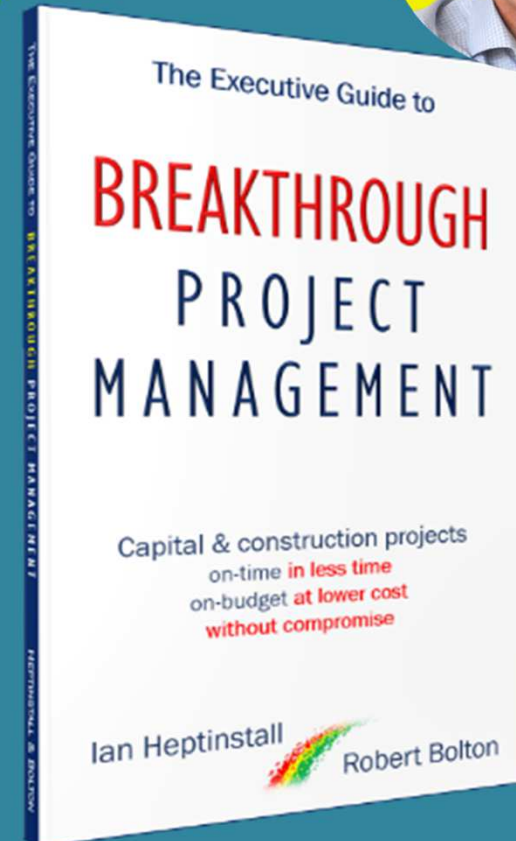
Summary ideas for capital project executives for

Project Alliancing (or IPD)

[cost risk aggregation, allocation and execution management]

Critical Chain Project Management (CCPM)

[schedule risk aggregation, allocation and execution management]



www.BreakthroughProjectManagement.com

14 Mining / Resources business entities



METGASCO



BHP



SINGAPORE MINING CLUB

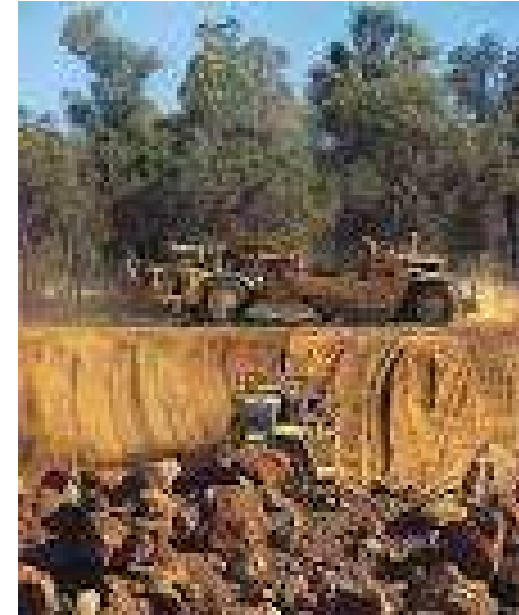


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Australian Mining Industry

- **Strong Growth or super cycle (2003 to 2012) and another growth spurt occurring.**
 - China, India, EMEA, SE Asia. Developed demand remain strong.
 - Renewable trends driving Lithium, rare earths growth.
- **Capital Intensive**
 - Highly leveraged to market, operational & financial inputs
- **Portfolio Management** (Head Office – source of capital & marketing)
- **Business unit operating GOALS**
 - Safety
 - Meeting regulatory requirement
 - Budgeted production targets
 - Increase Life of Mine (LOM) – Increasing business value
 - Reduce Unit / Cost
- **Benchmarking** – Cost Curves - [natural decoupling point]
- **Increased Product segmentation** and specification for end user. (metals for renewables projects)



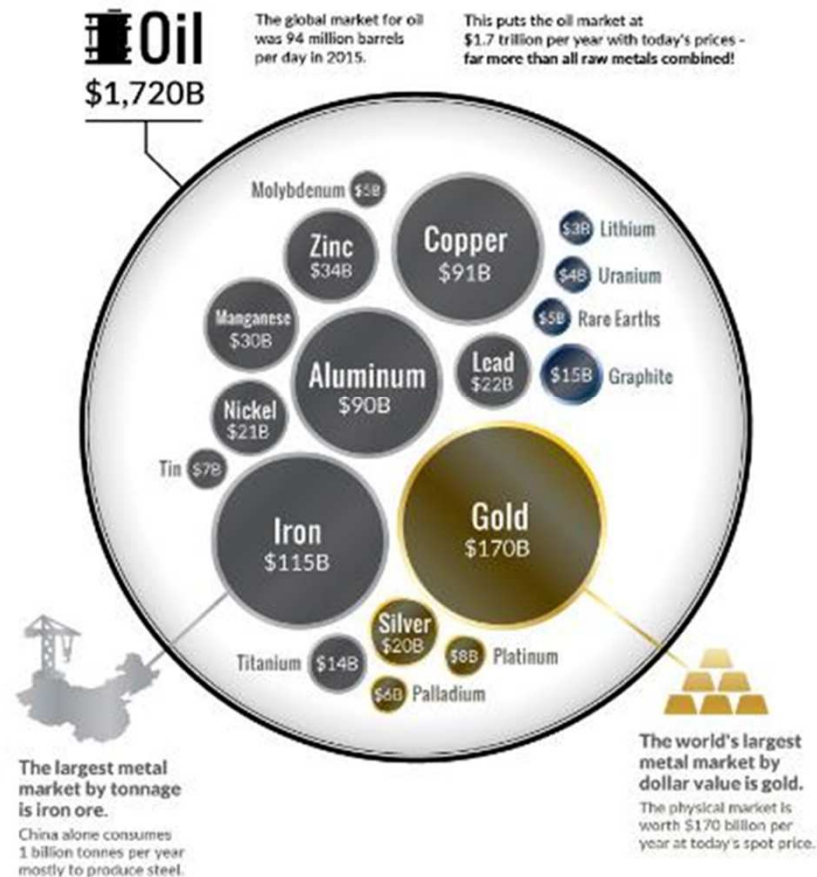
Relative size of the Mining Resources industry

- Metals markets are segmented into end use segments.
- Growth in renewable technology inputs

Chart of the Week

BIG OIL

The oil market is bigger than all raw metal markets combined

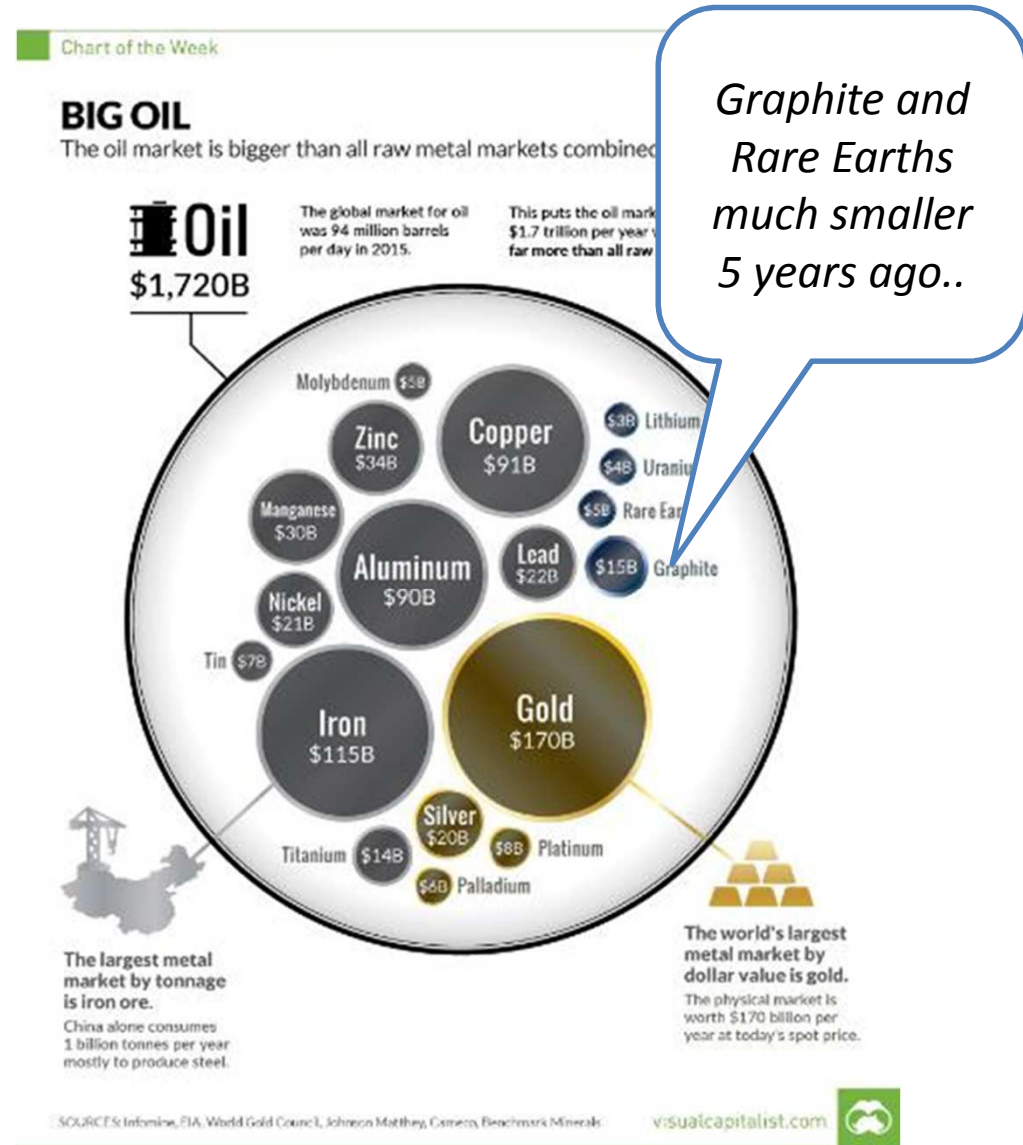


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Relative size of the Mining Resources industry

- Metals markets are segmented into end use segments.
- Growth in renewable technology inputs



*Graphite and
Rare Earths
much smaller
5 years ago..*



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Value chain and method to value

- Consistent across segments
- Constant market disclosure

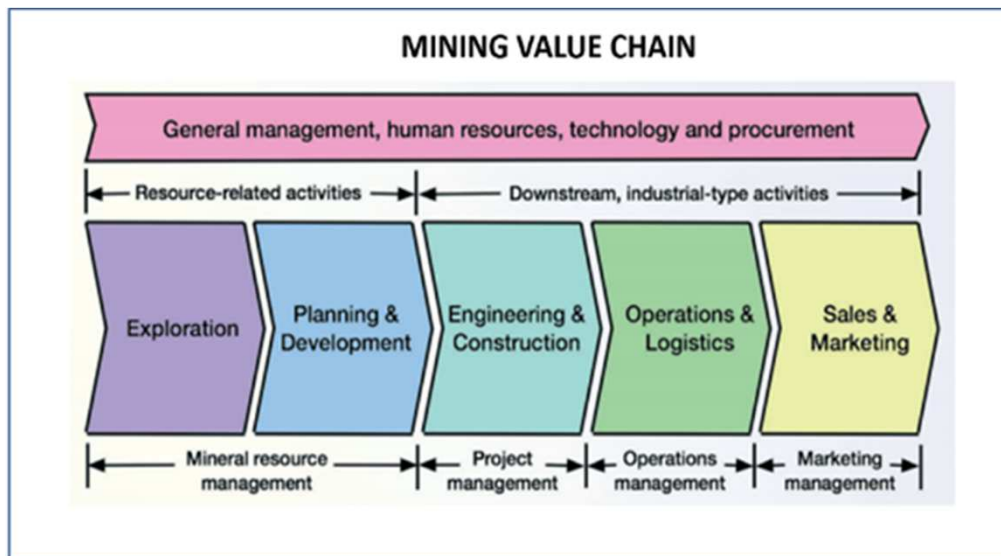
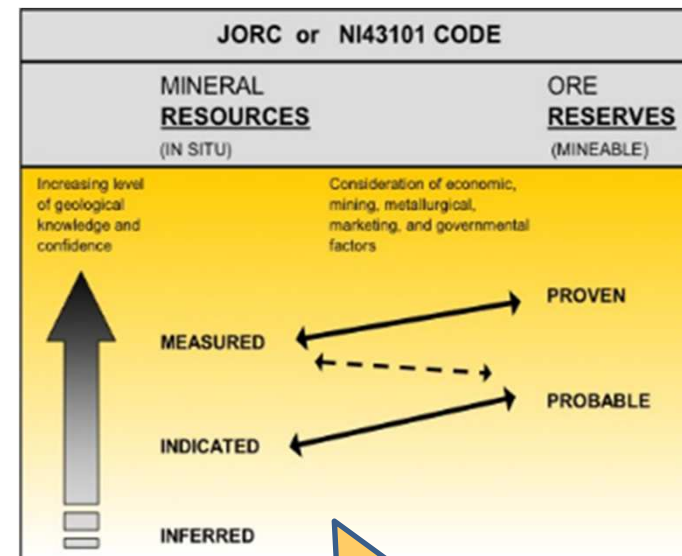


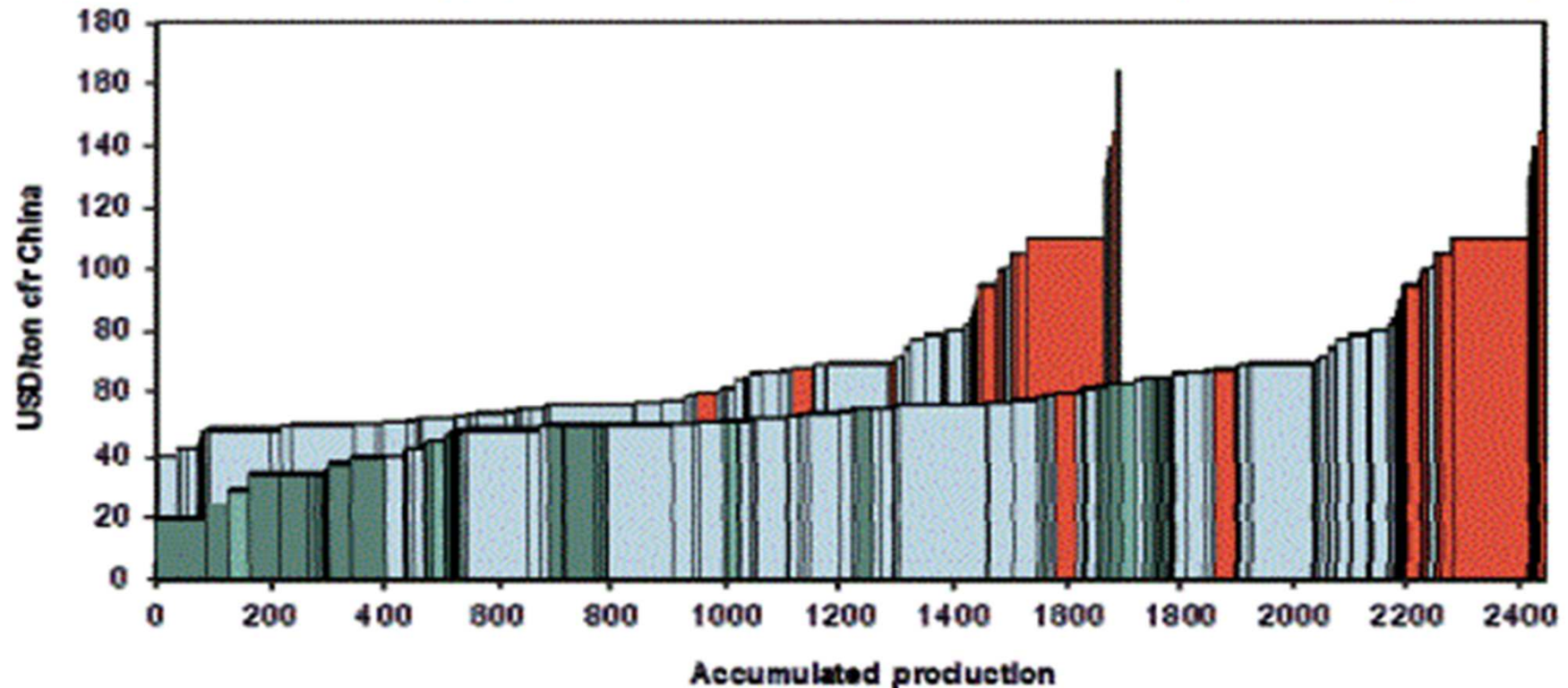
image source: Arndt et al., 2017



*JORC code
Value of Asset / Mine
– now and in the
future*

Cost Curves and market demand drives business behaviour

Figure 9: Iron ore supply cash-cost curve, 2013 and 2018 (seaborne growth)



Source: Handelsbanken Capital Markets, Raw Materials Group, Bloomberg



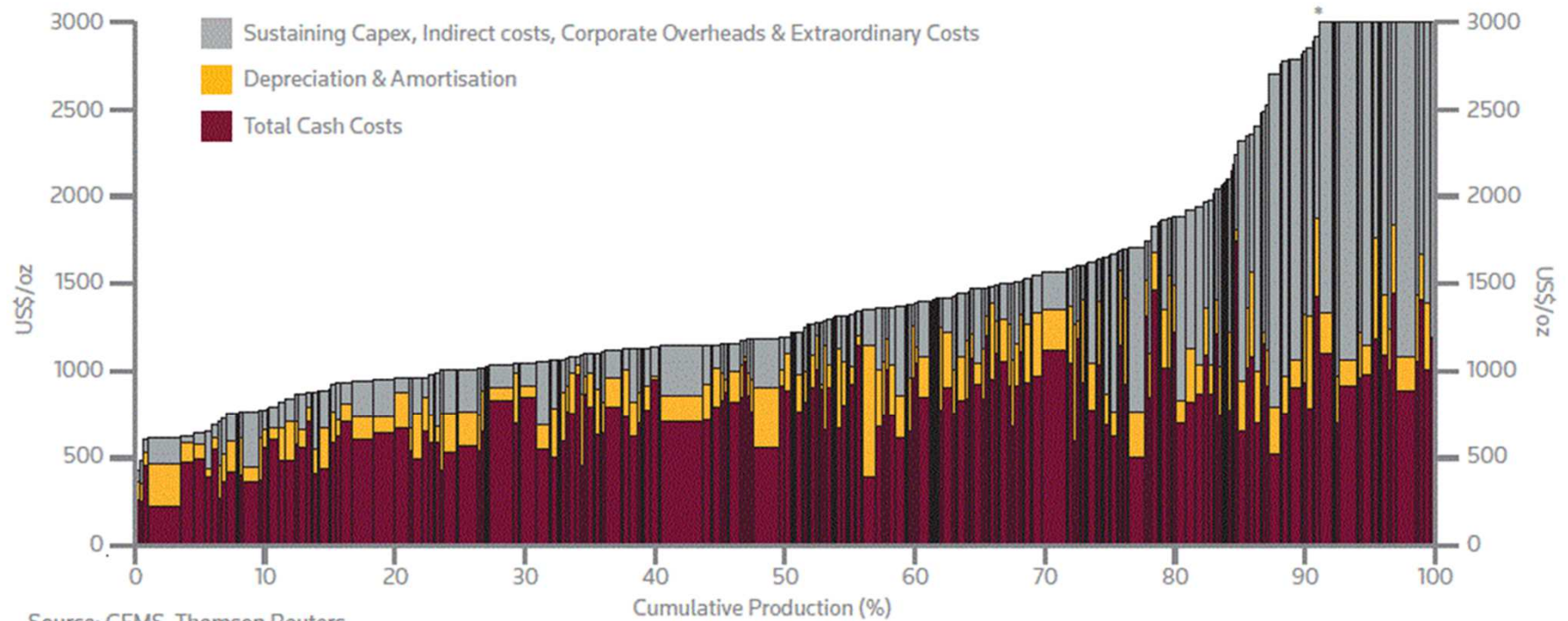
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Gold – cost curve example

2013 ALL-IN COST CURVE

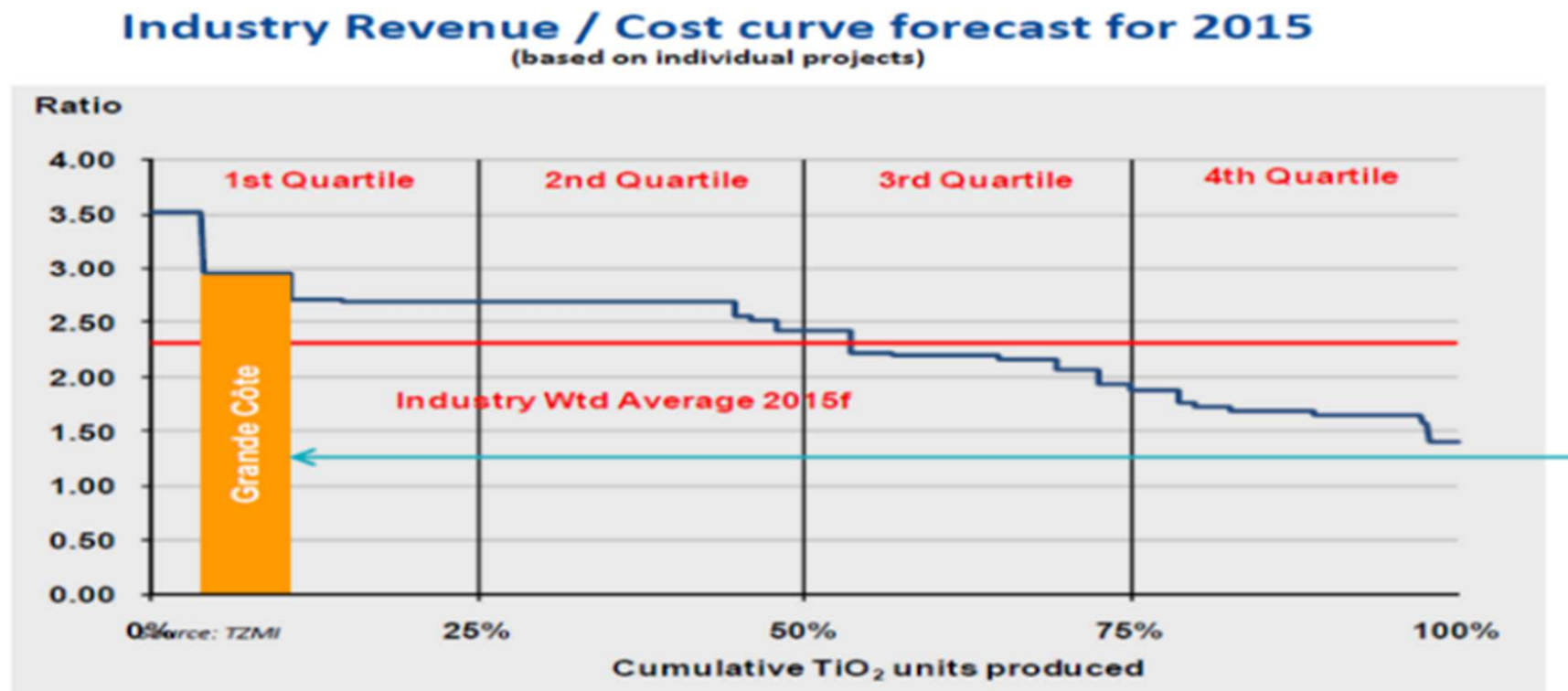


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Mineral Sands - cost curve



Note: R/C curve for 2015 based on TZMI's forecast:

1. production volumes for individual operations in 2015
2. long term real view of product prices
3. operating costs of the individual operations using real 2010 cost rates

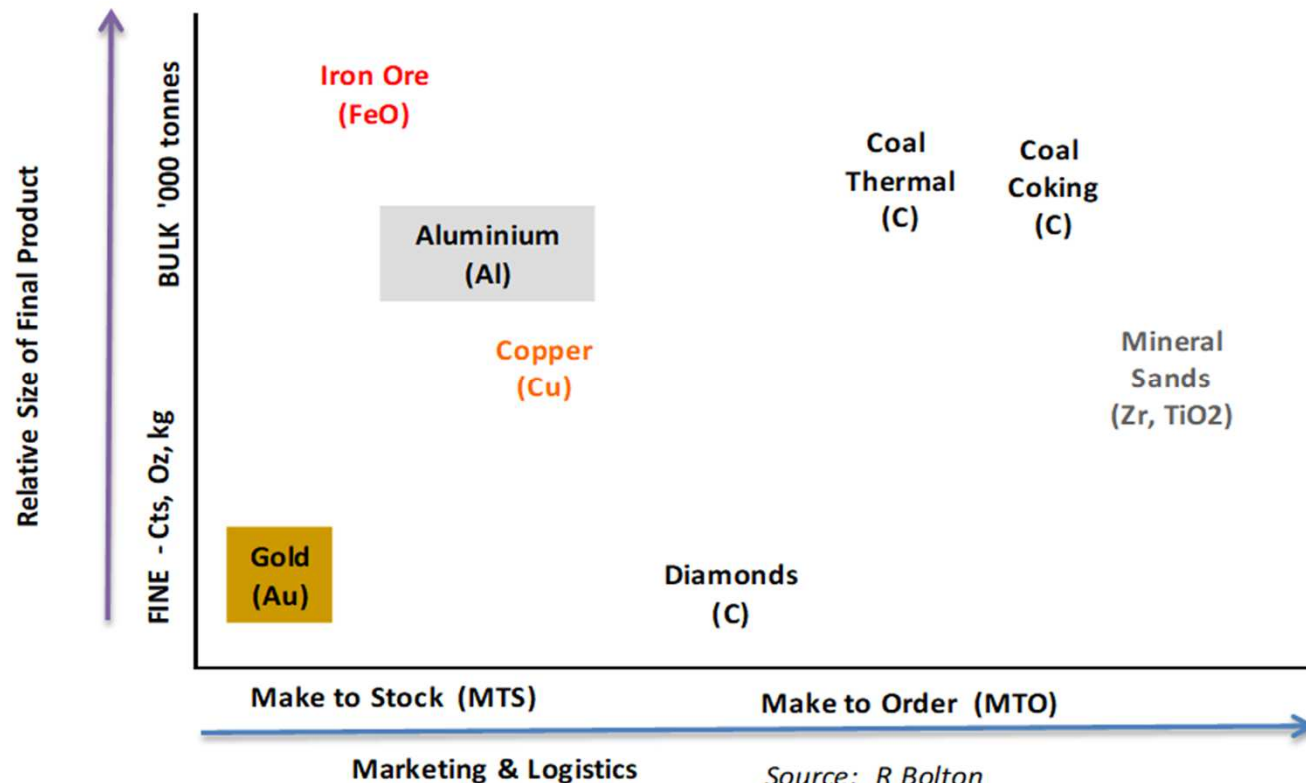


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Mine to Market (M2M)– Flow Profile 2012

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

Mining Resources - Typical Operational Flow



Source: R Bolton
Resource Industry Knowledge

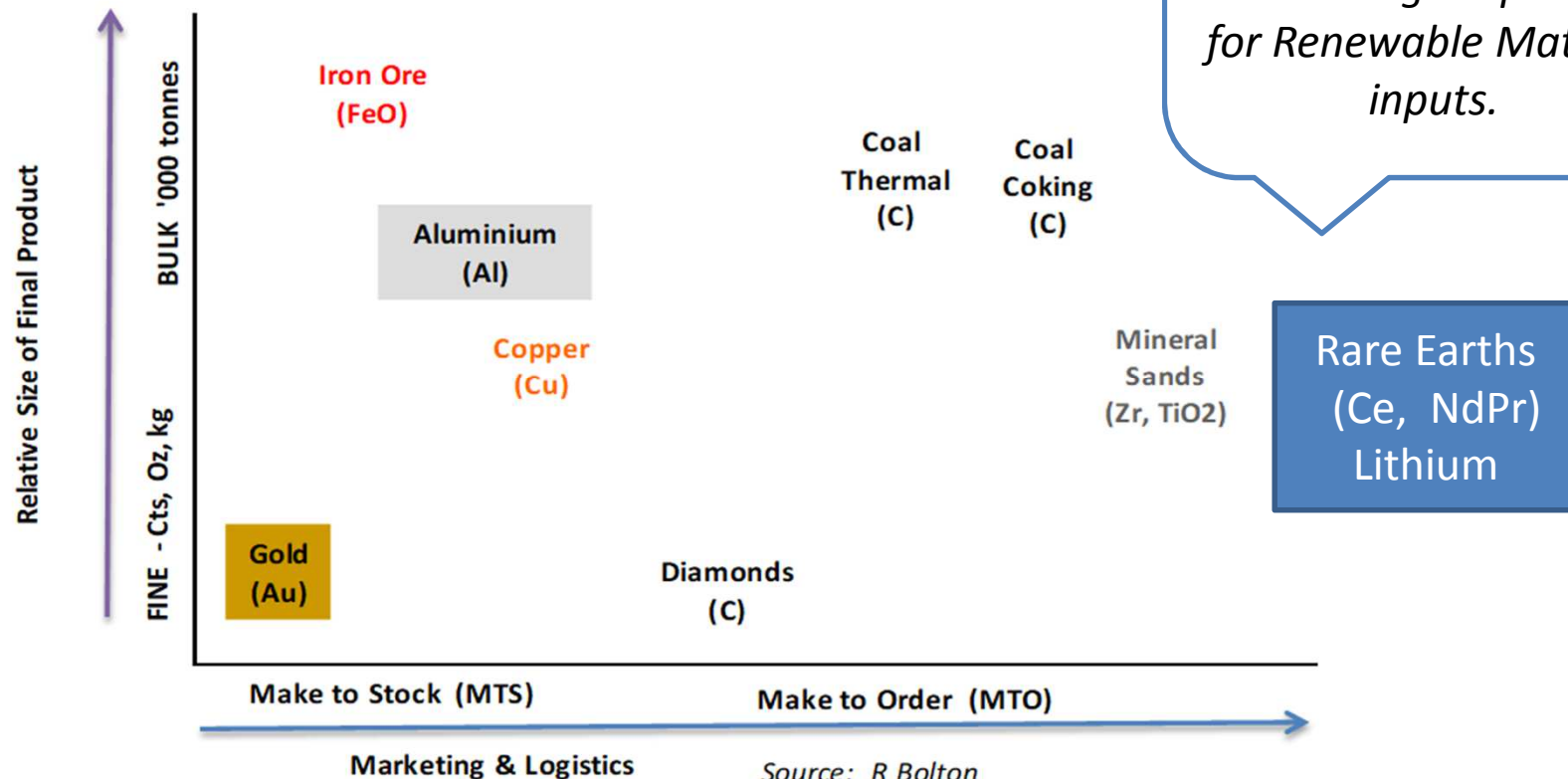
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Mine to Market (M2M)– Flow Profile 2012

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Mining Resources - Typical Operational Flow



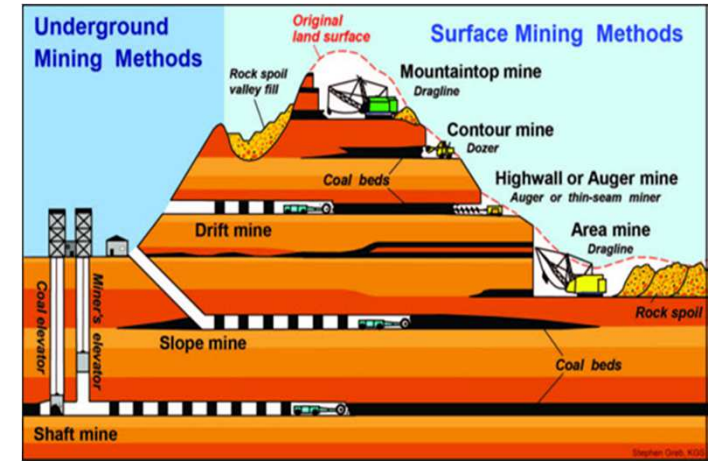
TREND: Greater product specification and segmentation is continuing. Especially for Renewable Material inputs.

Source: R Bolton
Resource Industry Knowledge

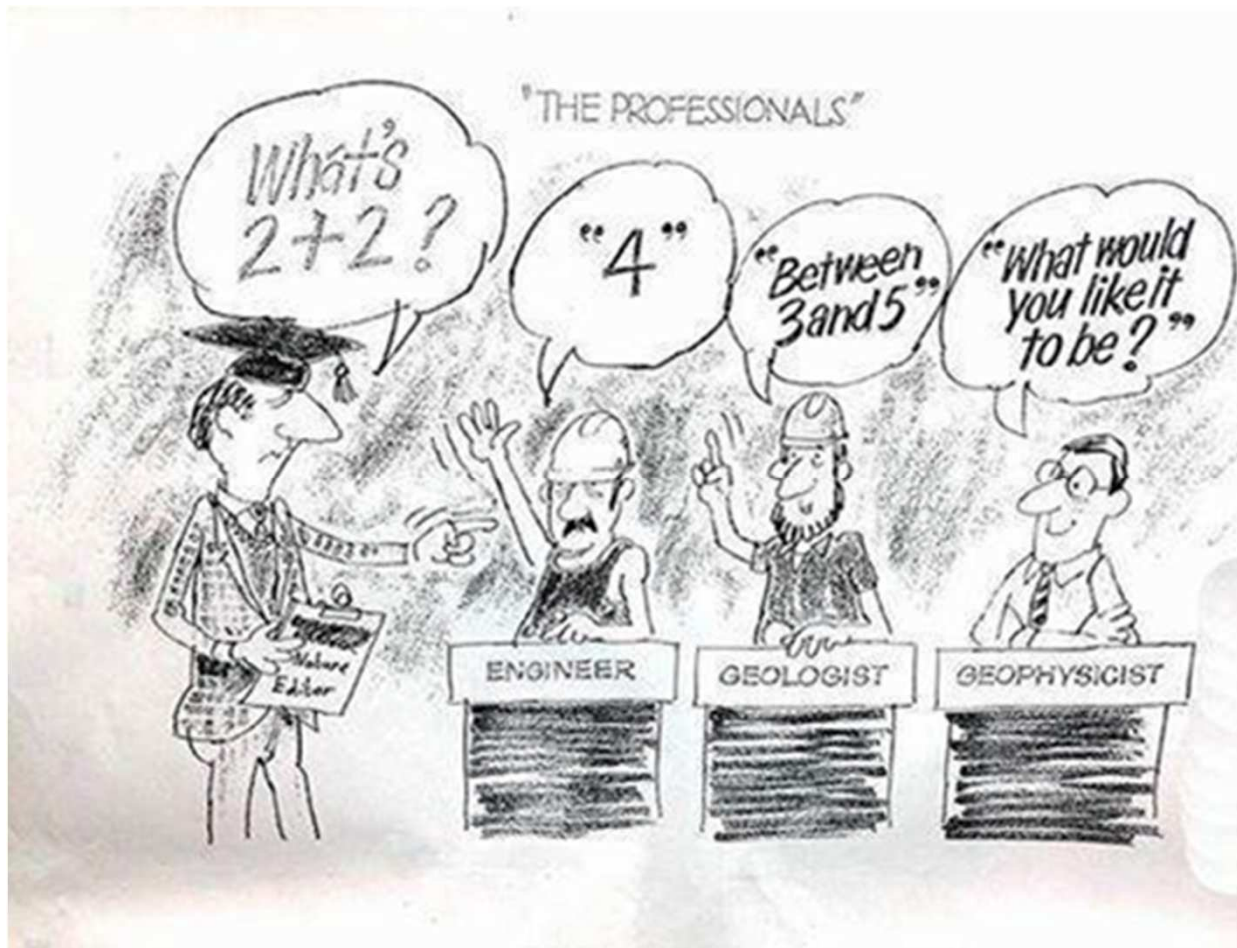


Business unit view

- **Business Unit leaders (General Managers) have a lot of autonomy.**
 - Considered “ gods “
 - Time poor – quick decisions
 - Revenue / expenditure - \$1 m to \$10m / day
- **Highly educated and skilled work force.**
 - Difficult to keep all role filled.
- **Majors will have technical division with CI and technical capability.**
- **Safety and license to operate (regulatory) is the main driver.**
- **Business Operations**
 - Strong silo organisations structure. This leads to silo of data.
 - Poor flow of information
 - Balance capacity, not flow.
 - “polishing the peg”.
 - Mostly engineering. They will all the details before making a decision.
 - Tend toward technology solutions. Not process and business systems.
 - Lots of planning. Less on managing schedule variation during execution.
- **Many processes and information systems**
- **Constraint management**
 - The market is unconstrained.
 - Have controls points and stockpiles (buffer). *Not understood.*



Lots of data, many views





Argyle Diamonds



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Argyle Diamonds - Turnaround

- *In 1993, Argyle was faced major business challenges*

- *Change in market (more Gem size)*
- *Increased variation to grade*
- *Increased competition*
- *Negotiations with key customer*



"Quote from West Australian 3 October 1995

- *Interventions:-*

- *BPR*
- *ThroughPut Accounting (TA)*
- *Activity Based Costing (ABC)*

- *Results*

- *Change to operating model and product pricing model*
- *Life of Mine (LOM) estimate increased by 3 years. Still operating.*
- *Significant change in shareholder value.*

"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 Argyles 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.

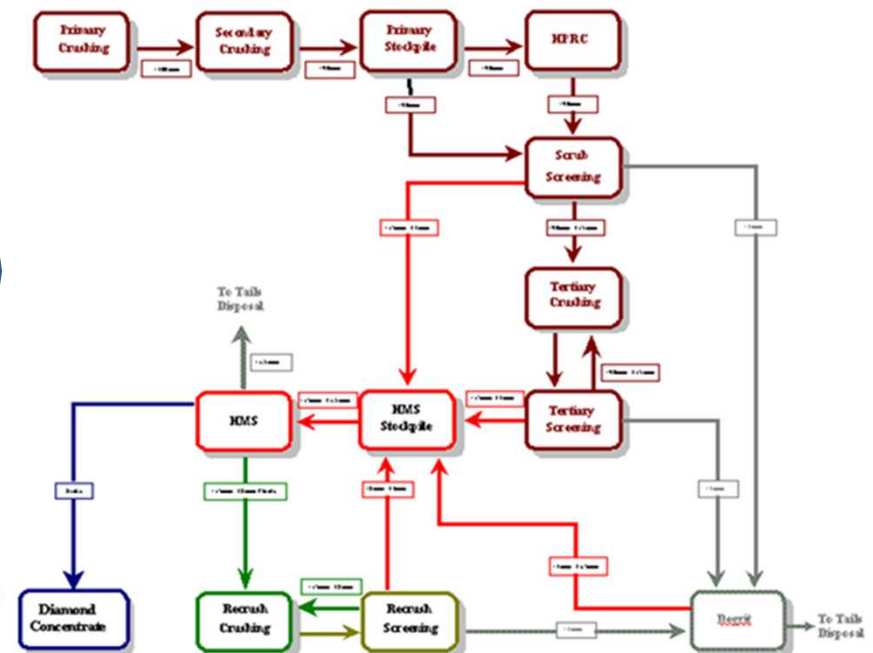
He said the move was part of the streamlining process under way at the plant and while the total number of carats produced would fall by about 15 %, the higher throughput would lead to lower operating costs.



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Argyle Diamonds

Intervention summary

*Business wide ThroughPut analysis, led to de-bottlenecking.
RESULT: Major increase in shareholder value.*

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.

Iluka Resources

Titanium Mineral Pigments



Zircon



Iluka Resources

- Problem (from Diagnostic)
 - *Iluka was the result of M&A activity*
 - *Not meeting operational targets*
 - *Grade variations not being consistently managed*
 - *Planning cycle not matched to physicals flow*
- Interventions
 - *ToC operations workshop – simulators*
 - *Technical Planning meeting*
 - *Rolling schedules*
 - *Blend material to meet customer needs*
- Results
 - *Record production rates after 3 month*
 - *Meet annual operational target*

Iluka Resources case study



“Mine to Market”



Throughput Focused Mining (TFM)
*A holistic approach to improving the flow in
a complex mineral sand operation*



World's leading Mineral Sands Miner

- 1, 000 people employed world wide
- 4 mines, 2 Separation, 2 SR plants

SW Operations – GM Concerns

- Merger of several Mineral Sands operations and business unit
- Existing systems not integrated
- Different culture and ways of conducting business
- Increasing market for SR Product
- Capital expansion being planned
- Mining operation becoming more difficult (grade)



- **ToC Introduction (P&Q)** July 2001
- **Holistic Review** - May 2002 - *What to Change?*
- **Interventions Injections)** - 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 - *Maximising Constraint*
 - Stockpiles (buffer) information used to increase flow and reduce variation
 - Manage SP plans to meet customer (shipping) requirements
- **Record SR Production rates – October 2002**



Holistic View from Diagnostic – 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.

*AS IS: What are
the existing
management
system
elements?*

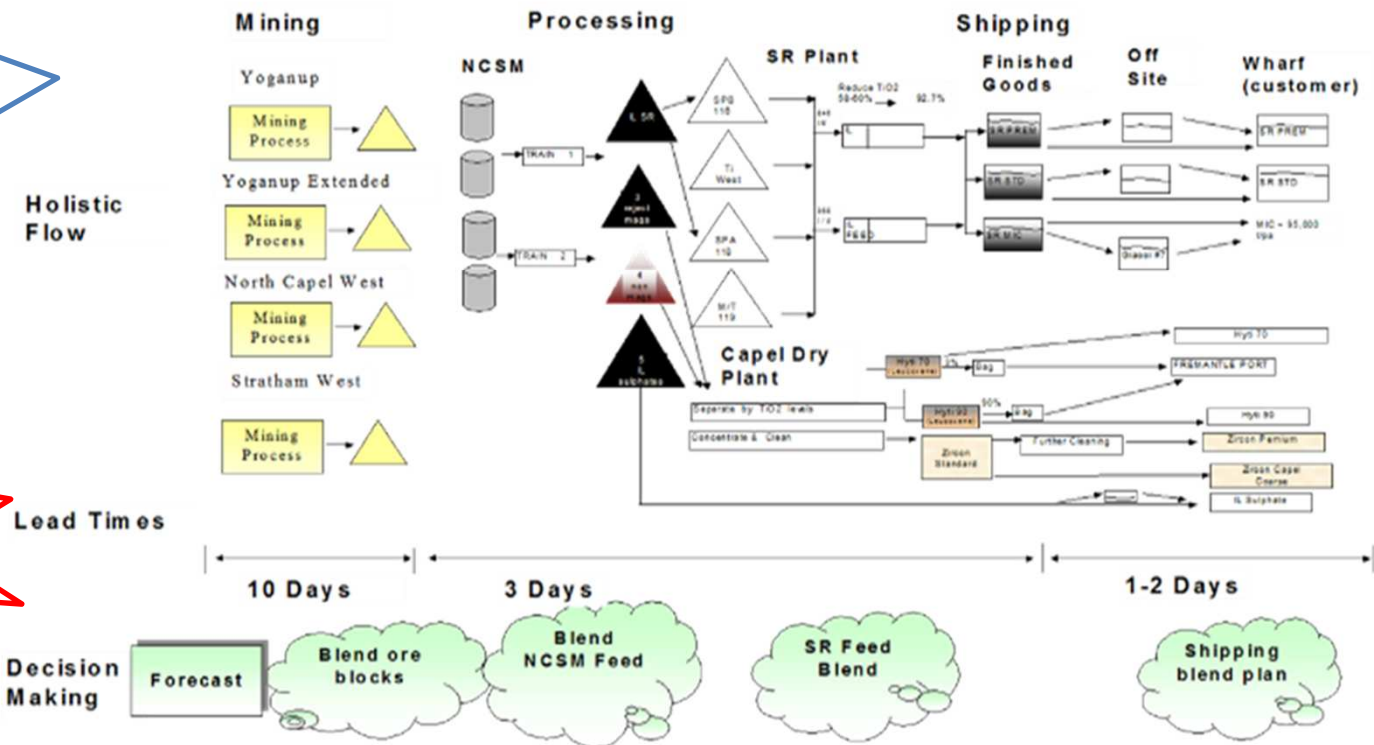
M2M Diagnostic – Holistic view of operation -

- The was disagreement over where the CONSTRAINT was. Most thought it was high unit cost process SR plant.
- Stockpile and storage bins were available as buffers. These were not managed.
- Limited communication between functions

Flow Network:
Created a
Holistic view for
1st time

Planning cycle
out of sync
with physical
flow

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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)

*Roadmap for a SHORT
TERM PLANNING and
MANAGEMENT SYSTEM*

AIM: Increase thru-put and increase operational stability.

I.e. Variation in the process is understood then managed.

Holistic View from Diagnostic – What to Change?

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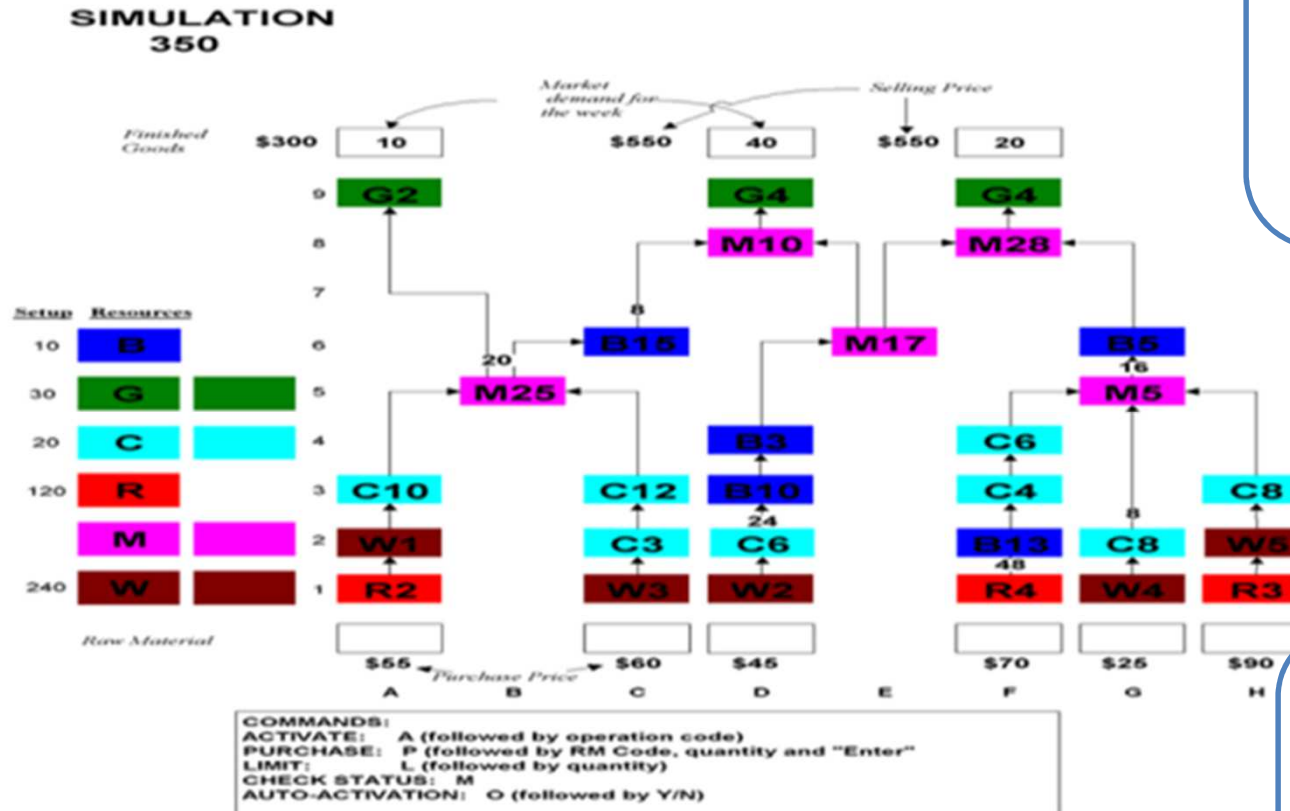
AS IS: Existing management system elements are mapped visually.

GAPS became clearer.

Operations simulator

PARTICIPANTS: [12]

How to schedule?
Build a sequence based
on limits



OBSERVATION:

Participants will schedule
very differently. This is
later reflected in
implementation phases.

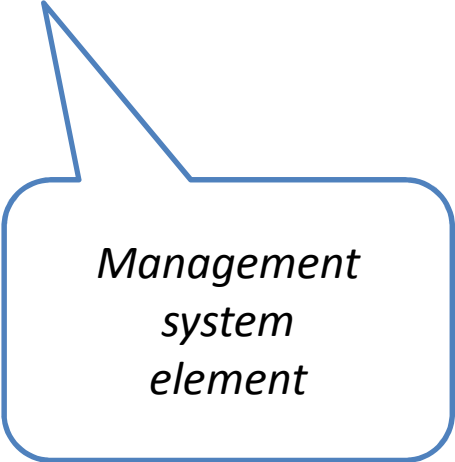


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Technical Planning meeting (alignment)

- 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



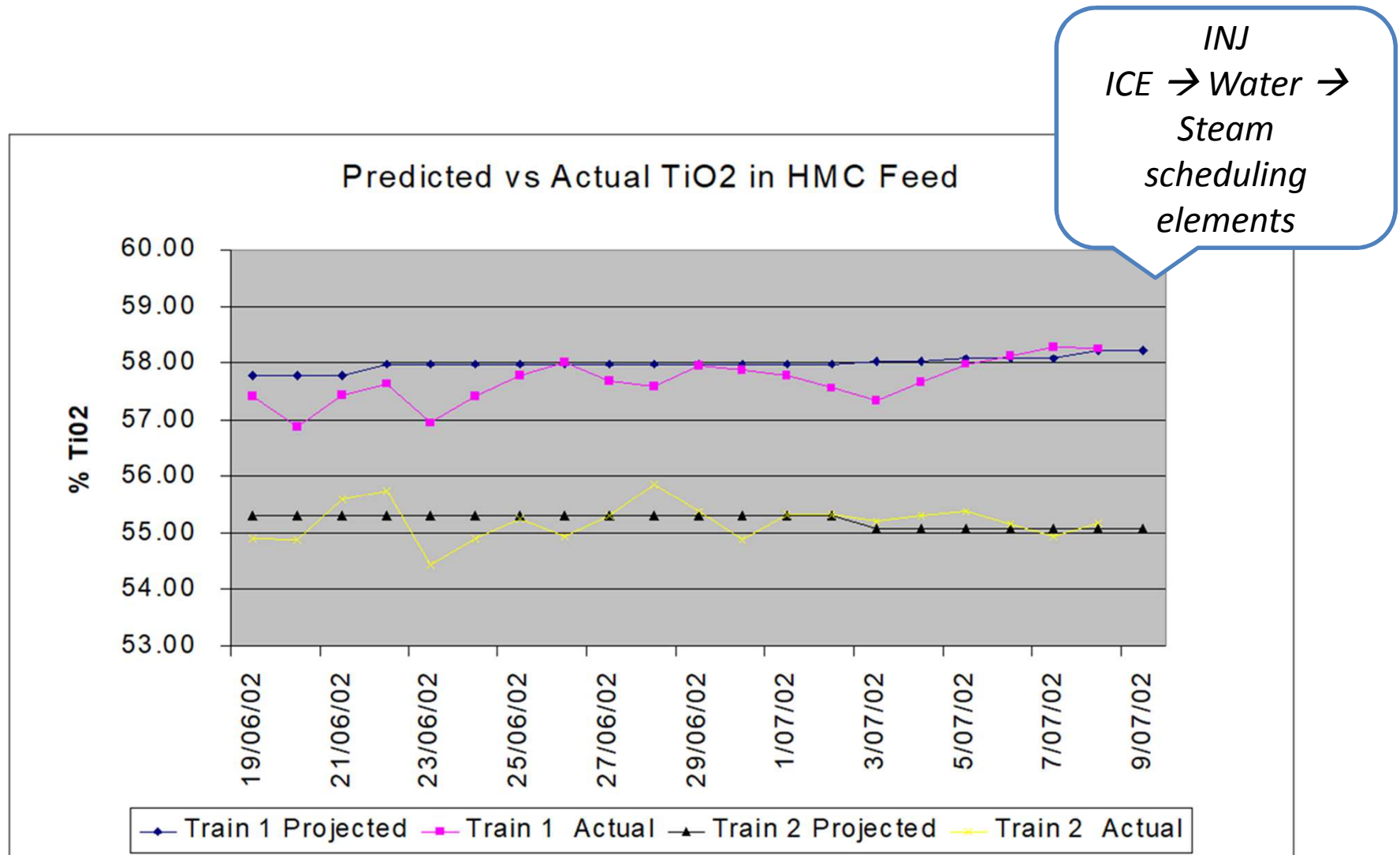
*Management
system
element*

Benefits – Technical Planning meeting

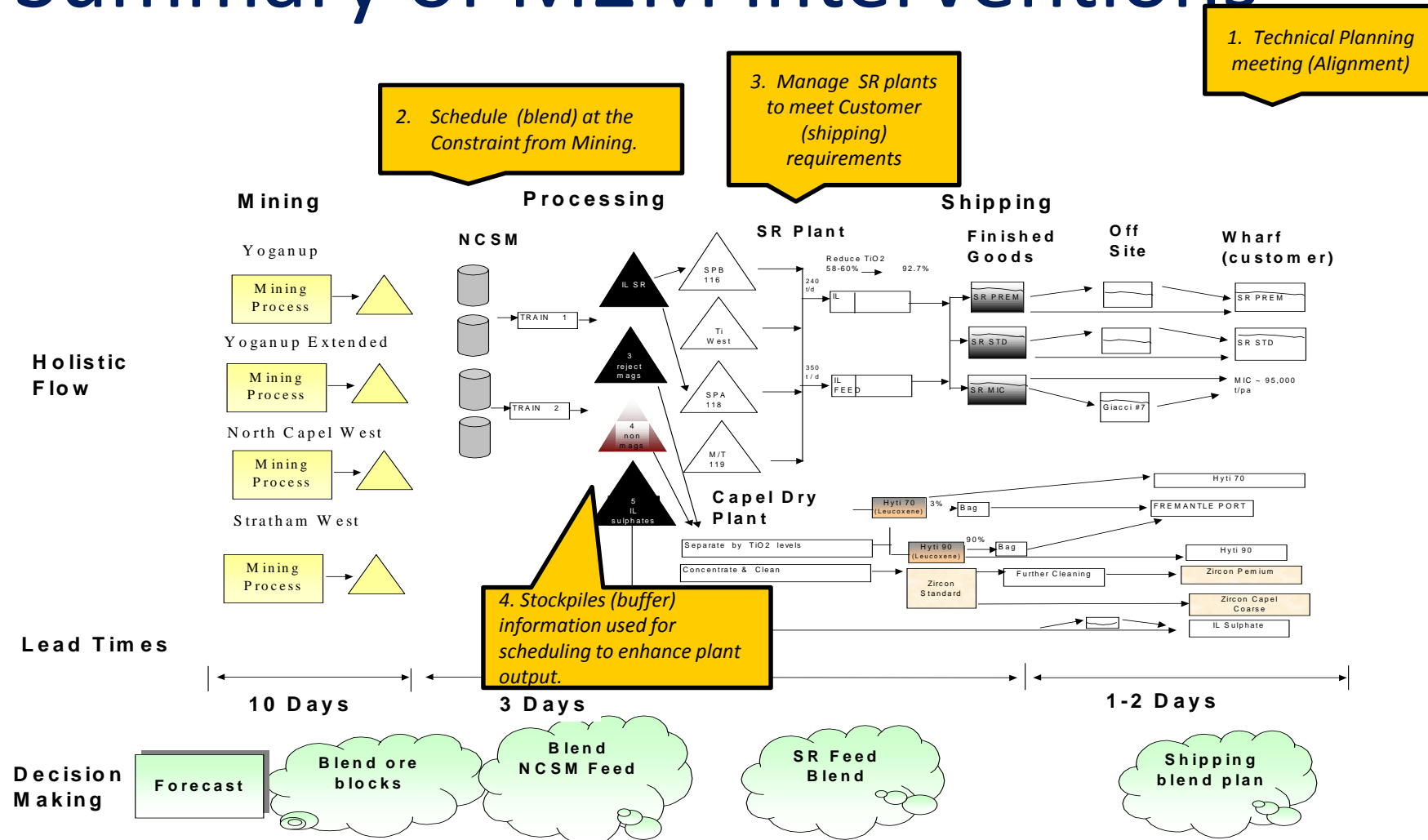
- Improved Communication
 - *ownership & resolution of issues increased.*
- Critical Issues raised prior to their impact
 - *Shipping is aware of what process can deliver number of weeks in the future.*
- Customer Requirements Communicated
 - *Customer specific specification are noted as required.*
- Quality and Logistical issues raised and actioned.
 - *18 / 26 issues raised were resolved in 1st 3 weeks. All were resolved in 12 weeks.*
- Pre-requisite of thinking customer back drove operational flow

*Problems raised
but not solved
in meeting.*

12 week blend reduced input variability



Summary of M2M interventions



Result → Operational Throughput at record levels

Benefits to Iluka

- *Record production rate ensured the 2002 targets were met. This was repeated over next 4 years.*
- *25million AUD capex for a 3rd SR plant was deferred.*
- *Priorities were determined based on meeting customer shipments and product flow.*
- *Increased T-put to Iluka due to less out of spec product. Operational margins improved.*
- *Ability to blend lower grade HMS into SR plant. This increased the value of the reserves being mined.*
- *Communications changed and improved between key functions to be more business like.*
- *Organisation Development and Structures became more robust. Roles & responsibilities were resolved post merger.*



ILUKA RESOURCES LIMITED

4 October 2002

MINE TO MARKET - A HOLISTIC APPROACH

In June 2002 a Mine to Market project was initiated to provide a holistic view of the South West Operations.

Part of this project involved exploring and applying the Theory of Constraints concepts scheduling to the short-term planning and management systems. We used the services of Robert Bolton of Probative Solutions to facilitate and apply these concepts.

Over the past 2 months the Processing (inc. Separation, SR, Day Services and Shipping), Mining and Laboratory teams have been collaborating to improve SR production whilst not impacting on grade. This collaboration has taken the form of weekly meetings, weekly scheduling at the Mine/Separation/SR interfaces and various informal discussion groups.

The result of this work is that SR1 and SR2 Kiln throughputs are sitting at record rates. This has been achieved through optimising our production scheduling to meet shipping requirements.

We aim to build to these improvements by focusing on further constraint management initiatives.

Yours faithfully,

TONY EMSLIE
Processing Manager – South West

Thinking Processes (TP)

$C \rightarrow E \rightarrow C$

Applying ToC thinking & solutions to mining

Buffer
Management (BM)

CCPM

Hybrid DBR

Transformation flow

Preparation [before]

- Commodity demand and cost curve
- Safety culture
- General Manger / leadership concerns

Diagnostic

- Map out flows
 - Physical, material, logical, signals & feedback
- Management system AS IS Gap
- General Manger / leadership
- Need for change
- Project theme

Education / Training / Design

- DBR simulator, CCPM
- Buy-in assessment of management team (stakeholders)
- Modify ToC solution to enhance flow
- Mix / match methods as required.

Implementation

- Holistic view with safety / environment
- Short Term planning (ICE → water Steam)
- Blending
- Information flow changes

Follow-up &reinforcement

- Review constraint movement signals
- Effect of change of grade
- “Manage the inputs to mangle the flow”

Future Trends

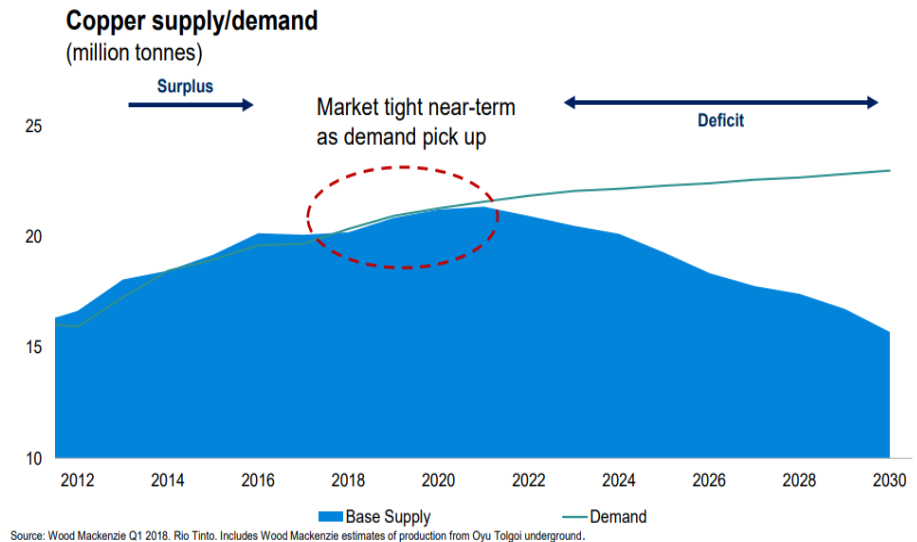
- Supply side becoming tight → will need capacity and output lift.
- Fixed price contracts are on the rise.
- Simulation modelling is on the increase.
- Increase in customer specification.
- Mining flow becoming more like a manufacturing operation.
- New uses for metals and minerals



Opportunities ahead

- Mini-boom is likely
- Mining people will need to think of their flows and business as a system
- You will need to know a little about their business and their language for them to listen
- *Give me a call !!!*

Global macro indicators remain strong for copper



RioTinto

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Source: Rio Tinto

Arnaud Soirat
Chief Executive
World Copper Conference
10 April 2018

Questions



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