Robots in Mining

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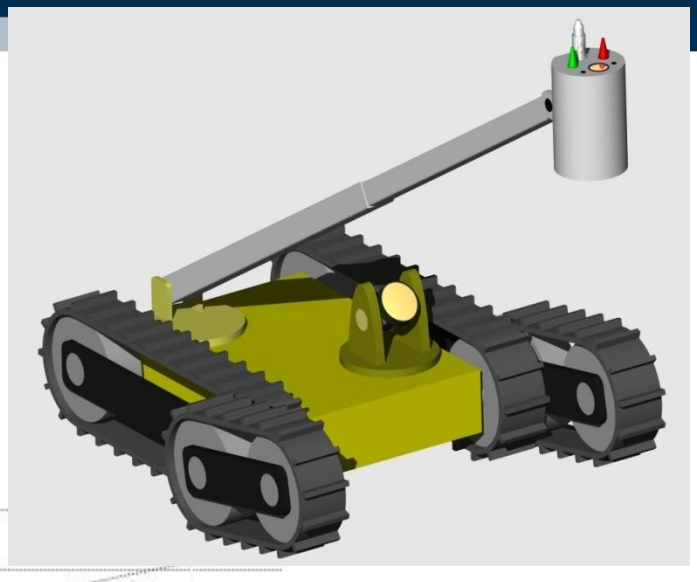
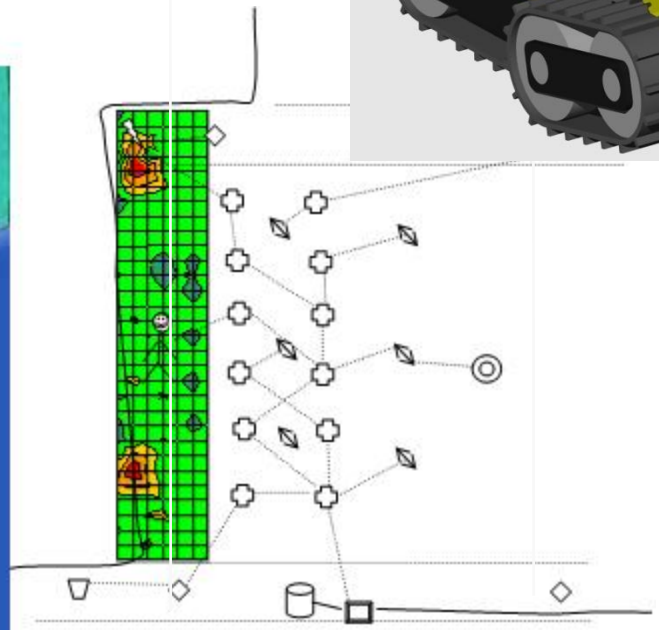
Outline of presentation

- Hypothesis
- Current mine safety statistics.
- Where is it unsafe?
- What do they do now?
- FOG – Fall of ground
- Who is at risk?
- What is the cost of incident?
- What can we do about it? The Robot Potential
- Technology
- Conclusion

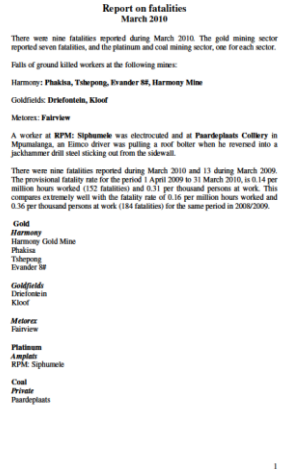
Yes Robots can improve mine safety

- Robot patrols unoccupied areas
- Generates a risk map
- Additional tool
  - Inform miners in making safe





Miner Safety Statistics



Report on fatalities
March 2010

There were nine fatalities reported during March 2010. The gold mining sector reported seven fatalities, and the platinum and coal mining sector, one for each sector.

Falls of ground killed workers at the following mines:

Harmony: **Phakisa, Tshepong, Evander 8#, Harmony Mine**

Goldfields: **Driefontein, Kloof**

Metorex: **Fairview**

A worker at **RPM: Siphumele** was electrocuted and at **Paardeplaats Colliery** in Mpumalanga, an Eimco driver was pulling a roof bolter when he reversed into a jackhammer drill steel sticking out from the sidewall.

There were nine fatalities reported during March 2010 and 13 during March 2009. The provisional fatality rate for the period 1 April 2009 to 31 March 2010, is 0.14 per million hours worked (152 fatalities) and 0.31 per thousand persons at work. This compares extremely well with the fatality rate of 0.16 per million hours worked and 0.36 per thousand persons at work (184 fatalities) for the same period in 2008/2009.

Gold
Harmony
Harmony Gold Mine
Phakisa
Tshepong
Evander 8#

Goldfields
Driefontein
Kloof

Metorex
Fairview

Platinum
Amplats
RPM: Siphumele

Coal
Private
Paardeplaats

1

- from DME (2010/03)
- March 2010
  - 490 000 employed
  - 400 000 suppliers[1]
  - 9 died, 7 in rockfall incidents [2]
- Prior year- March 2010
  - 152 fatalities (184 previous yr)
  - 0.14 per million hrs worked (0.16)
  - 0.31 per 1000 people at work (0.36)
  - Every 2.5 days a miner dies... In a potentially preventable accident
  - 1 over the course of this conference

1.. http://www.southafrica.info/business/economy/sectors/mining.htm
2. http://www.dme.gov.za/mhs/accident_stats.stm

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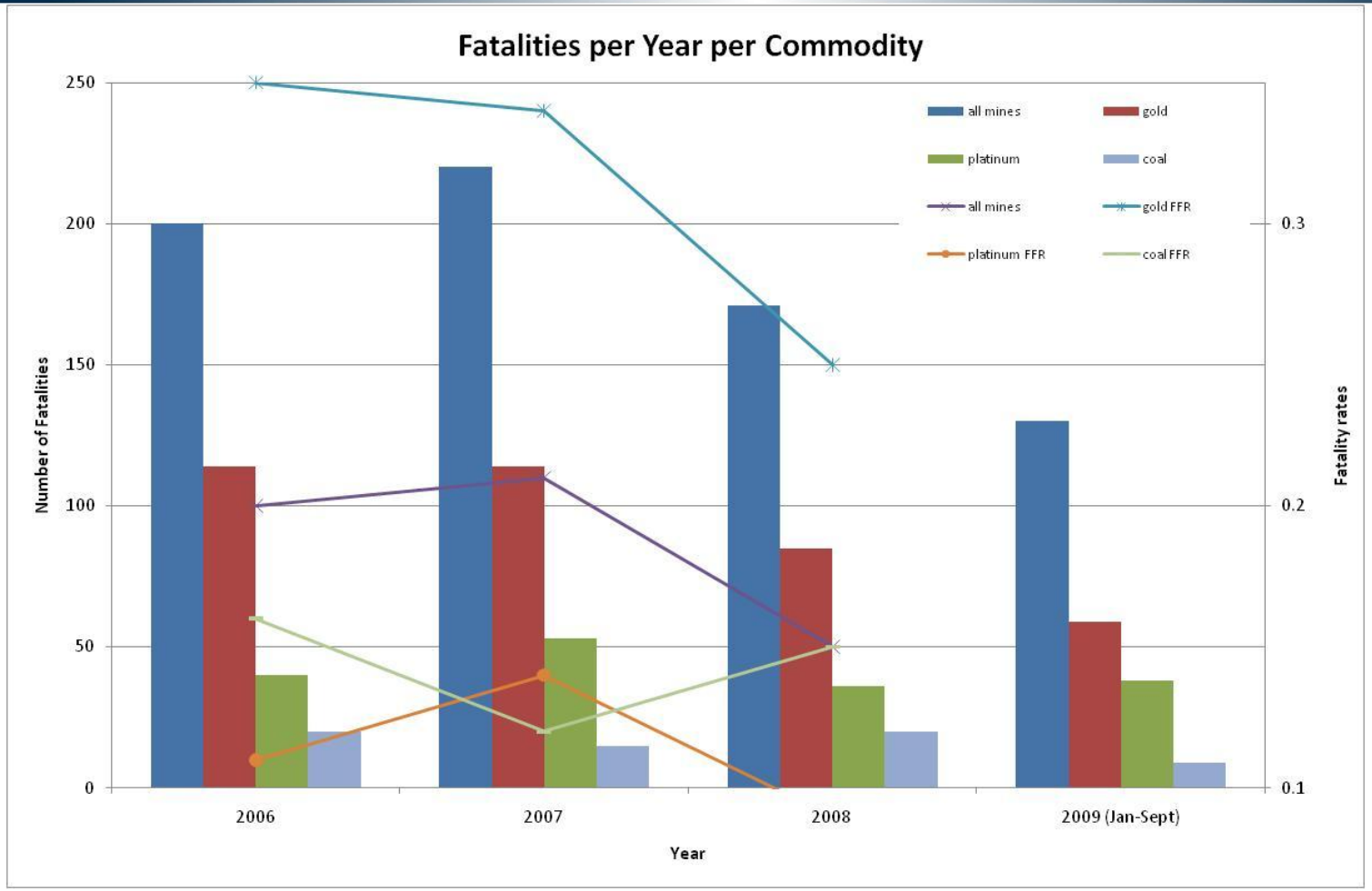
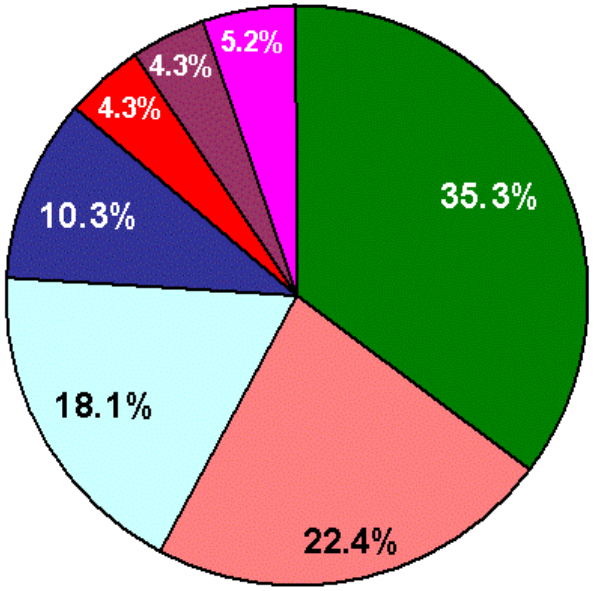
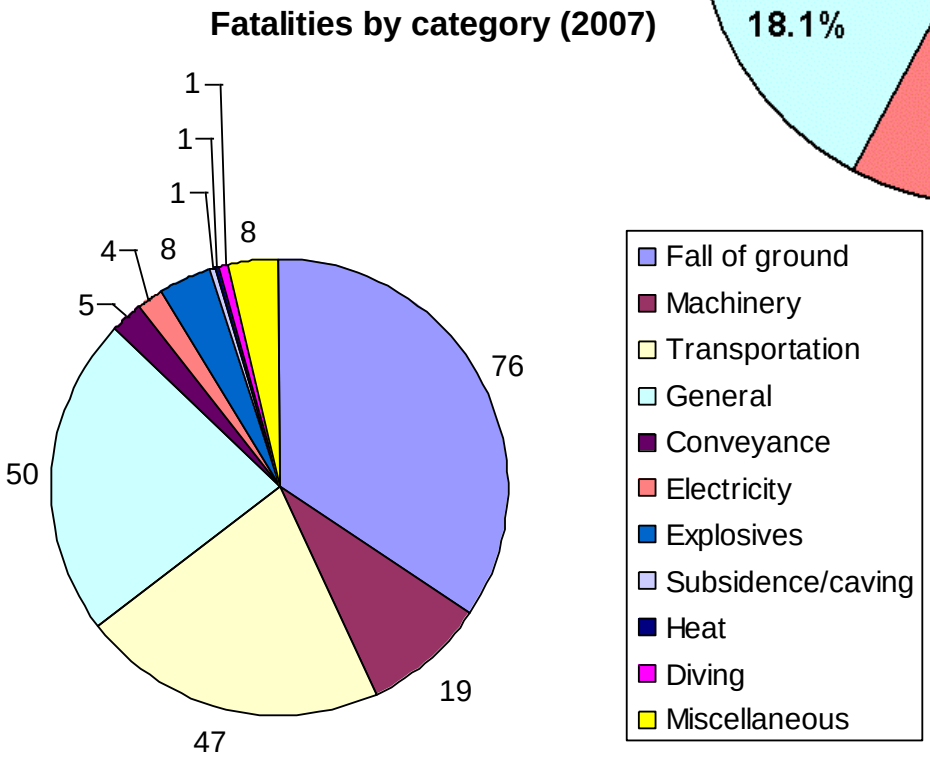
Annual Fatalities



- Good downward trend

What Kills People?





- South African Mining fatalities
- 2007 = 220 fatalities

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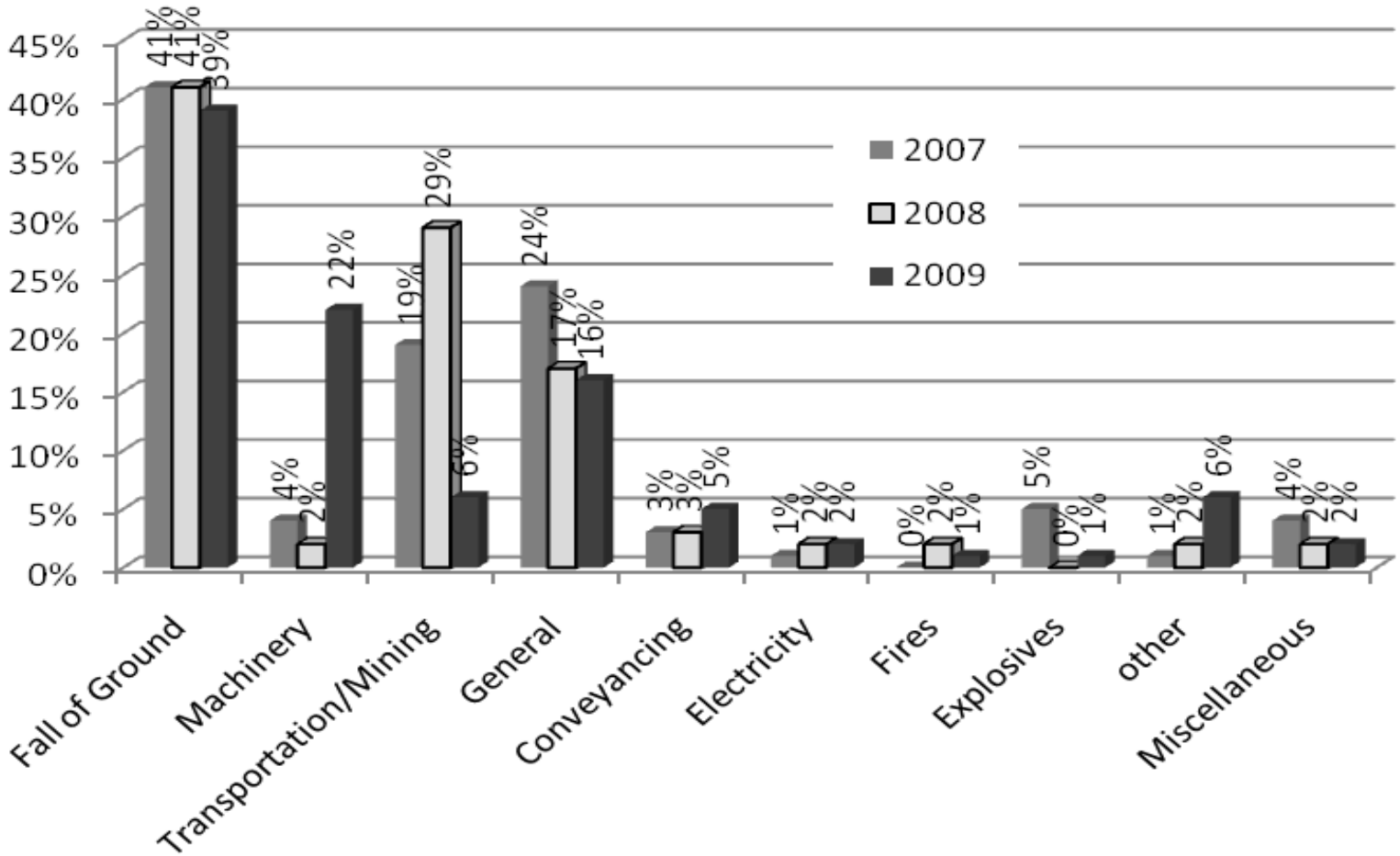
Change since 2007?



- Fewer fatalities
- Same ratios, same causes

What is a FOG and why does it happen?

- Statistical certainty unless the roof is supported.
- People are injured because:
  - Standing under unsupported unsafe hanging wall when it fails
  - Wrong place at the wrong time
  - The entry inspection is not done well, or at all
- 1993 examination of all FOG incidents indicated the primary reason was:
  - Inadequate examination, inspection or test[2]
- Everybody's job = Nobody's job
- There is no generic name for the job of "hanging wall examination"
  - Barring,
  - making safe,
  - early examination,
  - entry examination

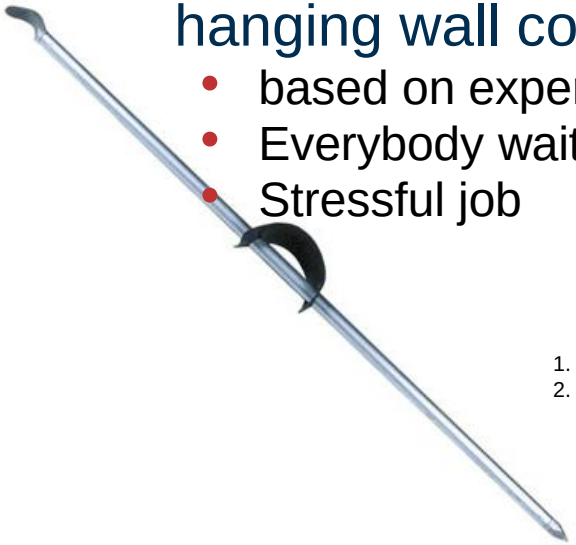
1. 1996 MHSC report GAP202
2. 1993 MHSC report GAP055

How is it prevented?

- Early entry examination process
- Taps the roof with hammer, based on what it sounds like
- Determine if it is unstable or not.
- If it is unstable – he can
  - Bar it down with pinch bar
  - Support with temporary support
  - Put in permanent support.
- executed
  - Re-entry into pre-worked area
  - After a passage of time
  - Shift change
  - After blast
  - When needed

What do they do exactly?

- Conventional Mining is cyclic –
  - Drill, charge, blast, clean
- Somebody determines if it is safe to work before miners enter.
- The worst job in the world?
- 50% of rock related fatalities are in the stope[1]
- Before human entry – somebody has to make it safe – responsibility of the shift boss.
- Pinch bar and hammer to detect and remedy unsafe hanging wall conditions
  - based on experience.
  - Everybody waits while it happens
  - Stressful job



1. 2001 MHSC report GAP727
2. 1993 MHSC report GAP055

The process

- Who is at risk?
  - Anybody involved in the making safe process
  - Anybody under unsupported ground
- The miner has tools to assist him
  - Pinchbar and hammer
  - Electric Sounding Device (ESD)
  - Thermal imaging
- A robot can be an additional tool

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Cost of an incident

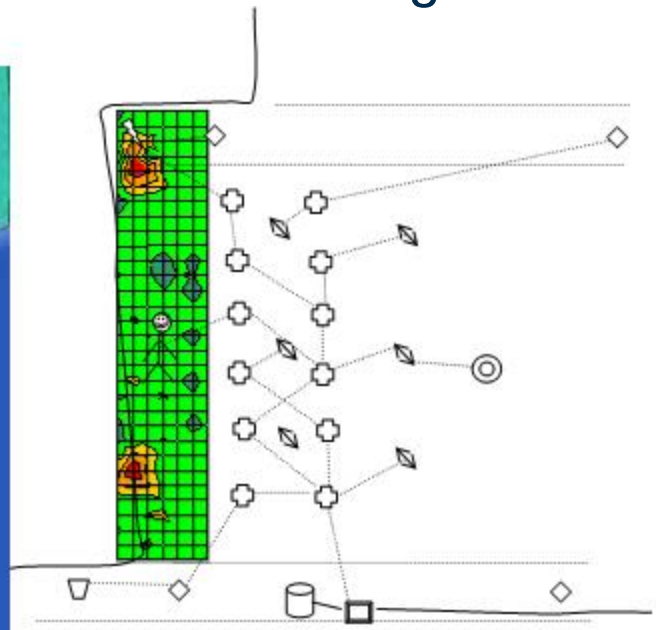
- Shaft/section closes for investigation – section 54
- Until all bodies are recovered
- In 2009, Anglogold Ashanti (AGA) SA ops lost 166 shifts,
  - with 98 of those due to Department of Mineral Resources (DMR) safety stoppages, and
  - 68 shifts due to voluntary safety stoppages.
  - During that period, there were 16 fatalities.
  - average cost of **R3 million/ shift** in lost revenue
  - this translates to **half a Billion Rand**
  - for a single gold mining company
- The industry cost?
  - 152 deaths
  - associated closures = R?

The Cost of inefficiency

- Mining is cyclic –
  - Drill, charge, blast, clean
- All blasts are co-ordinated in an empty mine
- Any single incomplete part implies a missed blast – and a missed cycle
- Blast ratio: number of blasts/number potential blasts
- Ideal = 100%
- Blast = 1.1m advancement, with 22 working days/month = 24m/month
  - Only 16m/month average
  - implying 66% blast ratio
- 1% improvement in blasts
  - = 1% more ore mined
  - = 1% more gold mined
- Millions to the bottom line
- Implication is a faster inspection
  - = better blast ratio = more profit

The Robots Potential to Assist

- Between blast and re-entry= 3 to 4 hours of unproductive time
  - fumes and seismicity
- Autonomous vehicle could patrol the area
- Generate a risk map of the upcoming shifts
- Akin to a weather map
- Faster making safe
- Indication of unsafe area= less standing in unsafe areas = fewer incidents



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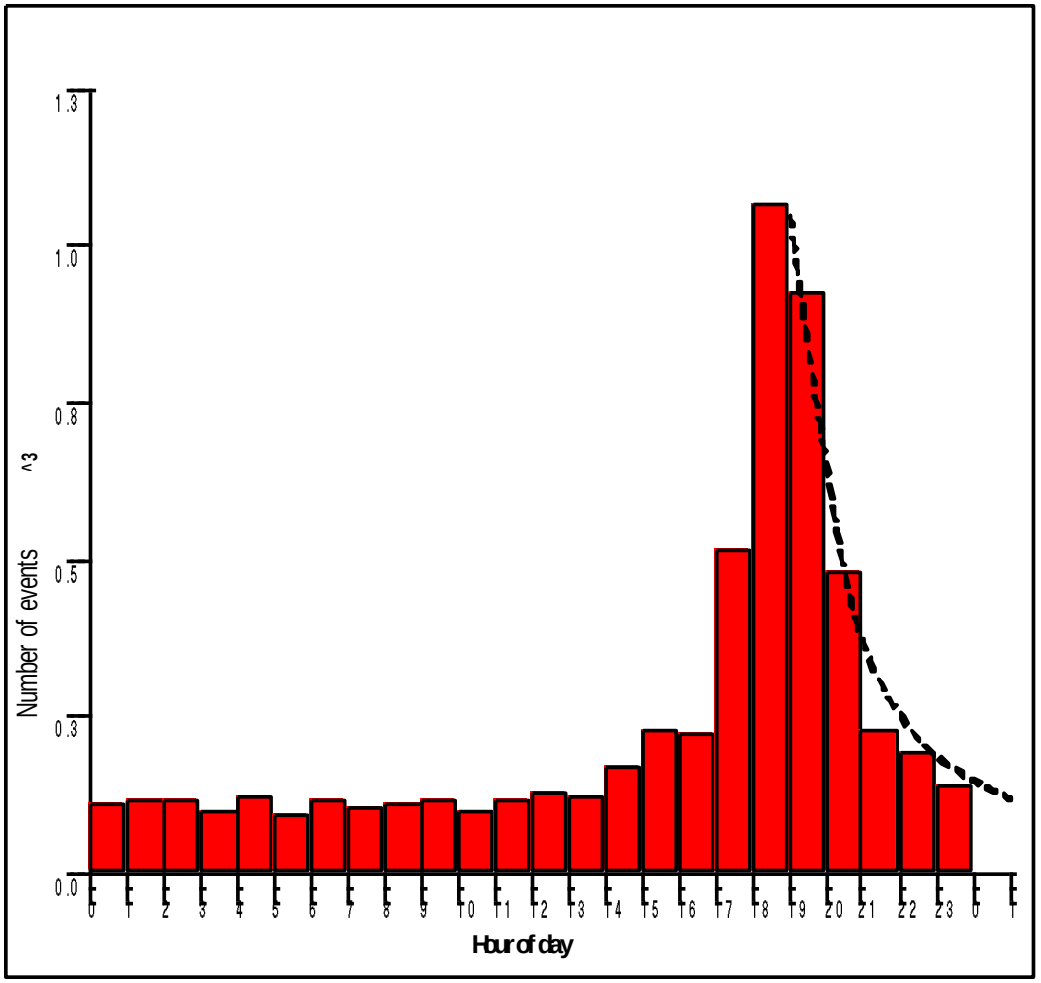
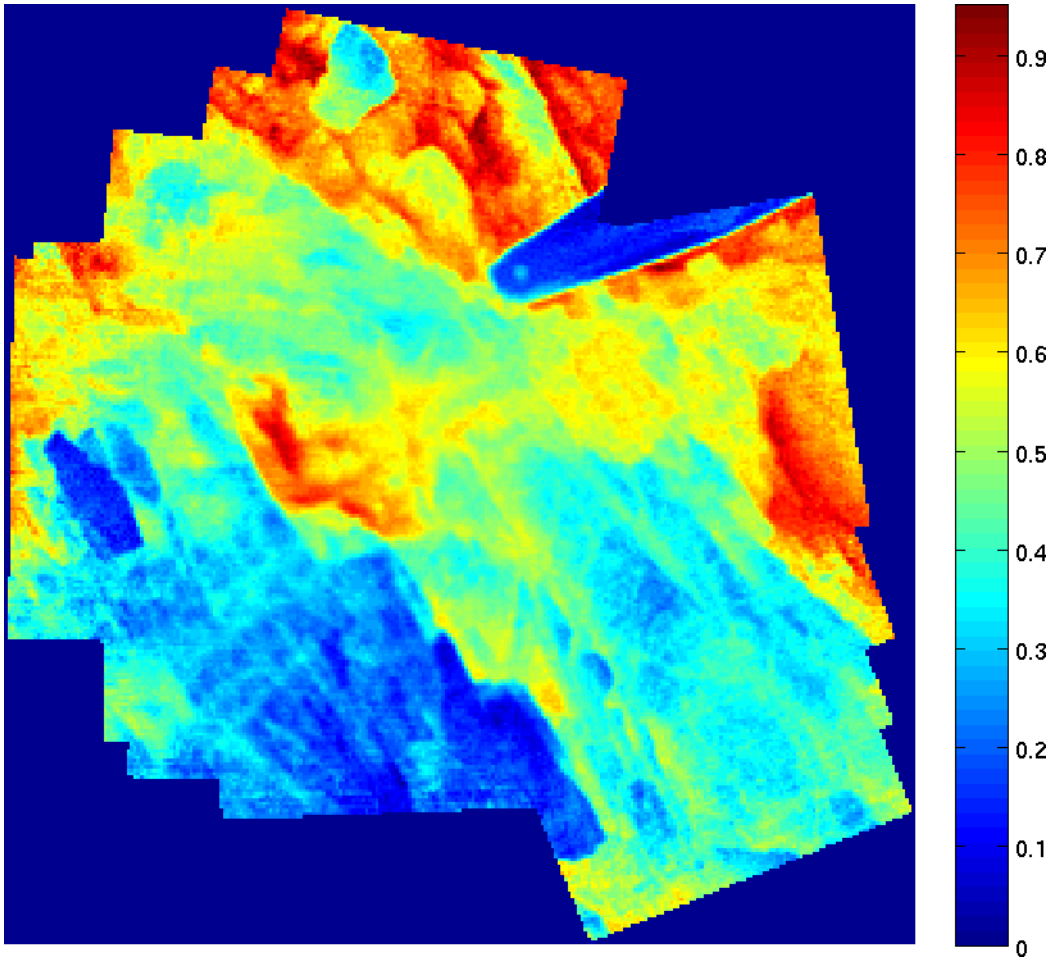
Blast Seismicity



- Increased after blast
- Time decay to background levels
- Typical 3 to 4 hours for mine wide blast

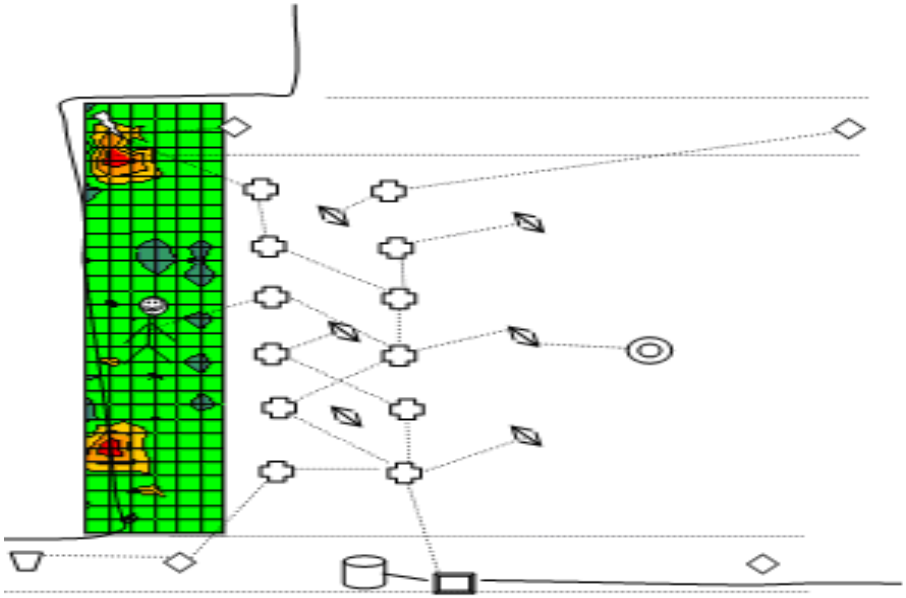
Thermography

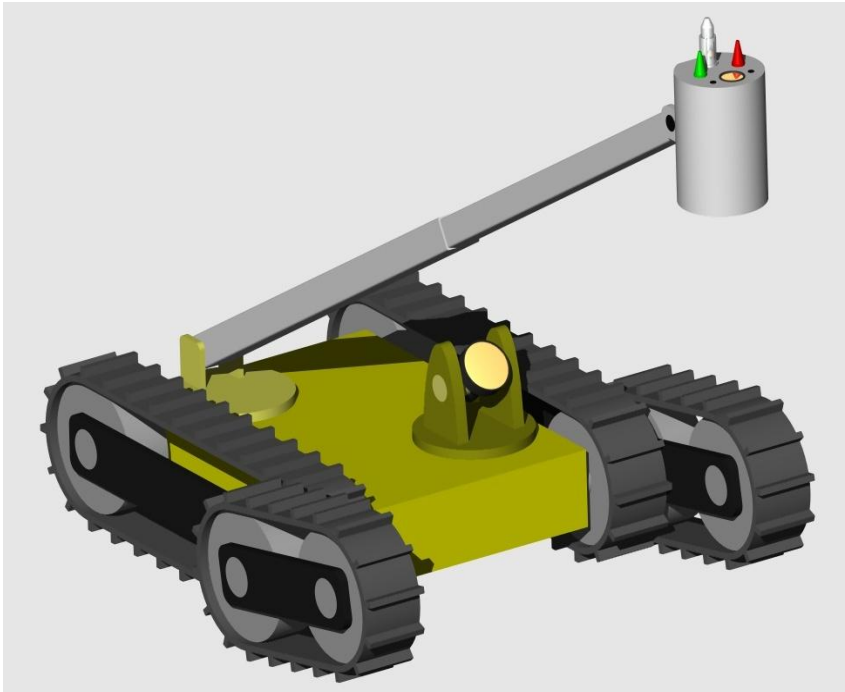


- Support shown
- “loose” rock apparent on LHS

So Robots can make mining easier

- Thermography to identify threat areas
- Sounding device to delineate boundaries
- Ultrasonic Beacon system for localisation (replacing GPS)
- Creates risk map for mitigating action in the coming shift





In Conclusion

- Robots can assist in making mines safer
- And more efficient
- Pre-examining the stope area prior to human entry
- Providing a risk map indicating where mitigating action is required
- Improving the current making safe process
- Saving approximately R800 million in lost production
- And upwards of 36 people lives
- Under current mining conditions.
- Future with more difficult mining conditions
- Potentially much more to contribute

Thank You