Effective implementation of tactics: low hanging fruit in mining operations

It’s the System – Stupid!

Manufacturing = Just-in-time
Mining = Just-in-case!

- Industries differ in at least two important respects:
  - Ability to know and control the environment
    - *Geological surprises*
  - Hostile nature of the mine environment
    - *Equipment reliability*

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Strategic and tactical are military terms

- Strategy = science and art of military command exercised to meet the enemy in combat under advantageous conditions
- Tactics = science and art of disposing and manoeuvring forces in combat

- Mining companies tend to be good at long-term, strategic, planning
- But poor at short-term, tactical planning because of:
  - Geological surprises and
  - Poor equipment reliability
- Analogy with military where “fog of confusion” on battlefield makes the effective implementation of tactics difficult
- Technology is now being deployed by the military to overcome this confusion
  - Military approach is the development of ***situational awareness***
- Different technology but a similar approach is being developed for and applied in mining operations

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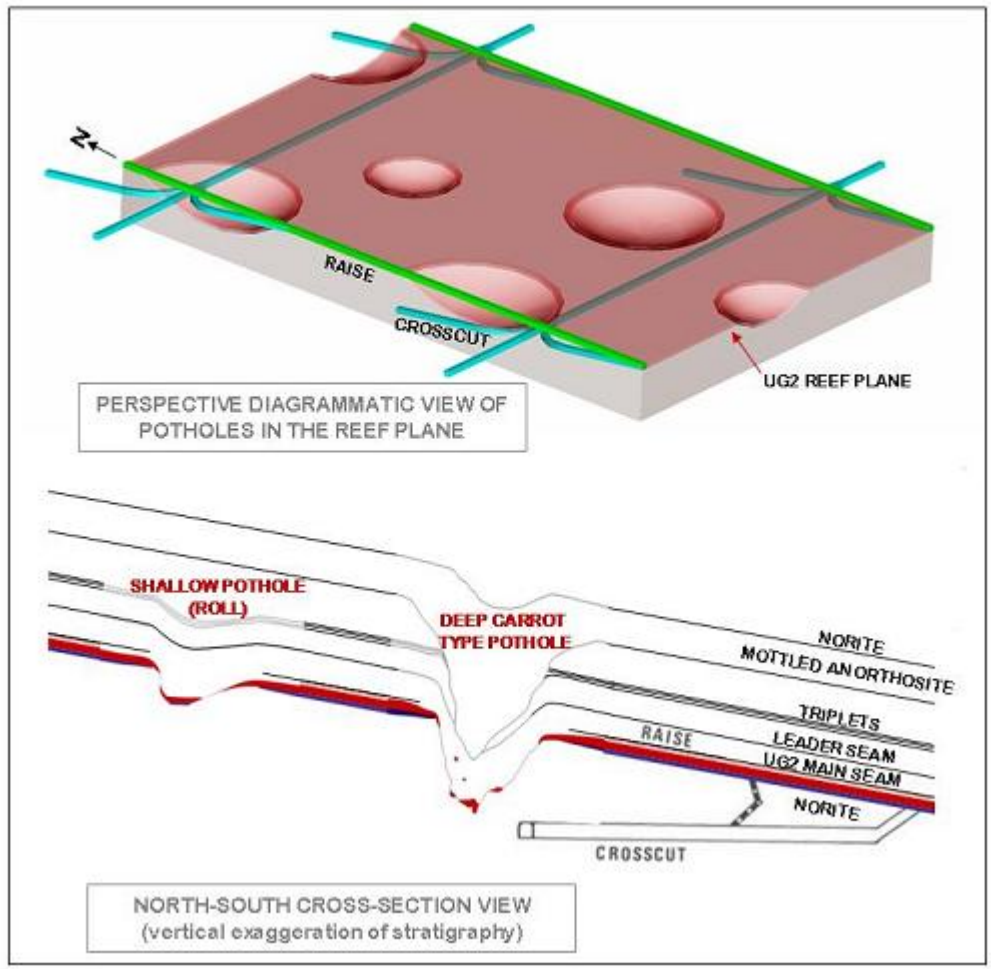
Resolving Geological Uncertainty

- Geophysics – widely used for exploration and in oil industry
- BUT, it has taken recent improvements in: computation, communications, and 3-D visualisation for this technology to start to be used routinely in in-mine exploration and planning
- Geophysics can characterise not just orebody geometry but also geotechnical properties
- **World-class work in Australia in:**
  - **Seismics - Brian Evans, Curtin Uni, Peter Hatherly, Sydney Uni**
  - **Borehole Radar – Mason, Sydney Uni**



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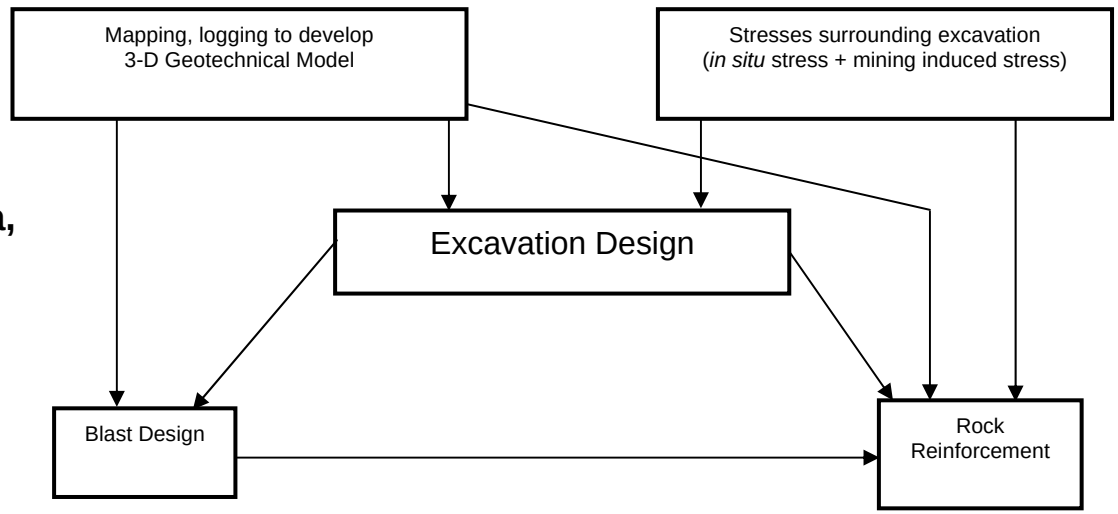
Geomechanics

- The design of an excavation and, indeed, the entire mining process, is largely an exercise in geomechanics
- Inputs required are maps of orebody geometry and, ideally, rock properties: strength, discontinuities, AND
- Stress
- Combination of design (shape) requirements and geometry and property info are inputs to blast design
- Rock reinforcement required is a consequence of in situ + mining stresses and blast design

Australian expert groups in coal led by Prof Hebblewhite, UNSW; in hard rock led by Prof Villaescusa, Curtin Uni; and in mass mining led by Dr Chitombo, UQ



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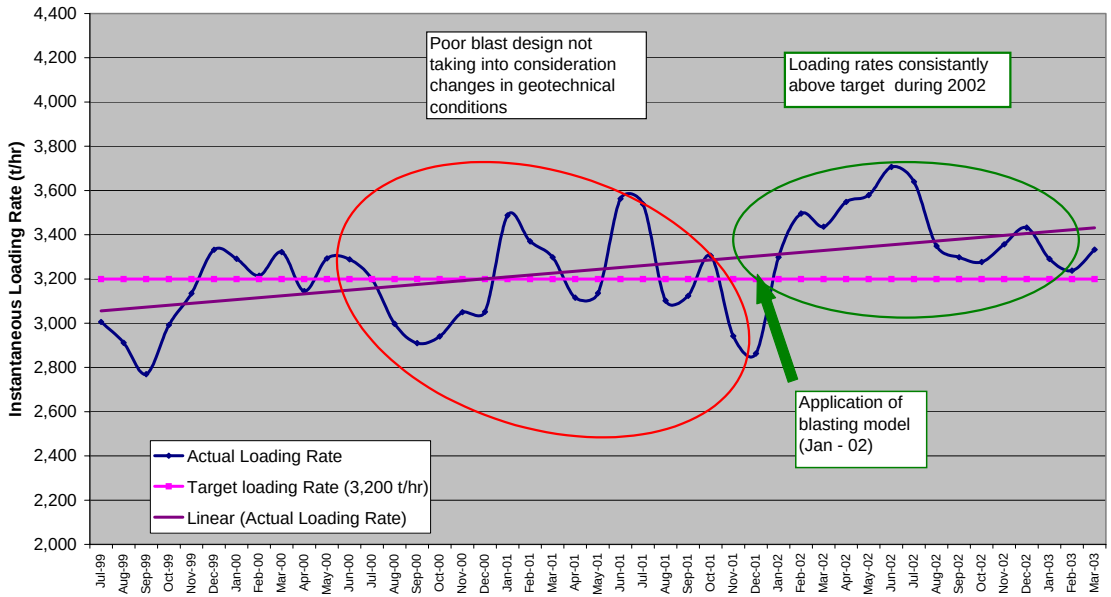
Production Control: Fragmentation

- Fragment size distribution from a blast is largely determined by the in situ discontinuities in rock mass
- Earlier approach of minimising costs of drill-blast proved false economy
- Need to incorporate geotechnical parameters in blast design and design blast for downstream customers
- Graph (Bye, 2005) plots loading rate before and after effective blast design implemented
  - Cost savings = US$4.6M in year (open pit platinum mine)



Expert group in Australia led by Dr Peter Knights

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Production Control: Loading (1)

- Effectiveness of digging operation depends on:
  - Rock fragmentation
  - Appropriate selection of digger
  - Position of digger with respect to muckpile and truck
  - Experience of operator, and
  - Dipper design
- Scale modelling can produce significant insights into digging process
  - 25:1 model
  - Characteristics of muckpile measured in field and reproduced in lab
  - Different dipper designs evaluated
  - Payload increases of 30% achieved

Expert group in Australia led by Dr Paul Lever

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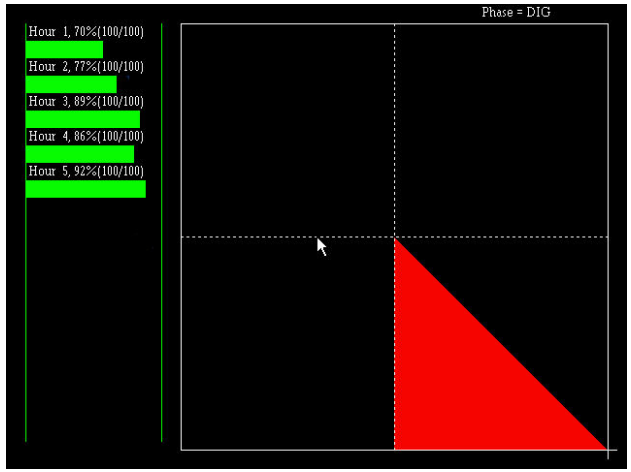
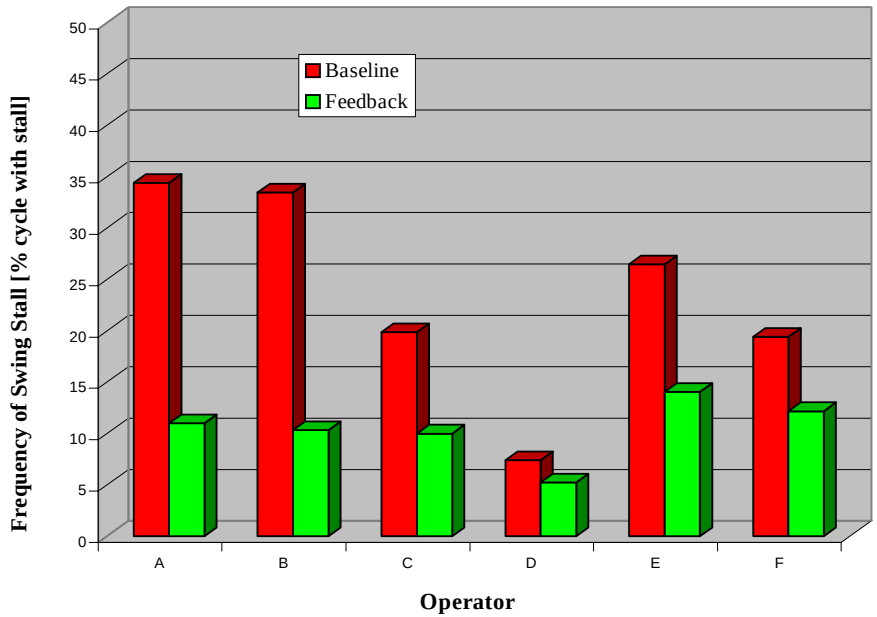
Production Control: Loading (2)

- Operator behaviour is the principal cause of equipment damage = poor reliability
- Operators generally do not have the information they need in the cab to operate the machines without damage
- Classic example is swing stalls caused by swinging in the bank

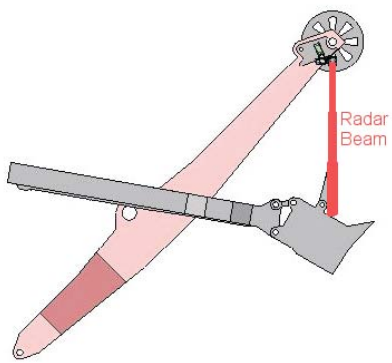
Technology developed and owned by CRCMining; licensed for electric rope shovels to P&H

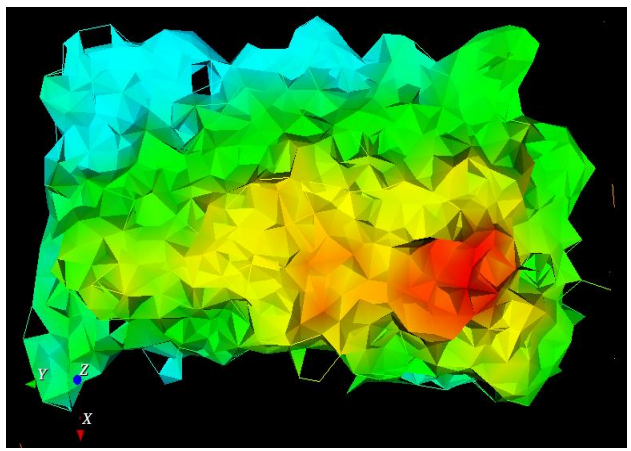




Production Control: Loading (3)

- Payload weighing system
  - **Developed by Dr McAree's team at Uni Queensland, licensed to P&H**
- Radar scanning system
  - Monitors fragment size distribution and bucket fill (gives bulk density)
  - Also monitors missing bucket teeth
  - **Developed by Dr Brooker, ACFR, Sydney Uni and Dr Widzyk-Capehart, Uni Qld**





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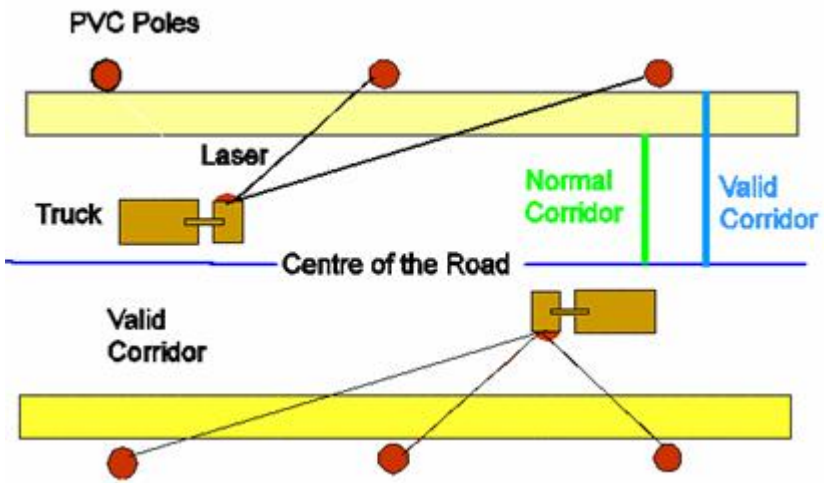
Production Control: Hauling

- Driver alert system
  - Uses scanning laser to define an allowable corridor for trucks on haul road
  - Helps prevent accidents by sounding alarm if truck wanders outside corridor
  - Commercial product installed at Alcoa's Huntly and Willowdale mines
  - Technology licensed to Komatsu



- **Technology developed by Prof Nebot's ACFR group at Sydney Uni**

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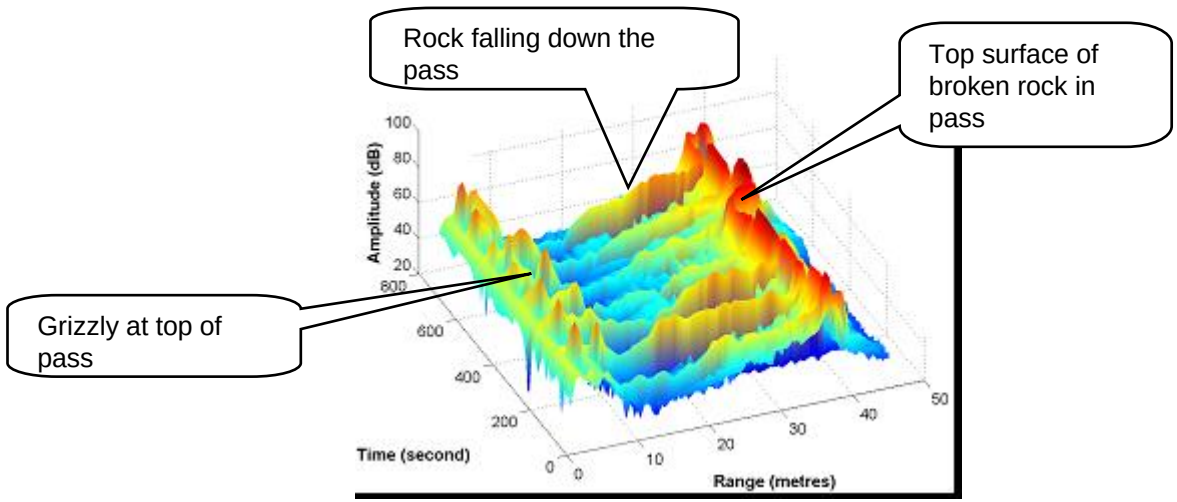
Production Control: Spatial Measurement

- Orepass and stope radars
  - Measure filling operations and levels of fill
  - Used in mines around the world
  - **Developed by Dr Brooker, ACFR, Uni Sydney**
  - **Commercialised through spin-off company AcuMine**



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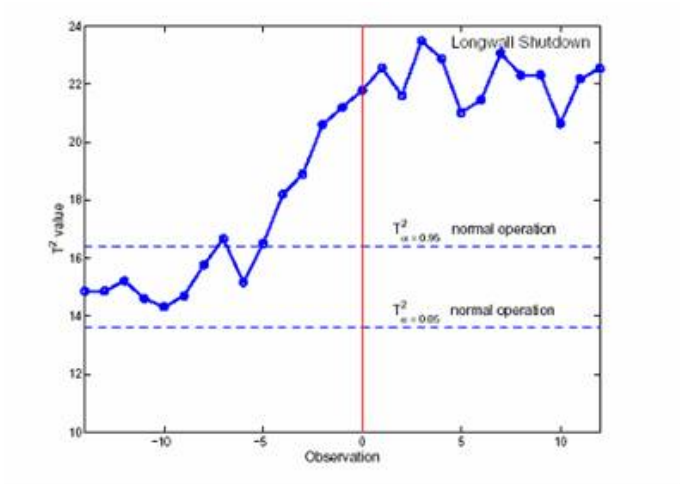
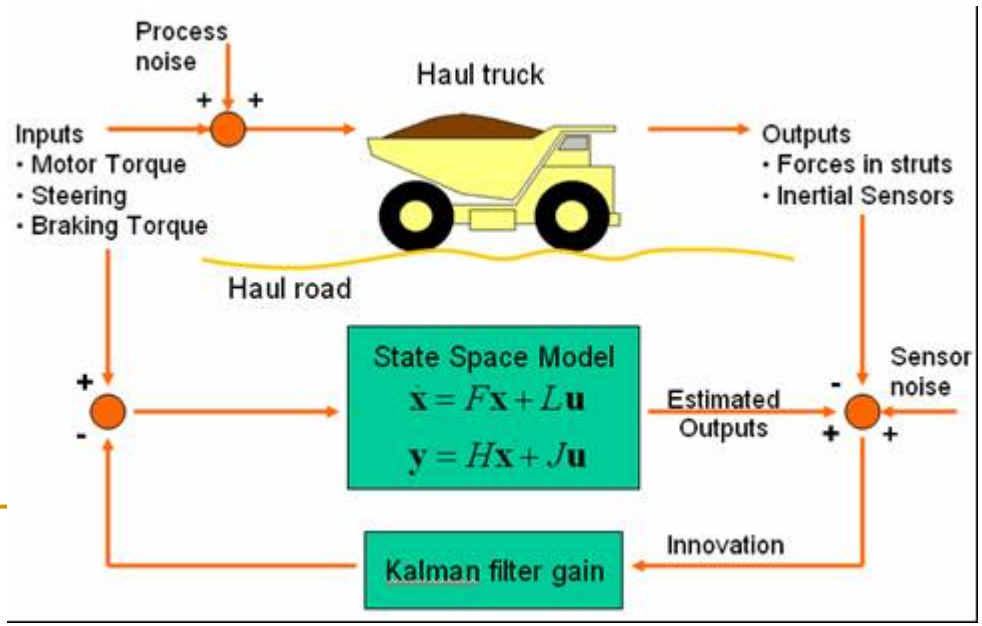
Equipment Reliability

- Availability and utilisation of mining equipment is notoriously low compared with other heavy industries
- Worrying is the fact that many failures are both acute (take a long time to repair) and chronic (occur frequently)
- Bongers (UQ PhD, 2003) developed a combination of multivariate statistical procedures and neural networks to predict failures on a longwall face
- Siegrist (UQ PhD, 2004) developed methodology to monitor conditions causing wear and premature failure of tyres





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Summary and Conclusions

- Australian military is developing a system they call ***network centric warfare***
  - "Everybody in the organisation is connected – when a target or threat is detected everybody who needs to know about it finds out immediately. Intelligence and logistics information is updated constantly and is available to all who require it. NCW is about sensors, data links, and smart high-speed processors which turn raw data into useable information."
- Military's goal is shared situational awareness, whereby critical information is fed to key decision makers on a need-to-know basis.
- The parallel with the mining industry is apparent
  - Tactical mine planning requires accurate information about the current situation
  - Also need to forecast how things are likely to change and react pro-actively
  - Need to reduce the frequency of unplanned incidents
- Currently mines are overloaded with data
  - **Situational awareness** requires that this **data** be processed into **information** and that this information be passed to the **right people** to be **acted upon**, thereby facilitating **operational control**
- We need **Network Centric Mining**
  - A range of technologies now being developed, mostly by research groups across Australia, will make this possible in the near future

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What is a Cooperative Research Centre (CRC)?

- Cooperative Research Centres (CRCs) are funded for a finite period (7 years) by the Commonwealth Government to:
  - Bridge the gap between research and industry
  - Solve specific problems
- Key features of a CRC are:
  - Research Program is driven by the research users, ie the industry
  - Research is performed cooperatively by several universities (and others)
  - Centre is established a an incorporated joint venture with an industry-dominated Board

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What is CRC Mining?

- Incorporated[1] Joint Venture between:

- Anglo Coal
- Anglo Ashanti Gold
- BHP Billiton
- Rio Tinto Technical Services
- Hamersley Iron
- BHP Billiton (WMC)
- Phelps Dodge
- Peabody Energy

- P&H MinePro
- Komatsu
- Caterpillar

- Universities of: Queensland
  Sydney
  Curtin
  Newcastle
  Arizona

[1]Tax-Exempt, Not-for-Profit Company Limited by Guarantee

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Research Partners

- University of Queensland
  - Mining Engineering
  - Mechanical Engineering
- University of Sydney
  - Australian Centre for Field Robotics (ACFR)
  - Mining Geophysics
- University of Newcastle
  - Electrical Engineering – Power Electronics
- University of Arizona
  - Mining and Geological Engineering
- Curtin University
  - Mining Engineering
  - Geomechanics – Underground Hard Rock

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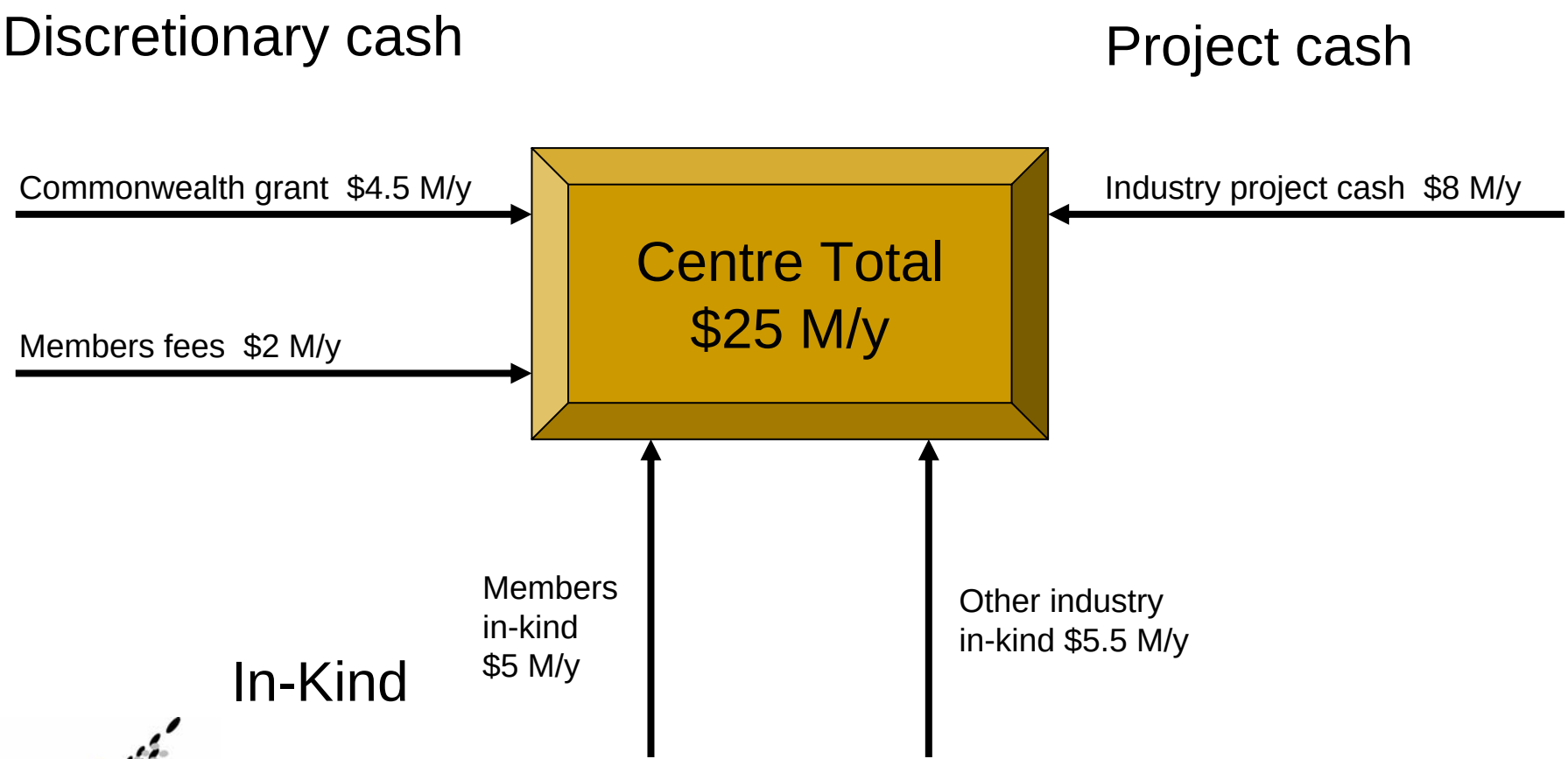
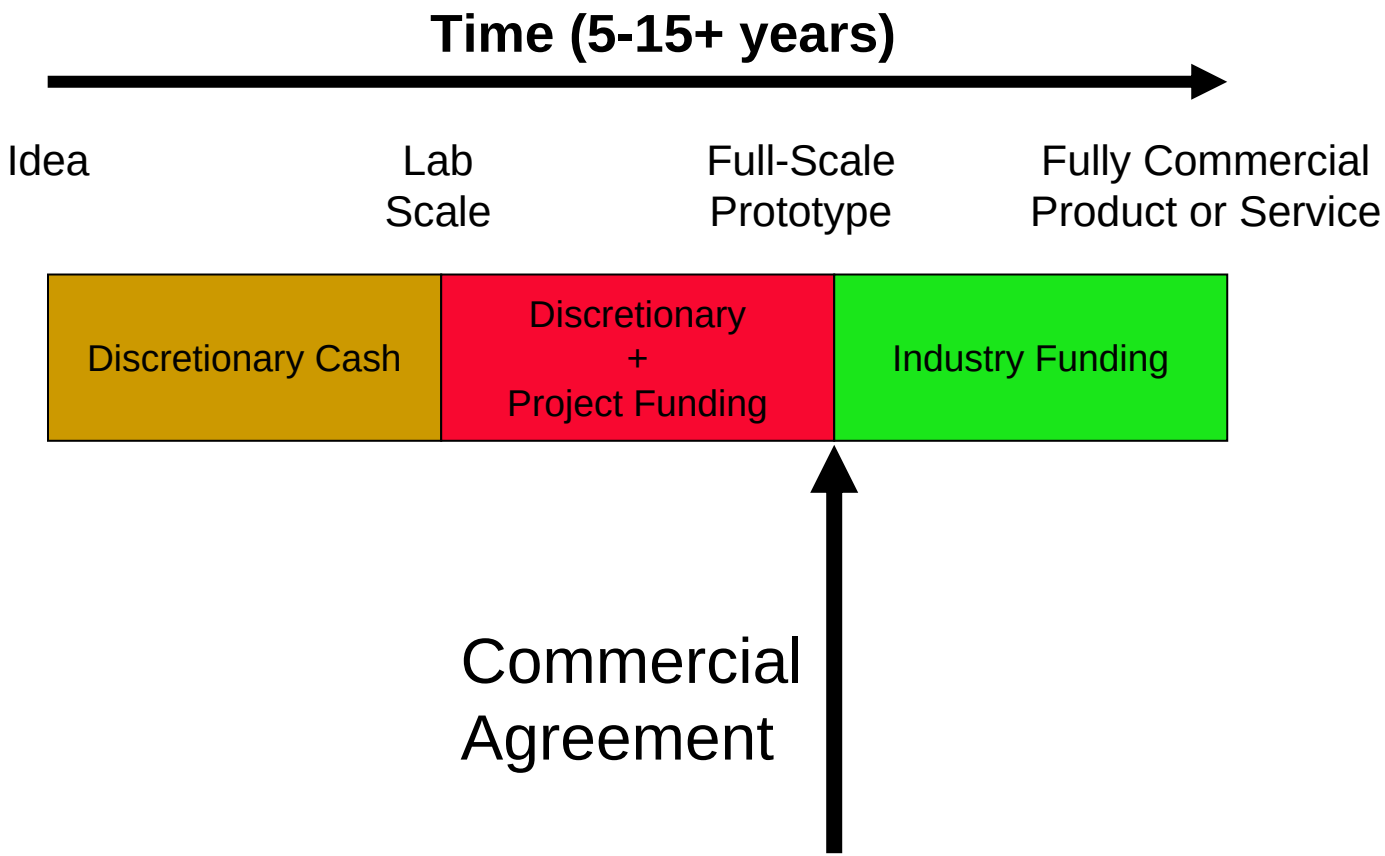
Centre Funding



Project Commercialisation



The End