

So we've survived ...
What now?



Canadian Engineering Associates Ltd.

Good People doing Good Work

Vision Statement



To provide quality engineering and consulting services to the global metallurgical industry by employing skilled competent experienced personnel that mitigate the need for cumbersome systems and procedures by simply knowing what they are doing and doing it well.

This delivers lean rapid highly-successful outcomes in a collegial atmosphere of mutual trust and respect.



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Topics



01

The Law
Of
Diminishing
Returns

02

Efficiency
vs
Redundancy

03

Technology

04

Mining
is not
Manufacturing

05

It's \$/t!
Not \$...
Not tons...

06

Data
Analysis
Vs
Analytics
Vs
Artificial
Intelligence

07

It's All
About
Skilled
People

The Boom Years



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The Boom Years



The Boom Years



Rapid Expansion

- Focus on Capacity
- Expand at High Cost

Projects

- EPCM Dominates
- Overruns

M&A

- Grow or Be Eaten
- Premium Prices Paid

Balance Sheet

- Assumption of Debt

Focus on
Maximizing
Revenue

Head Grades
Decline

Not The Boom Years



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Not The Boom Years



Not The Boom Years



Cost Cutting

- Focus on Reduced Spending

Projects

- Lump Sum
- More Controls

Focus on
**Minimising
Cost**

Head
Grades
Decline

M&A

- Shed non-core
- Growth of 2nd and 3rd tier

Balance Sheet

- Reduction of Debt
 - Divestments
 - Write downs

A crowd of diverse people is gathered on the edge of a cliff. Some are looking over the edge, while others are falling off. The scene is a metaphor for herd mentality and the dangers of following the crowd without critical thought.

Herd Mentality The Last Prolonged Upswing

Growth at high (any?) cost

- ▲ Dilution of fixed cost
- ▲ Consolidation
- ▲ Bigger is better
- ▲ Risk is acceptable as the returns are there
- ▲ Fast track projects producing record overruns
- ▲ Shortage of skills leads to plethora of management systems

Herd Mentality

The Last Prolonged Upswing

How did that play out for shareholders, employees?


What happened when the party was over?



Herd Mentality The Last Prolonged Upswing

Debt and loan servicing

- ▲ Cost cutting deep
- ▲ Write downs
- ▲ Hollowing out of skills (baby with the bathwater effect)
- ▲ Entrenched systems
- ▲ Residual shareholder expectations

A crowd of people is shown falling off a cliff. The people are falling in a line, one after another, from the top of the cliff. The crowd at the top is dense, and as they fall, they form a long, thin line. The background is a bright, hazy sky. The overall scene is a metaphor for herd mentality and the dangers of following the crowd without thinking for oneself.

Herd Mentality The Last Prolonged Decline

Cost cutting at high (any?) cost

- ▲ O/H reduction
- ▲ Minimised Sustaining Capital
- ▲ Minimized Maintenance
- ▲ Operating Staff Reductions
- ▲ Projects on hold/terminated
- ▲ Fire sales to ease debt
- ▲ % EBITDA protected

A stylized illustration of a herd of people in business attire falling off a cliff. The people are shown in various stages of falling, from the top edge of the cliff to the ground below. The background is a light, textured surface.

Herd Mentality The Last Prolonged Decline

And how will that play out for
shareholders, employees?

The background of the slide is a colorful illustration of a herd of sheep. At the top, a large group of sheep is gathered on a cliff edge. As they move down, they begin to fall off the cliff. The sheep are depicted in various stages of falling, with some still on the cliff and others in mid-air or having already fallen. The illustration is done in a simple, cartoonish style with bright colors.

Herd Mentality The Last Prolonged Decline

Today, we face many issues

- ▲ Approaching skill shortage
- ▲ Aging Equip/Infrastructure
- ▲ Head grades still declining
- ▲ Asian competition
- ▲ Residual shareholder expectations

Law of Diminishing Returns



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Adage

**“90% of Returns come
with 50% of the effort”**

Law of Diminishing Returns



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Flipside

It takes **50%** of the effort
for **10%** of the returns

Law of Diminishing Returns



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Obsession

With the **10%**
(milking the last drop)

which takes disproportional effort

Law of Diminishing Returns



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When does it make sense to invest in added capacity?

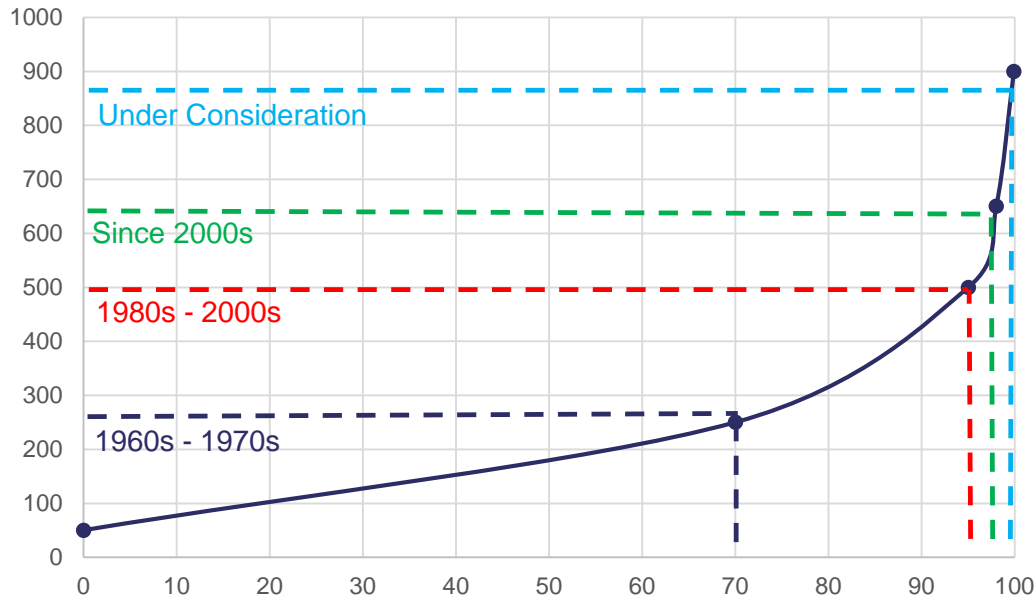
Beware of promises that the last 10% is easy

Law of Diminishing Returns

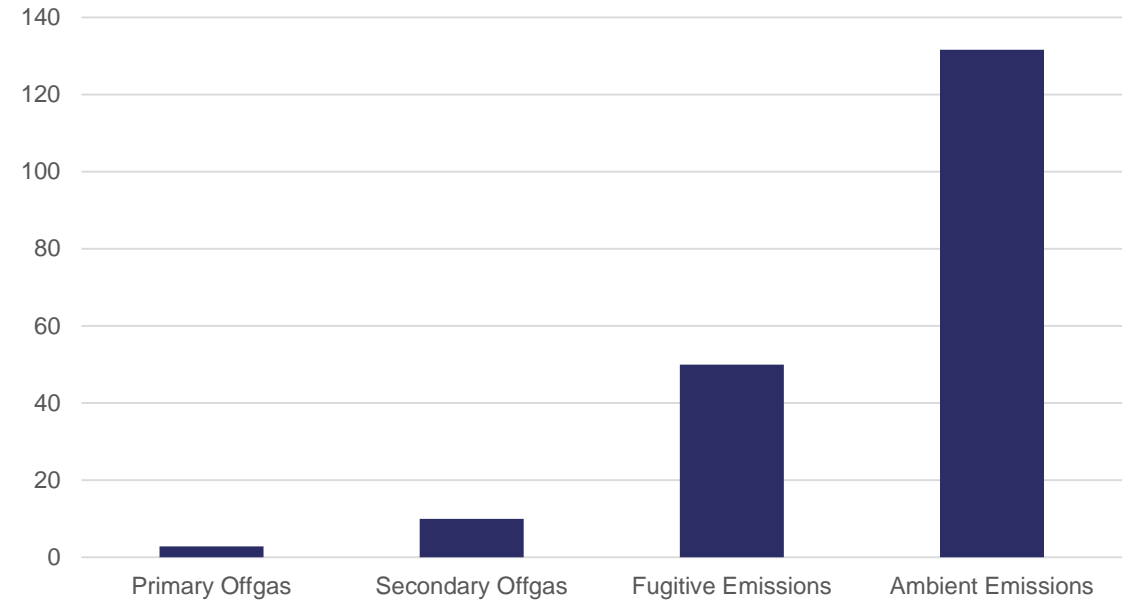


Copper Smelter Emissions

Gas Treatment Cost (k\$) vs SO₂ Capture (%)



Relative Cost per Unit of SO₂ Captured (\$M/%)



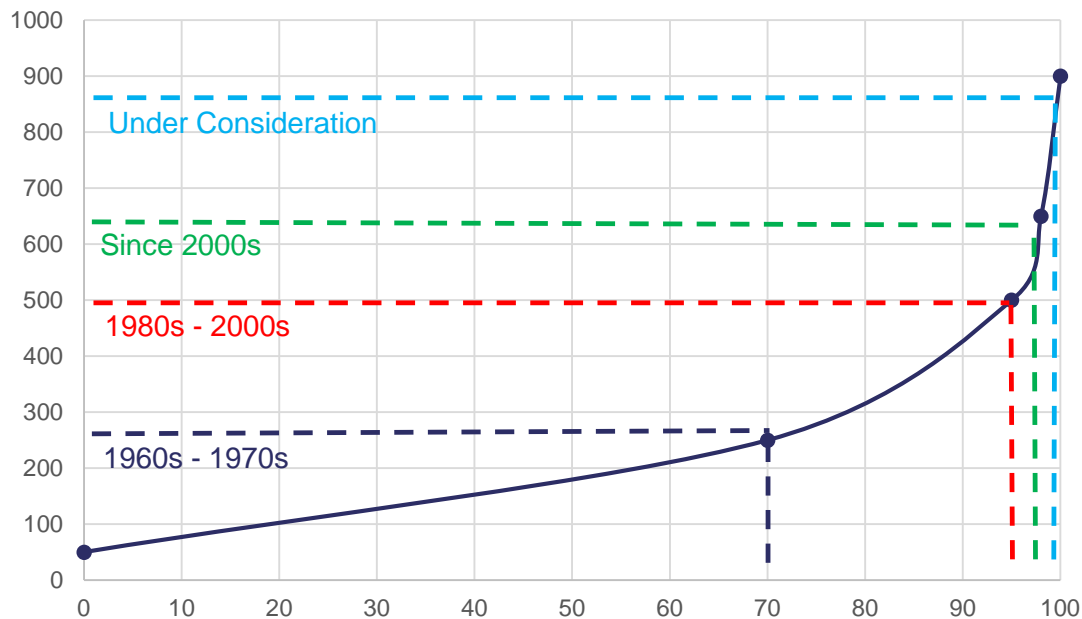
Law of Diminishing Returns



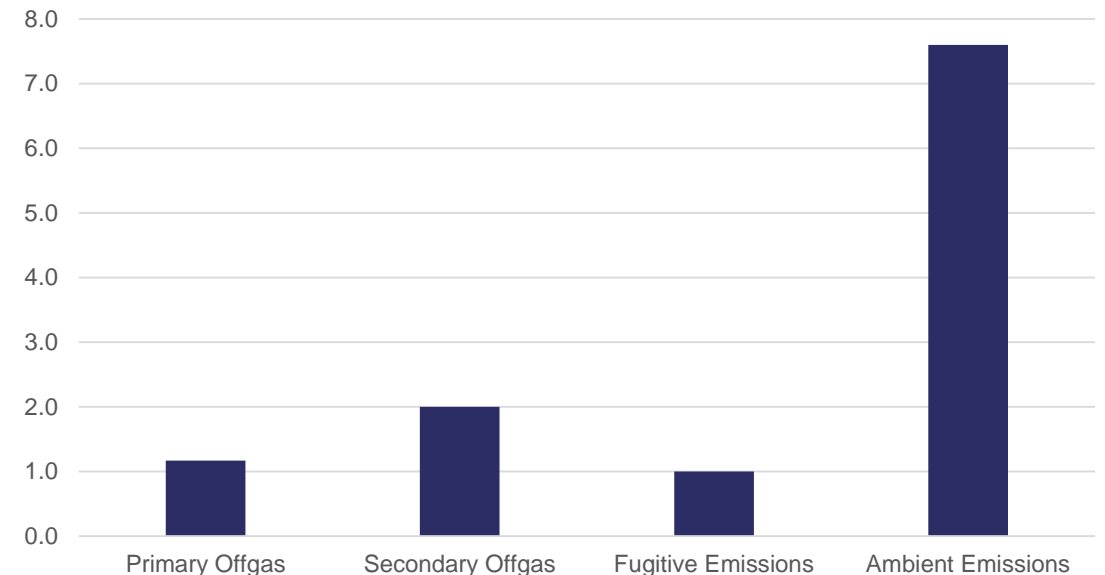
Copper Smelter Emissions

The power of the diminishing denominator

Gas Treatment Cost (k\$) vs SO₂ Capture (%)



Relative Emission Reduction per Cost (% redn / M\$)



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Law of Diminishing Returns



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Understand the **Big Picture**

Don't fall for the “**denominator**” trick that exaggerates benefit

Find a **new cow**, don't obsess with the last drop of milk

Efficiency vs Redundancy



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Efficient Systems use a high proportion of total available capacity

Redundancy is installed available capacity to deal with perturbation

Efficiency vs Redundancy



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**THESE ARE
OPPOSITES**

Efficiency vs Redundancy



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Is the **5%** increase of efficiency improvement worth
the **50%** decrease in redundancy?

The only constant in mining is the **variability**,
which favours **redundancy**

Efficiency vs Redundancy



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August 14th 2003 Blackout

Efficiency vs Redundancy



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August 14th 2003 Blackout

- ▲ US/Canada Power Grid HIGHLY Optimized (Over 98% Efficient @ peak load)
- ▲ Trees brushed against transmission line in Ohio
- ▲ Alarm system failed to warn of issue
- ▲ Pushed local system over limit, led to shutdown of 3 other lines
- ▲ System now asking over 100%, cascade shutdown
- ▲ 11 lives lost, \$6B losses
- ▲ System continues to run at high efficiency, it will happen again
- ▲ \$6B = 40,000km of redundant transmission lines

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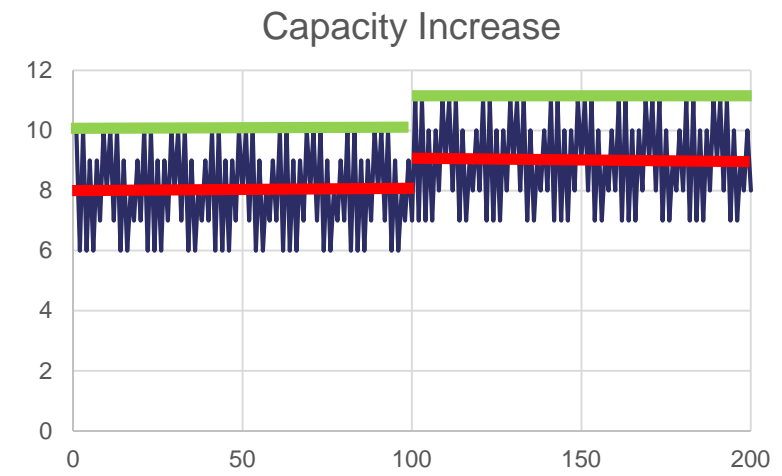
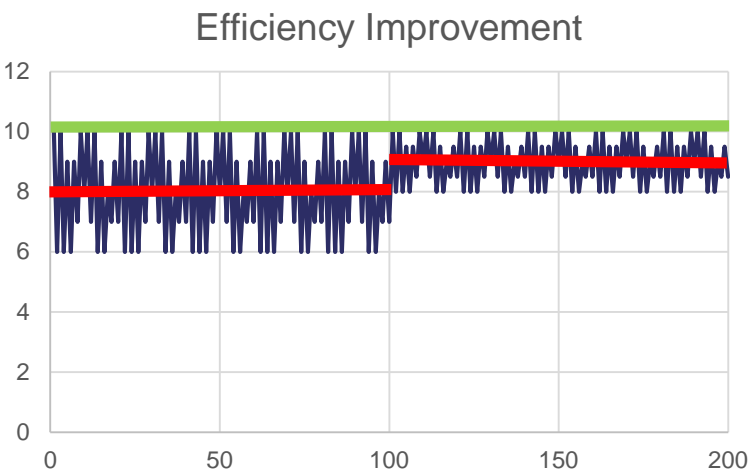
Efficiency vs Redundancy



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Improved Efficiency Inherently Brings Increased Risk

This needs to be acknowledged during decision making



Technology is great, but...



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Commonly held Misconceptions

Technology is **inexpensive**

Technology is great, but...



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Development times are long

With Sincere Apologies to RioTinto Australia!

**Original Schedule :
Complete July 2014**

**First PILOT Run:
Sept 2017**

Technology is great, but...



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Cost overruns rampant

Original Budget:
Difficult to establish but
Around \$40 - 50M

(200 Locos, 25 trains)

Spend to Date:
At least \$317.5M

(About the cost of 200 locos)

Technology is great, but...



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Benefit

▲ Labour Saving

- ▲ Reduction in operator costs significantly offset by increase in skilled labour cost

▲ Reduced Cycle Time

- ▲ Elimination of rolling stock

▲ Lower Maintenance Cost

- ▲ Per km

Technology is great, but...



7:40 AM

Toronto
Mostly Cloudy

1°

7:40 AM

Toronto
Mostly Cloudy

-2°

Commonly held Misconceptions

Technology is **stable**

The more **complex** the system,
the less reliable

Technology is great, but...



7:40 AM

Toronto
Mostly Cloudy

1°

7:40 AM

Toronto
Mostly Cloudy

-2°

Steady increase in
“glitchiness”

“Ingenuity Gap”

Technology is great, but...



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Technology offers great promise

Still in its infancy

Go in with eyes wide open and don't believe the promises made

Technology is great, but...



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**KEEP
CALM
AND
Keep it
SIMPLE**

Apply the KISS principle

The Promise for Underground Production Optimization Systems

Endemic Wireless

Real Time Scheduling Optimization

Technology is great, but...



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**KEEP
CALM
AND
Keep it
SIMPLE**

The real world biggest benefit?

Not the **last 10%**, more fundamental!

Knowing **where** your people and equipment are

Being able to **communicate** with them

Technology is great, but...



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Remember the losses on the overrun projects from the last cycle?

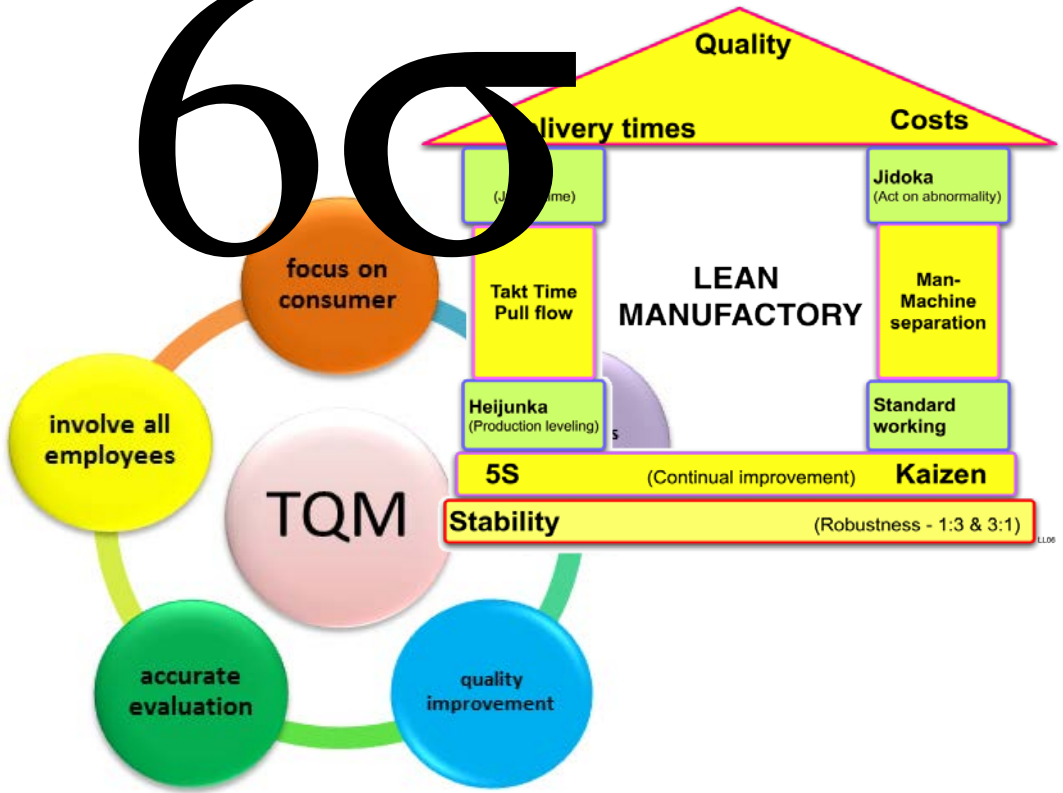
Don't make the same mistake on massive technology adoptions

Mining is not Manufacturing



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6σ



Think before Embarking on Optimizations, and Stop Kidding Yourself

Benefits typically exaggerated using the diminishing denominator

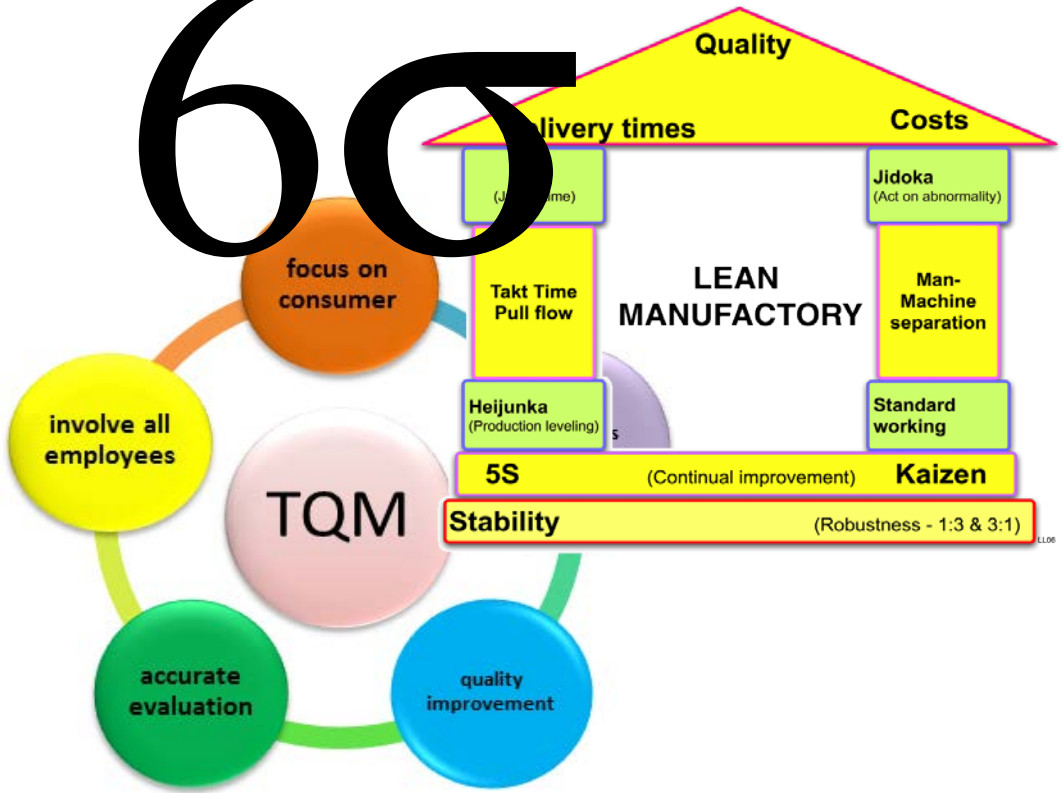
10% reduction in losses, not **1%** improvement in throughput (and less than 1% of revenue; variable cost)

Mining is not Manufacturing



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6σ



Think before Embarking on Optimizations, and Stop Kidding Yourself

Frequently assumes stable measurable inputs

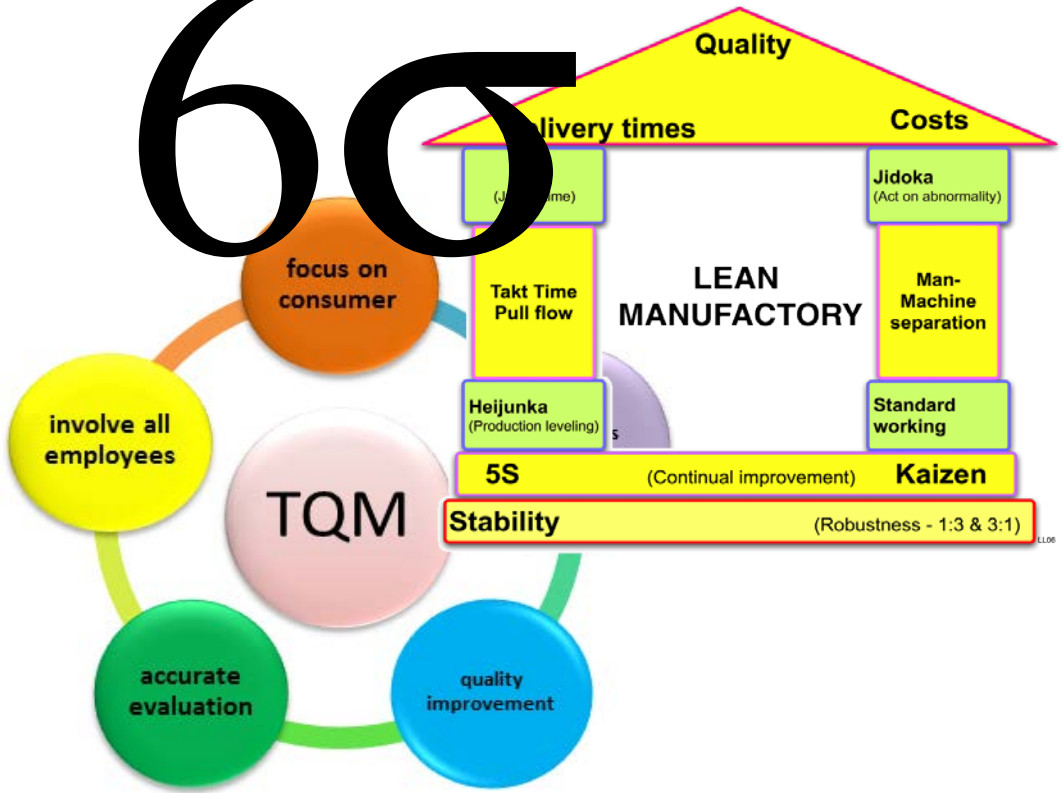
First time you really know the ore is when it is metal

Mining is not Manufacturing



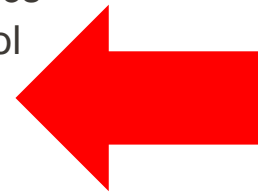
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6σ



Factors affecting throughput

- Weather
- Rock Mechanics
- Dilution Control
- Grindability
- Floatability
- Filterability
- Heat Value
- Minor Elements
- Labour
- Supply Chain (in and out)
- Maintenance/Availability
- Political Stability
- Social Licence
- Many many others



ALL HAVE SIGNIFICANTLY MORE VARIABILITY IN MINING

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Mining is not Manufacturing



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Before focussing on the expensive “easy stuff”

Sophisticated control of

- ▲ **Supply chain**
- ▲ **Maintenance/reliability**
- ▲ **Production**

Mining is not Manufacturing



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Look at the inexpensive “difficult stuff”

- ▲ Do your mine planners talk to your miners?
- ▲ Do you miners talk to the mineral processors?
- ▲ Do they talk to the smeltersmen?
- ▲ Do your smeltersmen talk to your mine planners?

Mining is not Manufacturing



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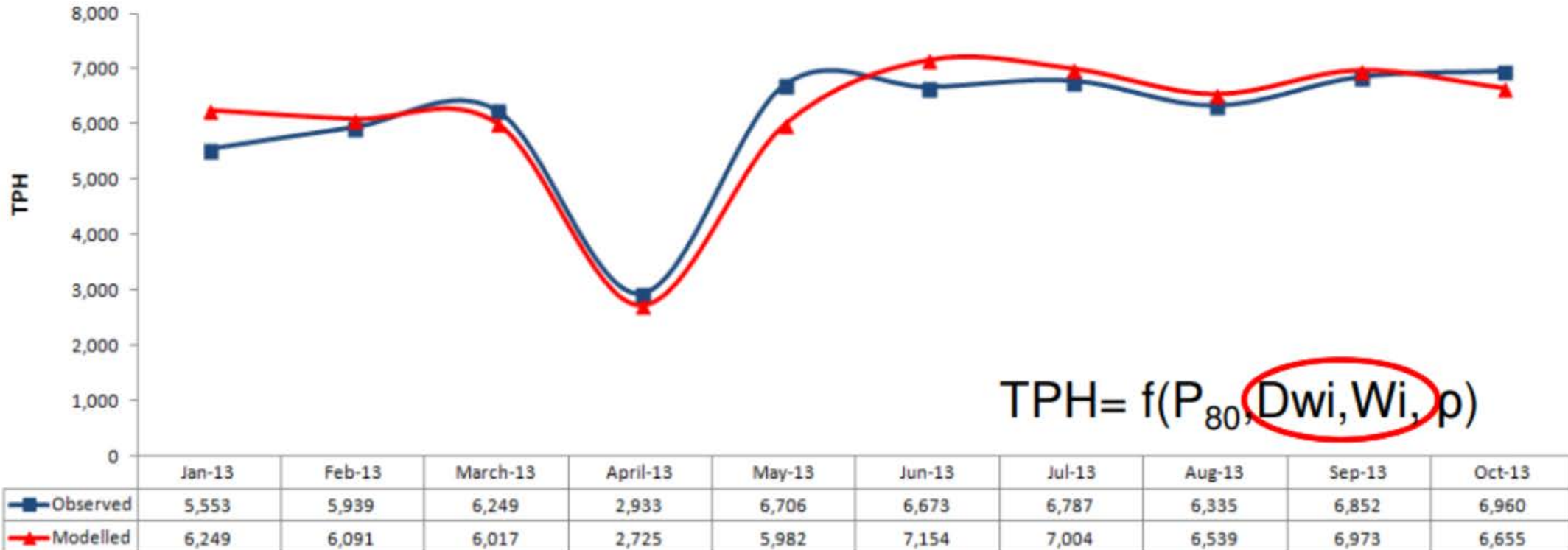
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Monthly Instantaneous Throughput



$$TPH = f(P_{80}, D_{wi}, W_i, \rho)$$

Unit Production Cost



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Companies Compete on Unit Cost (e.g. Gold Industry AISC in \$/oz)

Decade of focus on \$\$\$s

Easy to flip to focus on oz/lbs/tonnes (like the last boom)

Unit Production Cost



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Discipline to weight EQUALLY

Decreasing the numerator with cost reduction, and

Increasing the denominator with production increases

Unit Production Cost



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HONESTY to accept that one affects the other:

Mantra of consequence free cost reduction must stop

Acceptance that increased production carries cost

Analysis, Analytics, Intelligence **CA ENQ**

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Demystify the Hype

Analytics have been around for MANY decade

Sophisticated multivariable regressive correlative modelling and control

All analytics and artificial intelligence relies on very simple principles

Analysis, Analytics, Intelligence **CA ENG**

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How to be artificially intelligent!

Log lots and lots of data

Plot everything against everything, and their squares, and their log (and the fourier transformation if you are seeking cyclic), etc

Do the same with group of data streams

Note any that have a high R^2 , and use this relation as a control parameter

You have just performed analytics and achieved intelligence

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Analysis, Analytics, Intelligence

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Difference today is that large computational power allows this is real time.

Undiscussed downside: Identifies correlations but bad at cause and effect

Rebuilding the skills



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Acknowledge the **capability**
of employees

Rebuilding the skills



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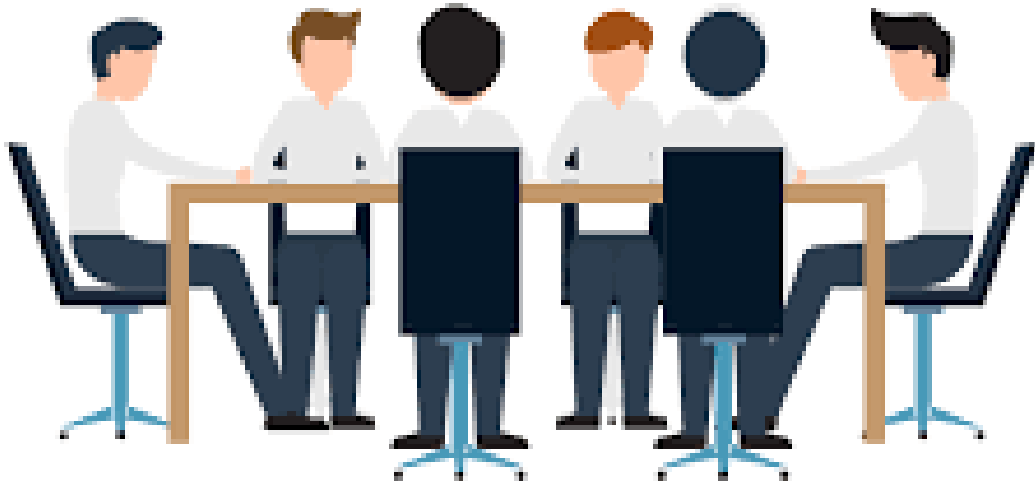
06

07



Train them, for real!

**Field training, paid mentoring,
apprenticeships**



Rebuilding the skills



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Don't put shareholder returns
ahead of **employee
satisfaction**

Rebuilding the skills



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Encourage
communication, within
and outside the company

Rebuilding the skills



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Attract good people

For Millennials/Gen-X in particular, this means \$\$\$\$

Conclusion



01



The future is in our people, not our systems and devices

02



Beware promises of great gains, don't be in the next herd racing towards unwise investments

03



Rapid data analysis is valuable (analytics), but skilled persons doing effective evaluation is still key

04



Efficiency carries risk, increasing capacity less so.

05



Give equal weight to \$\$\$s and tonnes, and understand how they affect each other



CA ENQ

Questions?