TECHNOLOGY TRANSFER & COMMERCIALISATION

Session 4

Dr. Ben Adair

CRC ORE

CEO & MD

WE ARE HALF WAY THROUGH OUR 2ND TERM: DELIVERY & COMMERCIALISATION

CRC ORE

Cooperative Research Centre focused on Optimising Resource Extraction in the minerals industry

Funded

Funded by the global minerals industry and the federal government

Independent. Not for profit .

Term

Commenced mid-2010.
Awarded a further 6-years funding until 2021

Identify, integrate and implement innovation to improve operational value and reverse declining productivity in the mining industry

Applied technology development and transfer focus

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Business Cooperative Research Centres Program

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Optimising Resource Extraction

A NEW ESSENTIAL PARTICIPANT

MINING

ANGLO AMERICAN

ANGLOGOLD ASHANTI

BHP

GLENCORE

NEWCREST MINING LIMITED

Teck

Sumitomo Corporation

METS

HATCH

imdex LIMITED

JKtech SMI Technology Transfer

METS IGNITED

ORICA

SODERN

SEDGMAN

metso

Researchers

AMIRA INTERNATIONAL

CSIRO

Curtin University

mriwa Minerals Research Institute of Western Australia

mining3 TRANSFORMINGMINING

QUT

ARC-CARC Canada

THE UNIVERSITY of ADELAIDE

UTAS

THE UNIVERSITY OF QUEENSLAND

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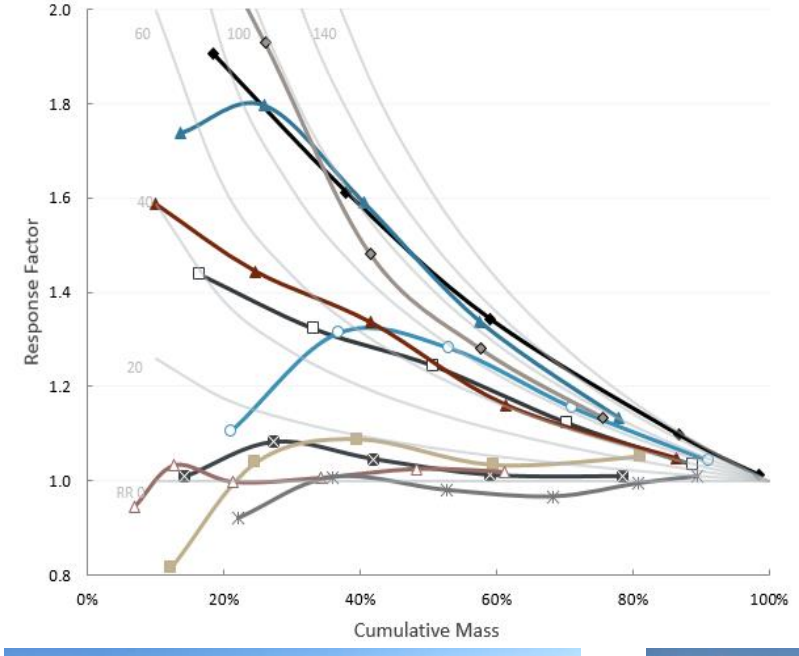
The “Brown Book” – A Legacy Piece

- Testing rock properties for Natural Grade by Size Responses involves screening samples into a number of different size fractions and measuring the grade and mass of each.
- The test results can be displayed as **Response Curves.**



Strength of Upgrade	Response Ranking
Very Low	0 - 20
Low	20 - 40
Med	40 - 60
High	60 - 80
Very High	> 80

Mine Samples (~30t)

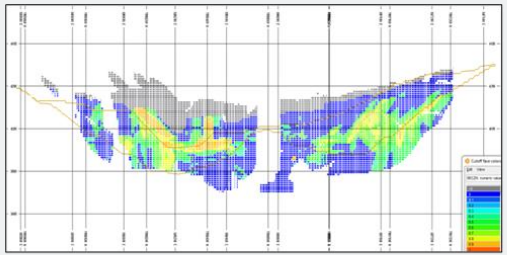
Sub-samples (~4t)

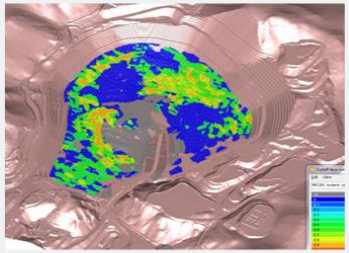
Laboratory Screening

A FULL SCALE PRODUCTION TRIAL & A BILLION DOLLAR PRIZE

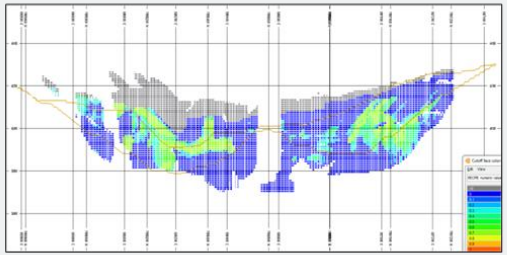
- Amenability testing indicates low waste halo (blue) and mineralised waste stockpiles show high promise for upgrading with Grade Engineering
- A full scale production trial has commenced
- The “size of the prize” is to reclassify these targets into ore feed – up to 1B$ in value (Extending LOM)

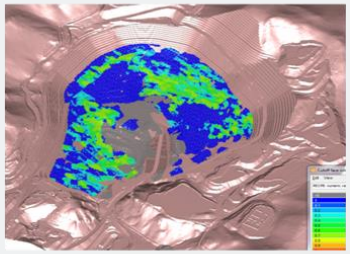
Zn Recovery



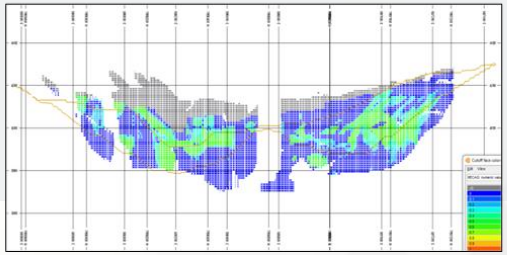


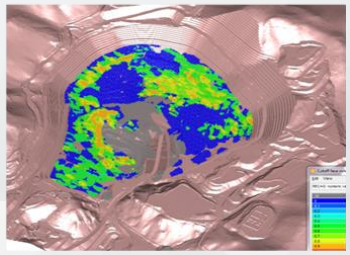
Pb Recovery





Ag Recovery





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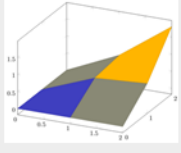
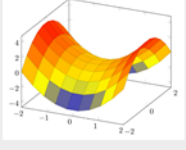
IES: VALUE DRIVEN BY OPERATIONS E.G.

BHP · ANGLO AMERICAN · ANGLOGOLD ASHANTI · Teck · Sumitomo Corporation

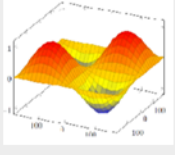
Cloud based mass simulations to optimise production (e.g. M2M) & define optimal Grade Engineering options & downstream processing for blasting, screening & sorting



- **Current consultant simulator**
  - 10s of simulations
  - Slow: manual operation
  - Accurate point prediction, poor trends



- **Usual site simulator (Excel)**
  - 100s of simulations
  - Medium: spreadsheet
  - Limited point prediction, good trends



- **Next Gen simulator (IES)**
  - 1,000,000s of simulations
  - Fast: cloud scalability
  - Good point prediction, good trends

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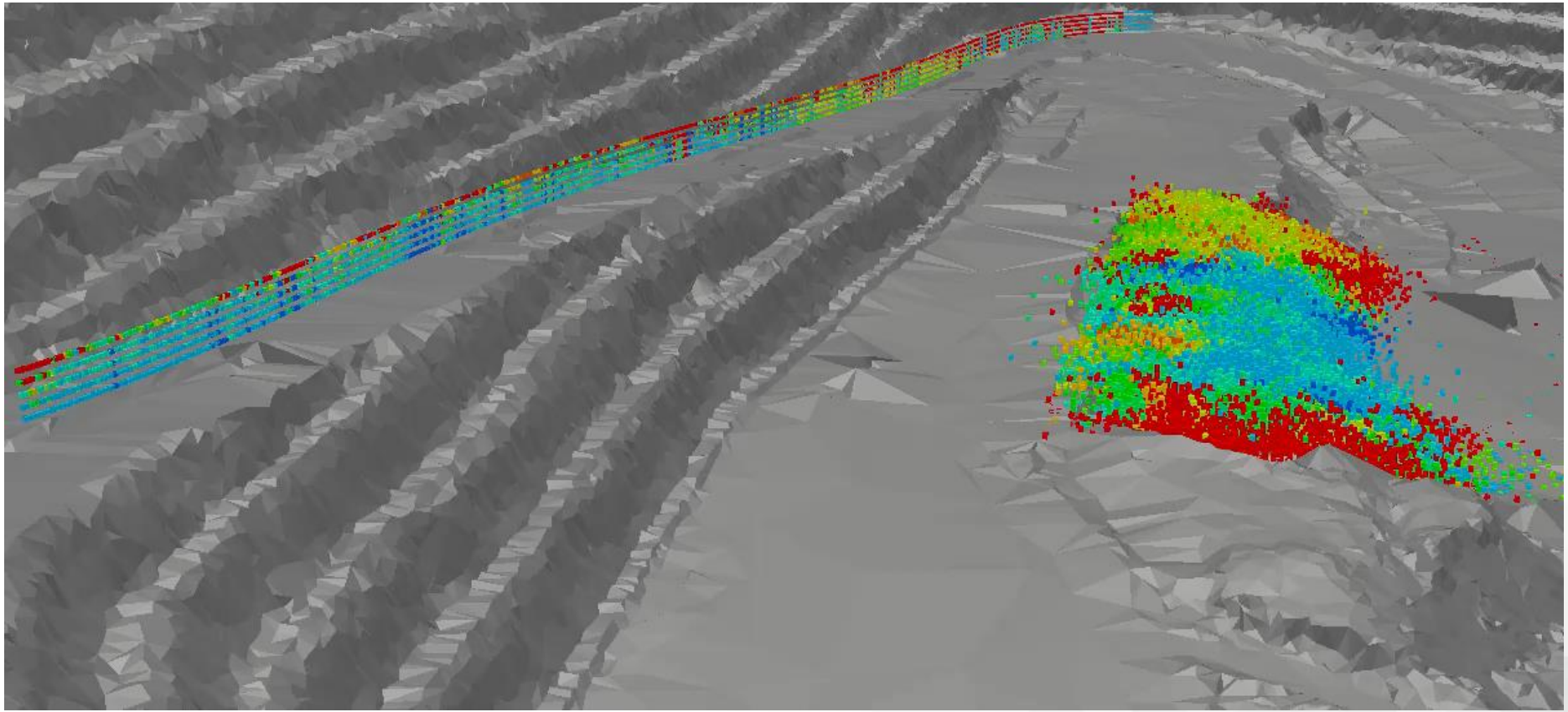
INTEGRATED GRADE ENGINEERING & IES:
LINKING SPATIAL & TEMPORAL



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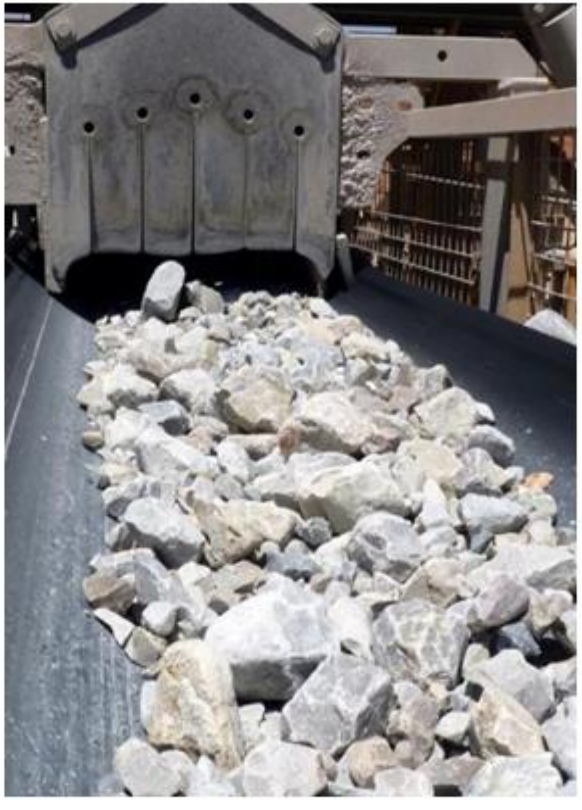
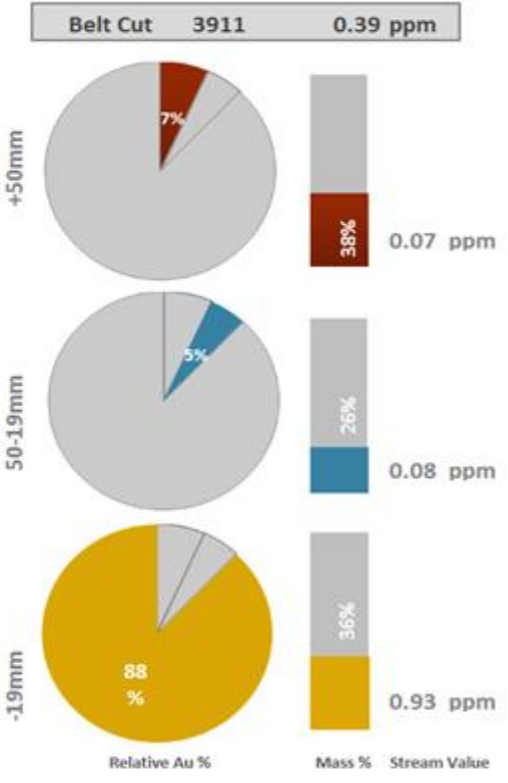
SEPARATING ORE FROM WASTE: GRADE ENGINEERING®

Grade Engineering® is an integrated approach to coarse gangue rejection matching separation technologies to ore specific characteristics to unlock value.

Grade Engineering Technologies

- Preferential Grade by Size Deportment – using screens
- Differential Blasting for Grade – using screens
- Sensor Based Bulk Sorting – additional value
- Sensor Based Stream Sorting – additional value
- Coarse Gravity Other Separating / Gangue Rejection Technologies





A simple example - data from operating Au mine

SENSOR FUSION: ADDRESSING GE LEVERS OTHER THAN SCREENING

Some Examples:

BHP, Anglo American, Newcrest, assessing a variety of sensor combinations, including e.g.

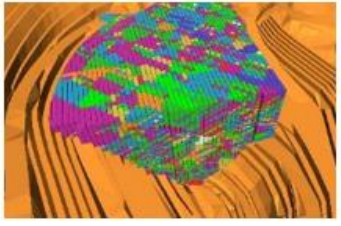
- ***Down Hole PGNAA***
- ***Cross Belt PGNAA***
- ***Cross Belt Magnetic Resonance***
- ***On-bucket XRF***

Particle Sorting (Various) through the Kalgoorlie Innovation Hub e.g. AGA

Heterogeneity & Sensor Landscape studies Teck & AGA

CRC ORE DELIVERY THEMES: INTEGRATED SOLUTION STACKS

DEFINE | EXTRACT | DELIVER



GE-enabled block models and mine plan optimisation

Instrumenting the bench with on-line data flows

Crushing and coarse separation in the pit

Combining Grade and Throughput Engineering

On-line sensing and separation of coarse streams

LIBERATE | RECOVER | CONTROL

Sustaining 'Whole of System' value

Optimising system value for energy, water and environment

IES-enabled integrated simulation across value chain

GE-enabled circuit design and advanced process control

Energy efficient enhanced coarse liberation

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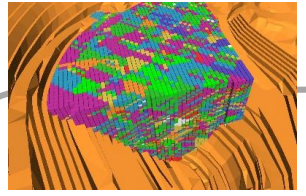
DIFFERENT INTERESTS FOR EACH OF OUR PARTICIPANTS

E.G. ORICA



GE-enabled Block Models and Mine Plan Optimisation

Instrumenting the bench

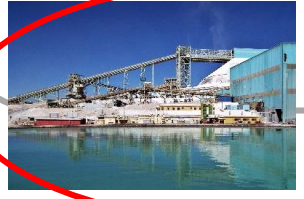
Sensing and coarse separation in the pit

Delivering combined Grade and Throughput Engineering

Sustaining value with Mine Performance Management

CRC ORE Delivery Themes

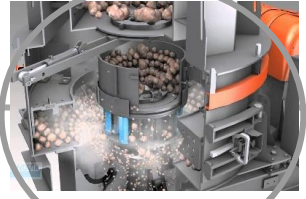
On-line sensing of coarse streams



Optimising system value across all operational metrics

IES-enabled integrated simulation across value chain

GE-enabled circuit design with advanced process control



Energy efficient enhanced coarse liberation

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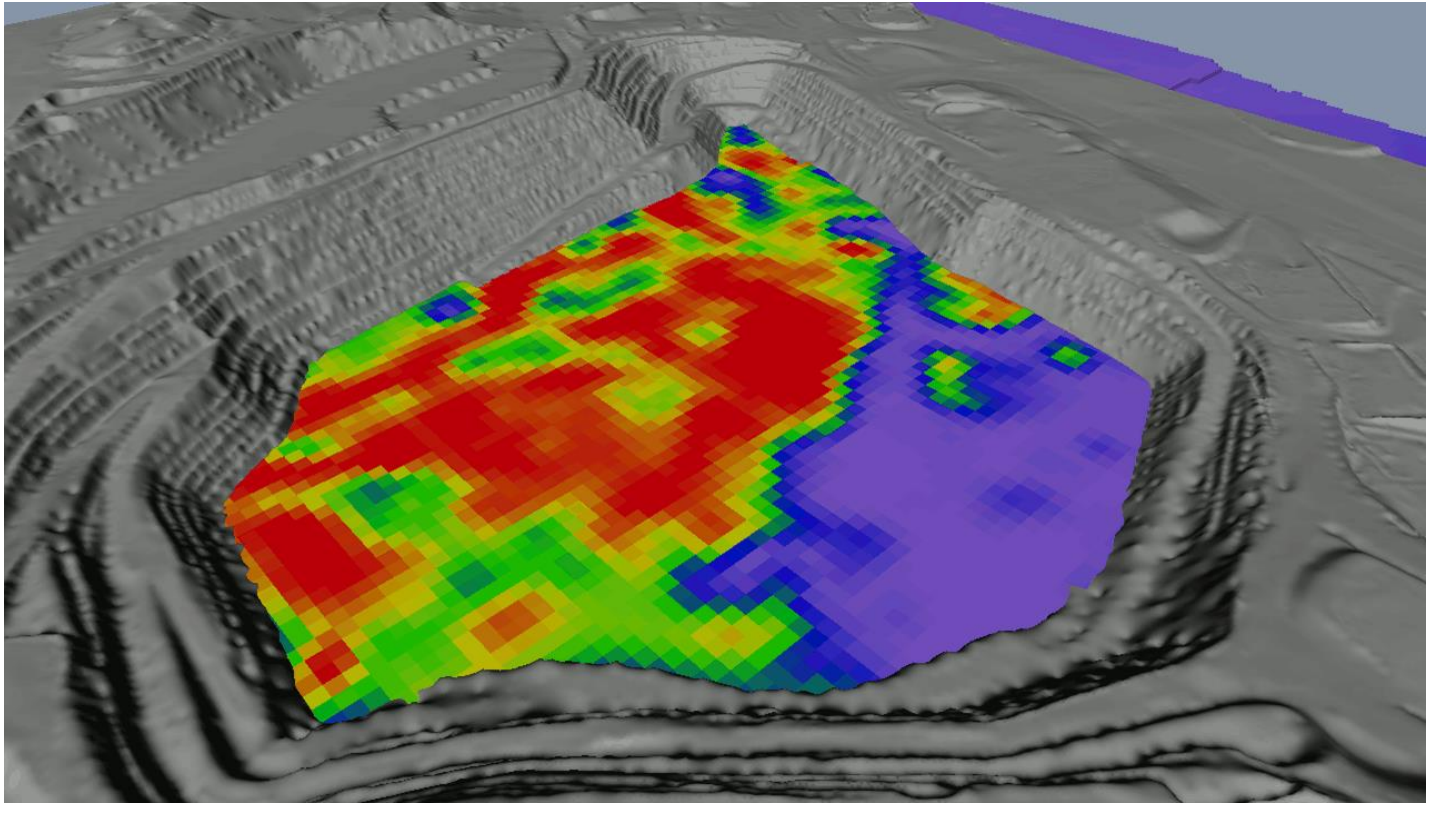
OUR FACILITATION ROLE E.G. MINERS & METS : INSTRUMENTING THE BENCH

NOW AN ACTIVE CONSORTIA:
ORICA, IMDEX, METS IGNITED, TECK & ANGLO-AMERICAN



IMDEX™ REAL-TIME SUBSURFACE SOLUTIONS

ORICA

METS IGNITED

ANGLO AMERICAN

Teck

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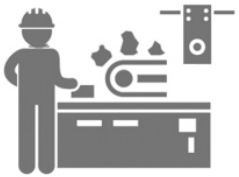
RESEARCH PROGRAMS:

UNDERPIN EXISTING & DEVELOP NEW TECHNOLOGIES

Program 1 Define
Improving feed quality



Program 2 Separate
Enabling mass separation

Program 3 Extract
Increasing extraction efficiency

Program 4 Control
Maximising system-value

mriwa
Minerals Research Institute of Western Australia

AMIRA INTERNATIONAL

NRC·CNRC Canada

The University Of Queensland

Curtin University

mining3
TRANSFORMINGMINING

The University of Adelaide

UTAS

QUT

CSIRO

clareo

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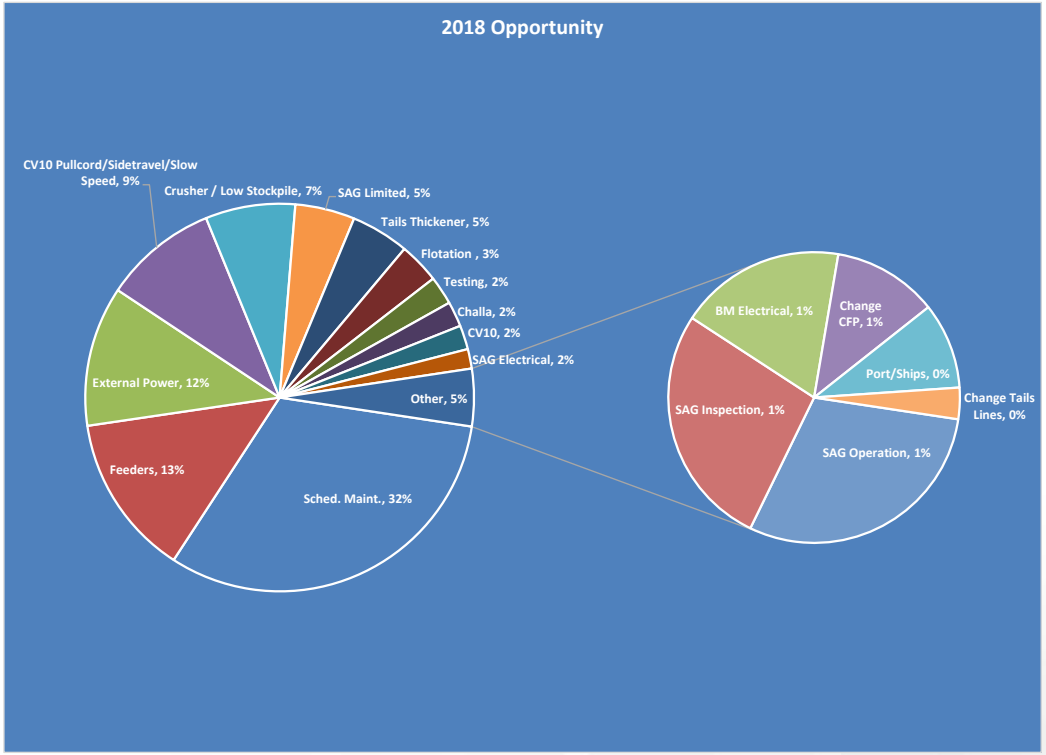
DEPLOY & SUSTAIN: THE CULTURAL PIECE
E.G. P4 WITH QUT & JAPANESE MANUFACTURING @ MSC

- "Modular" Innovation – "plug and play"
- New innovations quickly deployed and tested
- Approach is common <u>outside</u> the mining sector
  e.g. Ikea, Coca Cola, Nestle etc.
- Equipment bristling with sensors – we <u>measure</u> what we do
  e.g. opportunity costing – METS Engagement, Optimisation Strategies & opportunity to integrate with IES



Year	Tonnes	Value
2015	1,282,340	$ 57,978,758
2016	1,127,829	$ 68,758,285
2017	946,141	$ 62,183,940
2018	1,047,097	$ 68,818,761
Total	**4,403,407**	**$ 257,739,744**

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QUT

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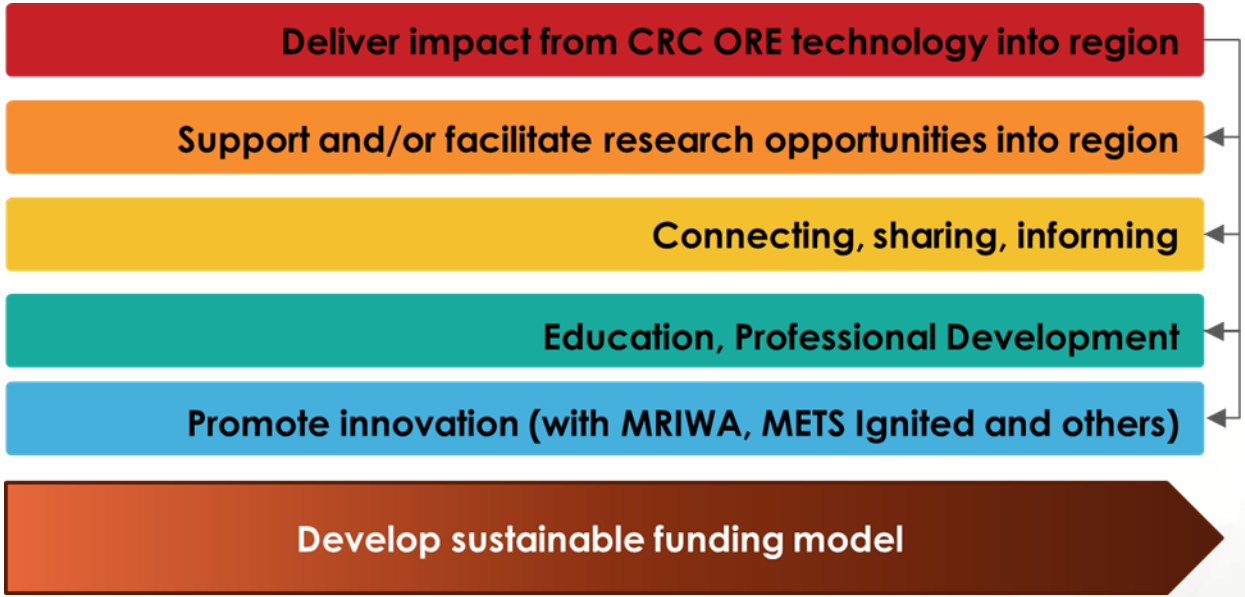
KALGOORLIE-BOULDER
MINING INNOVATION HUB

THE KALGOORLIE-BOULDER MINING INNOVATION HUB

ITS PURPOSE



The Hub will be run as a node of CRC ORE for two years

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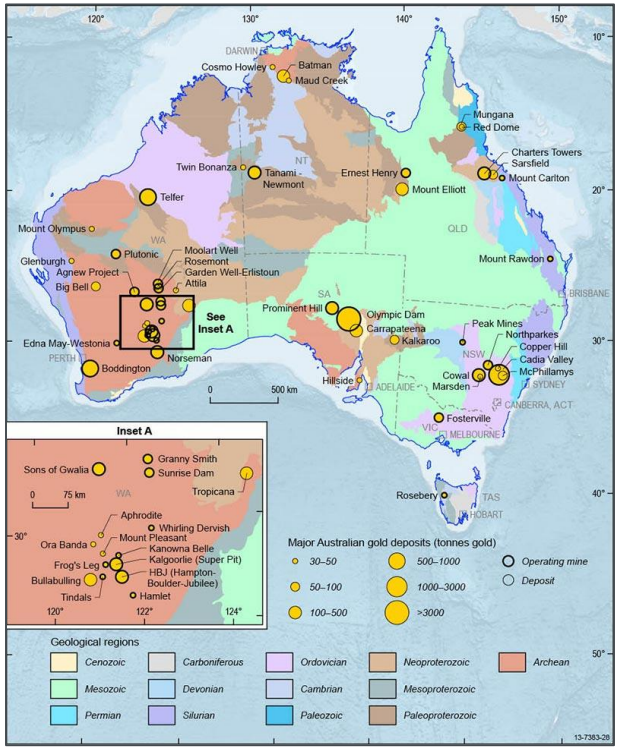
KALGOORLIE-BOULDER
MINING INNOVATION HUB

GUIDING PRINCIPLES



Must be sustainable

Must not compete with existing organisations

Must be driven by industry

Should align with the Kalgoorlie – Boulder Regional Growth Plan

Should be independent

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KALGOORLIE-BOULDER
MINING INNOVATION HUB

KEY SUPPORTERS OF THE HUB'S DEVELOPMENT: SET UP OTHERS IN AUSTRALIA?

mriwa
Minerals Research Institute of Western Australia

METS IGNITED
Engage in our future

City of KALGOORLIE-BOULDER

CME

WASM Curtin University

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Program

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SOME REFLECTIONS E.G. IMARC

- There are a number of ways to effect gangue rejection at scale
- Grade Engineering (e.g. ore heterogeneity and “sortability”) attributes can now populate block models & extraction scheduling modelled

- Ore tracking & linking of spatial and temporal data can optimise productivity
- Downstream processes need to be optimised to take advantage of Grade Engineering

- Mass simulations and multiple processing strategies can now be quickly modelled
- Conventional thinking destroys value in metal production, energy and water usage
- It is possible to combine more creative extraction systems with metrics to benchmark process performance as “best in class” across operations

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THE YEAR AHEAD: KEY ELEMENTS CONSISTENT WITH OUR STRATEGIC PLAN

- Successful GE production trial & value generation at MSC
- A suite of learnings from “Enhanced GE” site based studies
- Value generation from IES site engagements
- First drafts of “Brown Book” & associated “glossies”
- Technology transfer & commercialisation well underway for GE and IES
- A successful first year for the Kalgoorlie Hub
- Outcomes from our research portfolio realising tangible benefits & impact with Industry
- Exploring capacity building in research
- Transition planning for “End Of Term”
- Commonwealth Milestones
- Maximise value for our EP’s

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