

Mine Health and Safety Council



Technology transfer on minimising
seismic risk in the platinum mines

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MHSC

Presentation Outline

1. **MHSC Mandate**
2. **Percentage Fatalities by Classification**
3. **Fatality Frequency Rate**
4. **Fall of Ground vs Transportation and Mining Fatalities**
5. **Frequency of Disaster Accident**
6. **Project Aim**
7. **How Were Research Outcomes Achieved**
8. **Way Forward**
9. **Implementation of Research Outcomes**
10. **Research Conclusions**
11. **MHSC New Structure**
12. **Questions**

1. MHSC Mandate

MHSC is a national public entity established in terms of the MHSA, No 29 of 1996, Celebrating 20 years in May 2017.

- **Advise the Minister** on all occupational health and safety issues in the mining industry relating to legislation, research and promotion
- **Review and develop legislation (regulations)** for recommendation to the Minister
- **Promote health and safety culture** in the mining industry
- **Oversee research** in relation to health and safety in the mining industry

1. MHSC Mandate

*Technology,
Innovation
& product
development and
commercialisation*

Research outcomes inform alternative use of existing technology or introduce new mining techniques, technology and personal protective equipment to mitigate or eliminate exposure to occupational health and safety risks and improve outcomes

Research outcomes may be required to inform a review, update or amendment of existing occupational health and safety legislation, to drive the achievement of desired practices and outcomes within mining operations.

*Legislation,
regulation and
standards*

Training

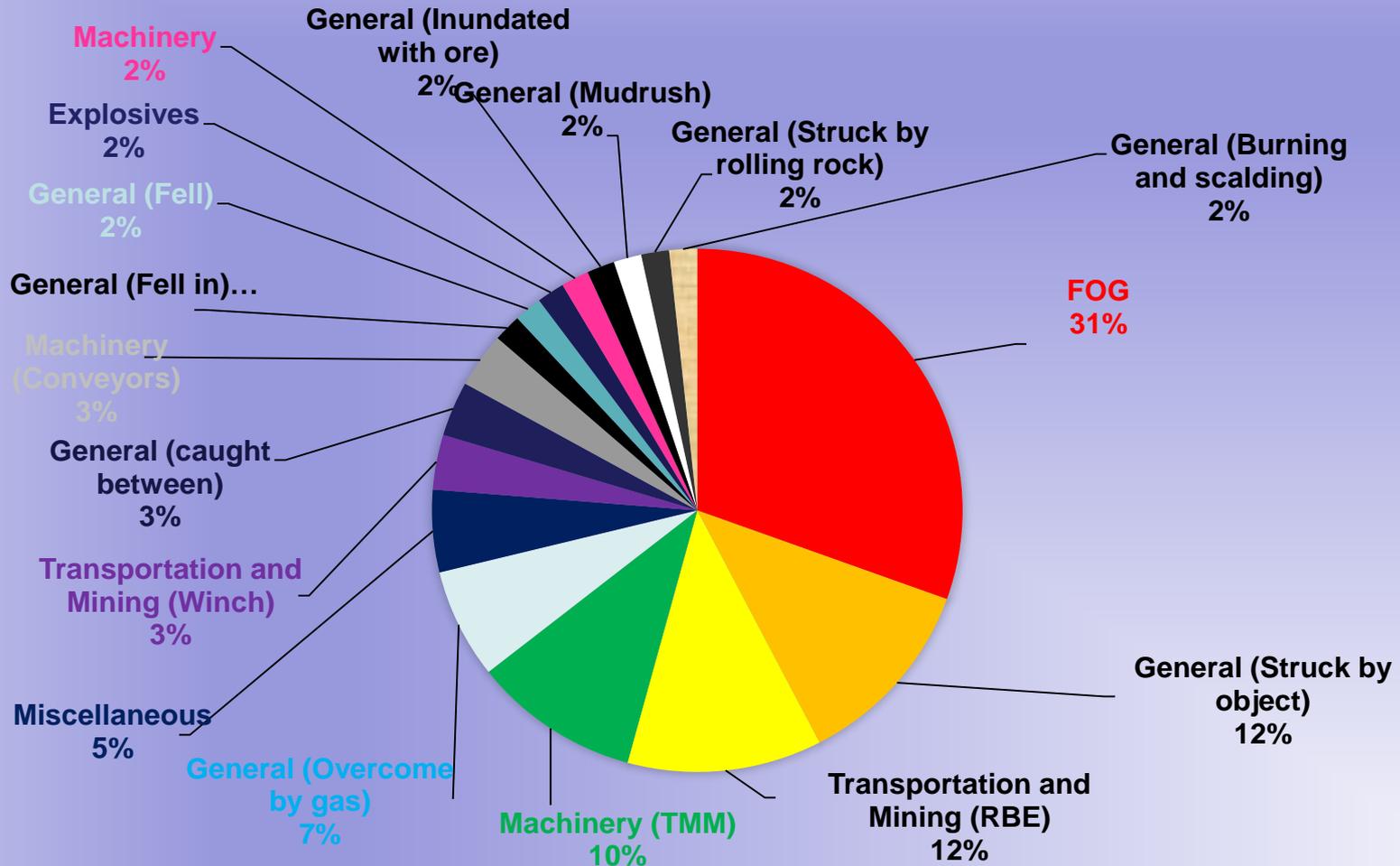
Research outcomes can be used to inform the design of occupational health and safety training interventions. Training interventions should also be developed to support the launch and promotion of new technology, innovation and products emerging from research activity.

Research outcomes to be publicised and promoted and industry-wide (nationally, regionally and internationally) through journal publication, and through marketing and promotion efforts.

Promotion

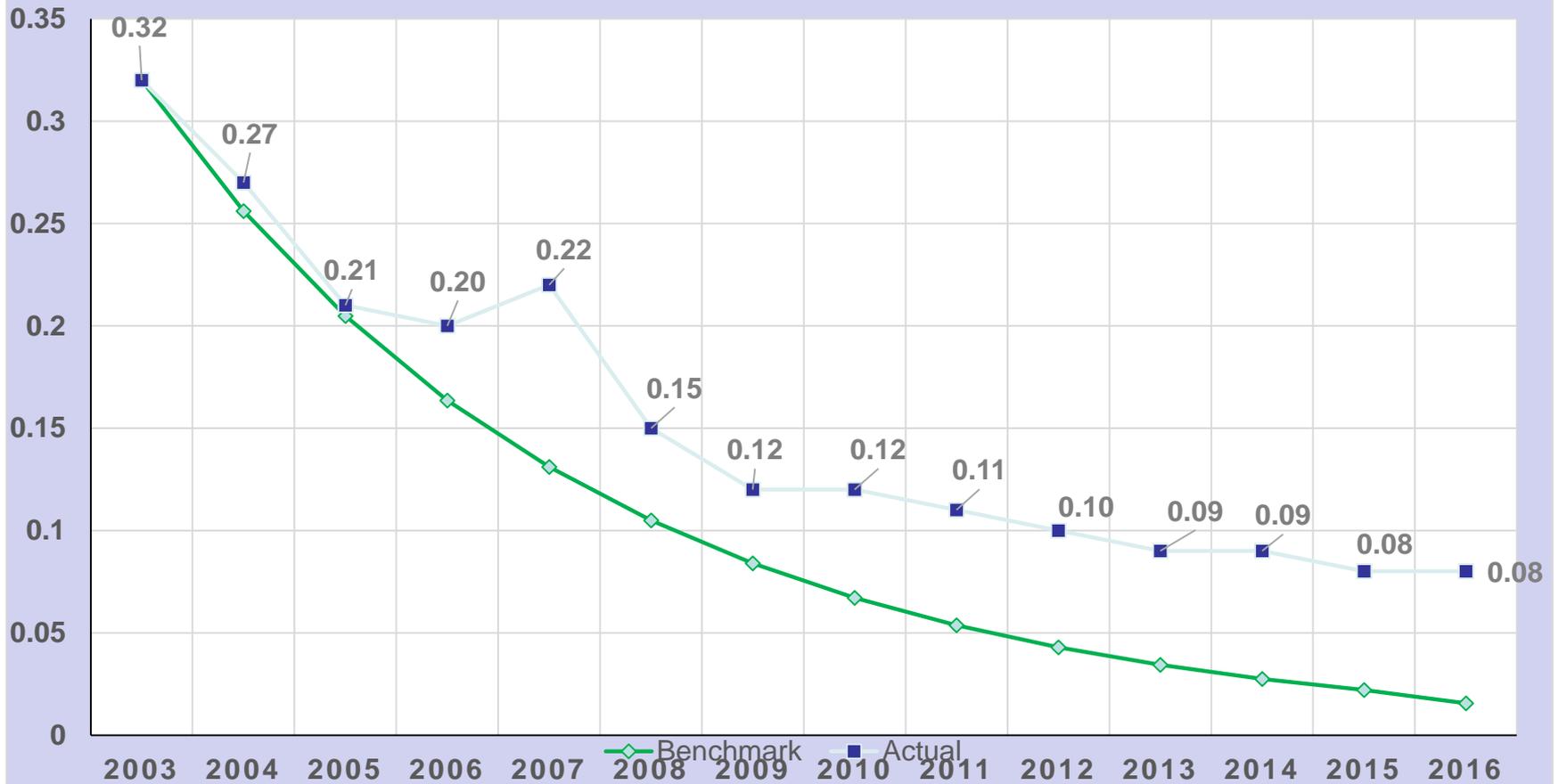
2. Percentage Fatalities by Classification

All Mines
Percentage Fatalities by classification (Provisional)
(01 Jan. - 11 Sep.) - 2017



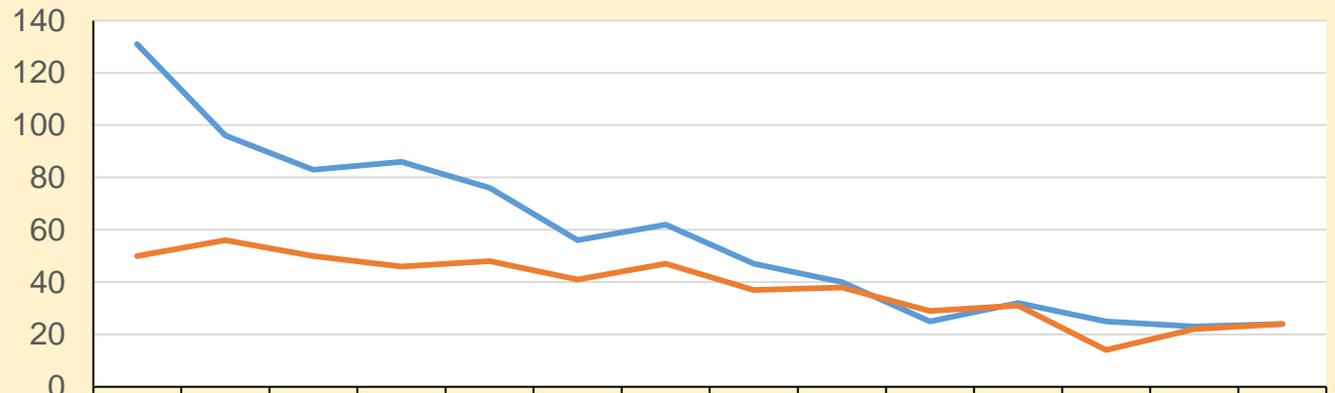
3. Fatality Frequency Rate

Fatality Frequency Rate
All Mines
2003 - 2016



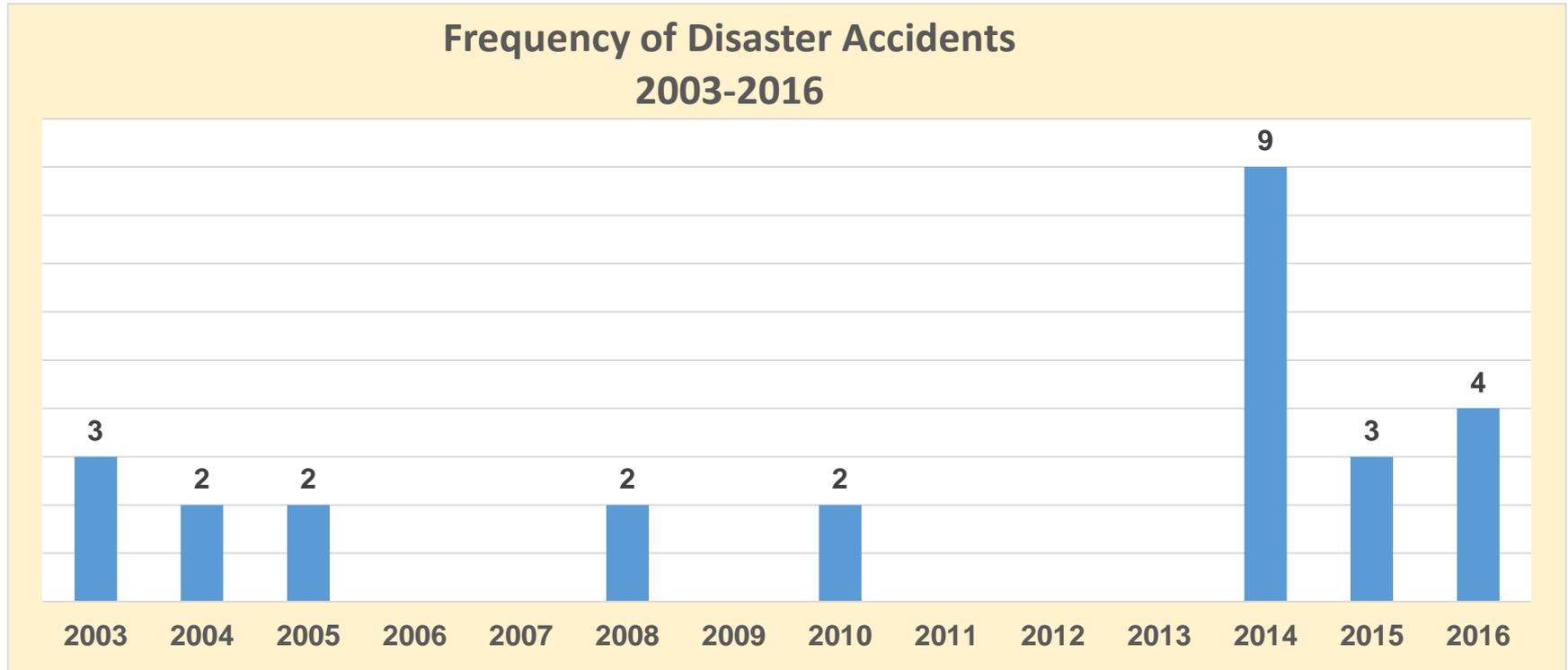
4. Fall of Ground vs Transportation and Mining Fatalities

Fall of Ground; Transportation and Mining Fatalities
2003 - 2016



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
— Fall of ground	131	96	83	86	76	56	62	47	40	25	32	25	23	24
— Transportation and Mining	50	56	50	46	48	41	47	37	38	29	31	14	22	24

5. Frequency of Disaster Accidents



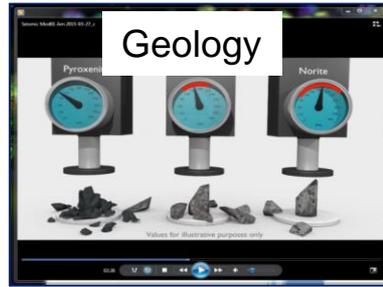
6. Project aims

MILESTONE
Project initiation (start-up presentation and report)
1. Learning materials for production personnel
2. Production personnel training roll-out
3. Learning materials for Rock Eng. personnel
4. Seismic system audit protocol
5. System audits
6. Audit results
Final report (approval)

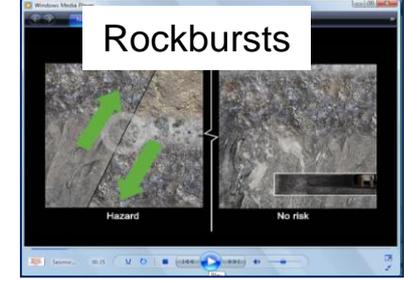
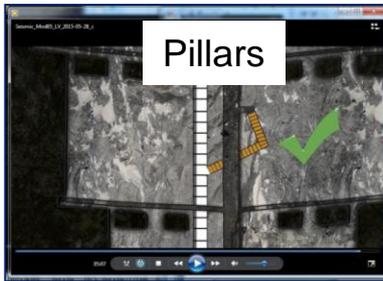
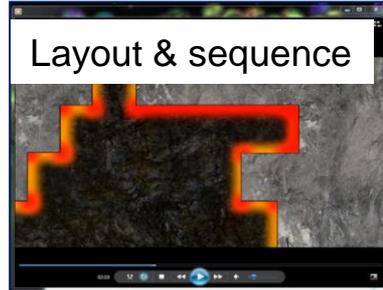
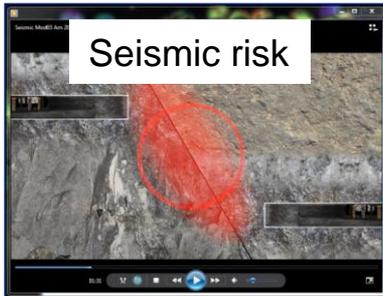
8. How were the research outcomes achieved?

- **Research outcome 1:**

- *Animated learning training materials for production personnel*



'The future is not what it used to be'



7. How were the research outcomes achieved?

- **Research outcome 2:**
 - *Roll-out of the production personnel training incl. train-the-trainer workshops on all mines with seismic hazard.*



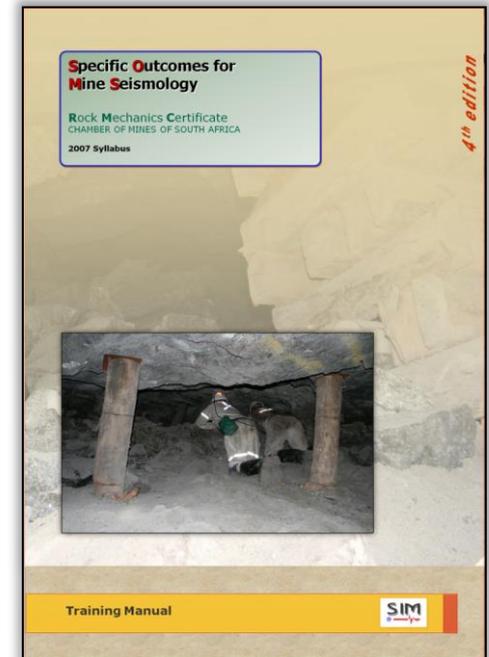
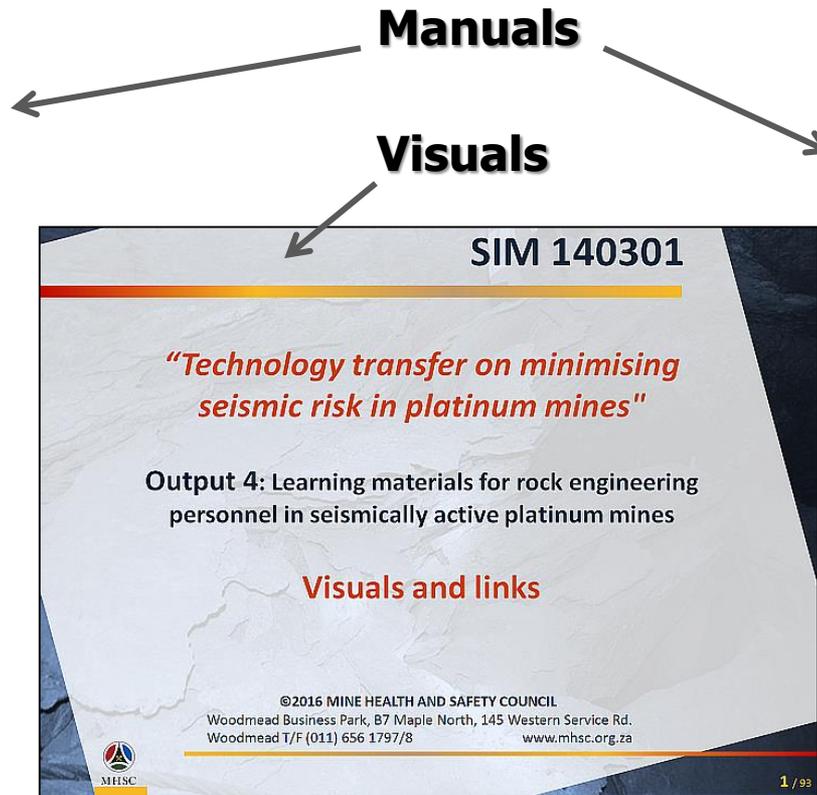
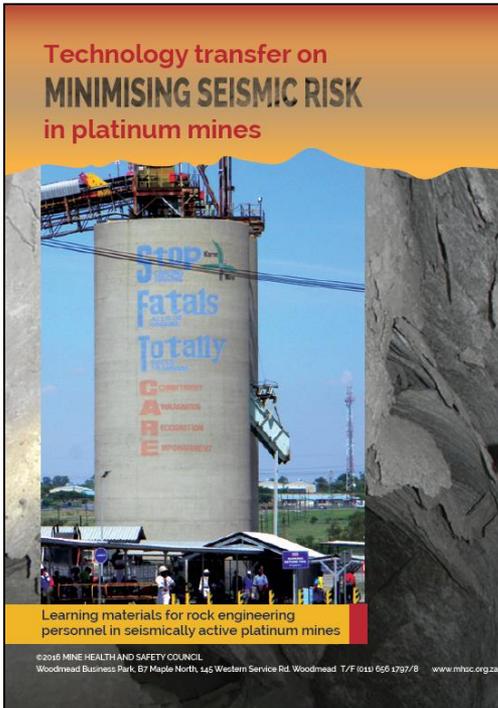
Implats Visitor Centre 6/11/2015



Bokoni Manager's Boardroom 24/11/2015

8. How were the research outcomes achieved?

- **Research outcome 3:**
 - *Training materials for rock engineering personnel*



8. How were the research outcomes achieved?

- **Research outcome 4:**
 - *Seismic system audit protocol in line with SIM100301 guidelines.*

Seismic system score card		Mine/shaft: Dishaba	Assessed by: WB and FE	Date: 15/3/2016
Section No.	Criteria	Comments	Score	
1. Seismic network planning, system settings & configuration	1. Monitoring objectives defined for different areas of the mine.	According to TSD, 5 standard MonObs declared (Jager & Ryder, 1999). Some cannot be met due to low seismic activity levels (2.6 events per day).	✓	7/10*40% = 28%
	2. Network station configuration planned according to monitoring objectives.	Originally installed for MER mining.	✓	
	3. Principal sites added to reduce depth.	1 shallow site; data show high z-error (see below)	✓	
	4. Principal sites defined to ensure minimum depth.	No.	✗	
	5. Sensor installation (<3 months).	Average 2-4 years; low priority due to low risk level.	✗	
	6. Filter settings and sampling rate match relevant Magnitude range.	Yes (1.65 to 3.3kHz)	✓	
	7. At least 80% of stations operational at all times.	80-90%, but slowly decreasing (see below); major faults with short repair times.	✓	
	8. Sensor health checked and reported on, and always above 80%.	Checked and reported: usually above 80% (see below).	✓	
	9. Sensor orientation and polarity checked (not required for smart sensors).	Not done for Dishaba and Tumela	✗	
	10. Synchronisation of system clocks for regional events.	GPS time base; suitable for exchange with neighbouring networks.	✓	

- 1. Network planning
- 2. Source quantification
- 3. Analysis & reporting

¹ Principal sites receive priority with respect to repair and maintenance and are each equipped with a UPS.

* bonus question: were calibrations blasts used to calibrate source parameters, e.g. location accuracy? __ Use confirmed rockburst locations as master events__

10. Implementation of research outcomes

• Roll-out of the training for production personnel

The screenshot shows the Lesson Builder interface with the following components and annotations:

- List of modules:** Points to the 'Available modules' table.
- Play list:** Points to the 'Selected modules' table.
- Sequence:** Points to the up/down arrow buttons in the 'Selected modules' table.
- Calibration:** Points to the 'Calibrate Screen' button.

Module Name	Duration
Module 1 - Geology	05:25
Module 2 - Stress	06:50
Module 3 - Seismic Sources	07:38
Module 4 - Layout & Sequence	05:47
Module 5 - Mining Practice	05:25
Module 6 - Gullies & Sidings	07:26
Module 7 - Pillars	11:15
Module 8 - Seismic System	08:40
Module 9 - Rockbursts	07:44
Module 10 - Rules	05:54
Module 11 - Seismic Hazard & Risk	06:20
Module 12 - Summary	16:27

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Module 10 - Rules	05:54
Module 1 - Geology	05:25
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Module 9 - Rockbursts	07:44
Module 12 - Summary	16:27

Total time: 00:49:58

Buttons: Calibrate Screen, Save Lesson, Load Lesson, Play, Loop, Save, Play, MHSC logo.

• Audit reports distributed, results presented to SANIRE

10. Implementation of research outcomes

• Research outcome 3:

- *Manual*
- *Visuals*

Stress field

Ryder & Jager Textbook:
Chapter 9.4, Pg 391 ff

Stress and excavations

Rocks and minerals

Merensky Reef (MER) Pyroxenite

Norite flake Lamprophyre (dyke) Pyroxenite (dyke)

8/19

Chapter 3

- **Sidings:** Sidings were often left far behind the advancing face and where they were close to the face, the sidings were brought closer by down-dip mining.
- **ASG hangingwalls** were often carried higher than the stope hangingwall due to strike gullies being too shallow, or where developing the strike gully was at too high an angle above the strike direction.
- **Lead and lags:** In many instances the recommended practices were not followed and resulted in very poor face shapes.
- **Holing** between panels when mining from different raise lines resulted in final reef blocks constantly decreasing in size while the stress loading increased.

Although the above examples are not necessarily conclusive, they do indicate that generally accepted good mining practices can yield lower seismic hazard. Sound mining practices should be applied in the platinum industry, in spite of the perception that practices such as proper sequencing, co-ordinated mining directions, leads and lags, gully sidings etc. are intermediate depth gold mining practices and are therefore not applicable to platinum mines.

Recommendation: The design and control mining directions, leads/lag distances, remnant formation, abutment creation, holing practices and mining sequences should be considered.

Multi-reef mining

At low middlings, the extraction of more than one orebody can result in stress field changes on the lagging mining faces leading to increased pillar loading and increased potential for unwanted pillar behaviours. This situation is exacerbated where mining one ore body is below a high-stress area on another orebody, such as UG2 mining below Merensky remnants. The potential for pillar crushing, as well as pillar bursting of slightly larger pillars, increases substantially in this scenario.

Recommendation: Ensure the proper sequencing of multi-reef mining remnants.

Confinement

Confinement of footwall material within and around a pillar on the Merensky horizon can be increased by maintaining an intact footwall, or reduced when creating a deep strike gully close to a pillar (i.e. a very low siding).

Similarly, confinement can be increased by leaving a larger than required pillar or by leaving substantial amounts of blasted ore or scaling in-situ around the pillar. The latter effect, i.e. weakening, results from the removal or cleaning of pillar scaling around a pillar.

The hangingwall conditions can have either a favourable or unfavourable effect on confinement: confinement is increased by an intact,

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Chapter 4

4 Mining practice to reduce seismic damage potential

In addition to the potential for mining practices to reduce the probability of seismic events, some of these practices are also valuable in reducing the likelihood and severity of seismic damage when a seismic event does occur. Implementation of appropriate mining practices now also become actions that remedy the potential effects of seismic events and should always be considered for implementation on this basis alone.

Stable ground conditions

Stress fracture orientation and density are not only a function of the mining depth, and also of the gully layout (lead / lag) and the siding's shape and depth.

Since fracturing could affect the local rock mass response to vibrations caused by a seismic event, it is critical to ensure stable ground conditions in and around gullies. This can be promoted by the following:

- Mining sidings in line with panel faces in areas where stress fracturing occurs.
- Sidings that are cut deep enough to ensure that scaling of the gully sidewalls does not negatively affect the pillar behaviour and that gullies do not reduce confinement of the footwall around the pillars.
- Selection of a suitable gully direction in relation to the reef strike direction to limit the damage to the hangingwall caused by gully development, and by maintaining deep gullies.

Hangingwall stability is an even greater concern where the exposed rock type is Norite. As mentioned earlier, noritic material often results in flat dipping, high density stress fracturing, a condition prone to instability during seismic events. The flaking of Norite into thin sheets with sharp edges is likely caused by the low tensile strength of this rock type.

Recommendation: Implement good gully and siding mining practices to prevent the creation of unstable fracturing. Prevent the exposure of the noritic material.

Support practice

When approaching potholes, the risk of exposure of noritic material in the hangingwall increases, and thereby the risk of seismic damage also increases. The planning of mining in and around potholes, including the design and implementation of appropriate support practices, is critical to limiting this risk.

Using support to address specific mining conditions in an attempt to ensure stable mining excavations is a well-known practice, and not a simple exercise. The most common methodologies to design support that are appropriate and likely to reduce rockburst damage from seismic activity include methods that will:

- ensure sufficient support resistance to the rock walls, whilst at the same time,

23

Visuals
47-49

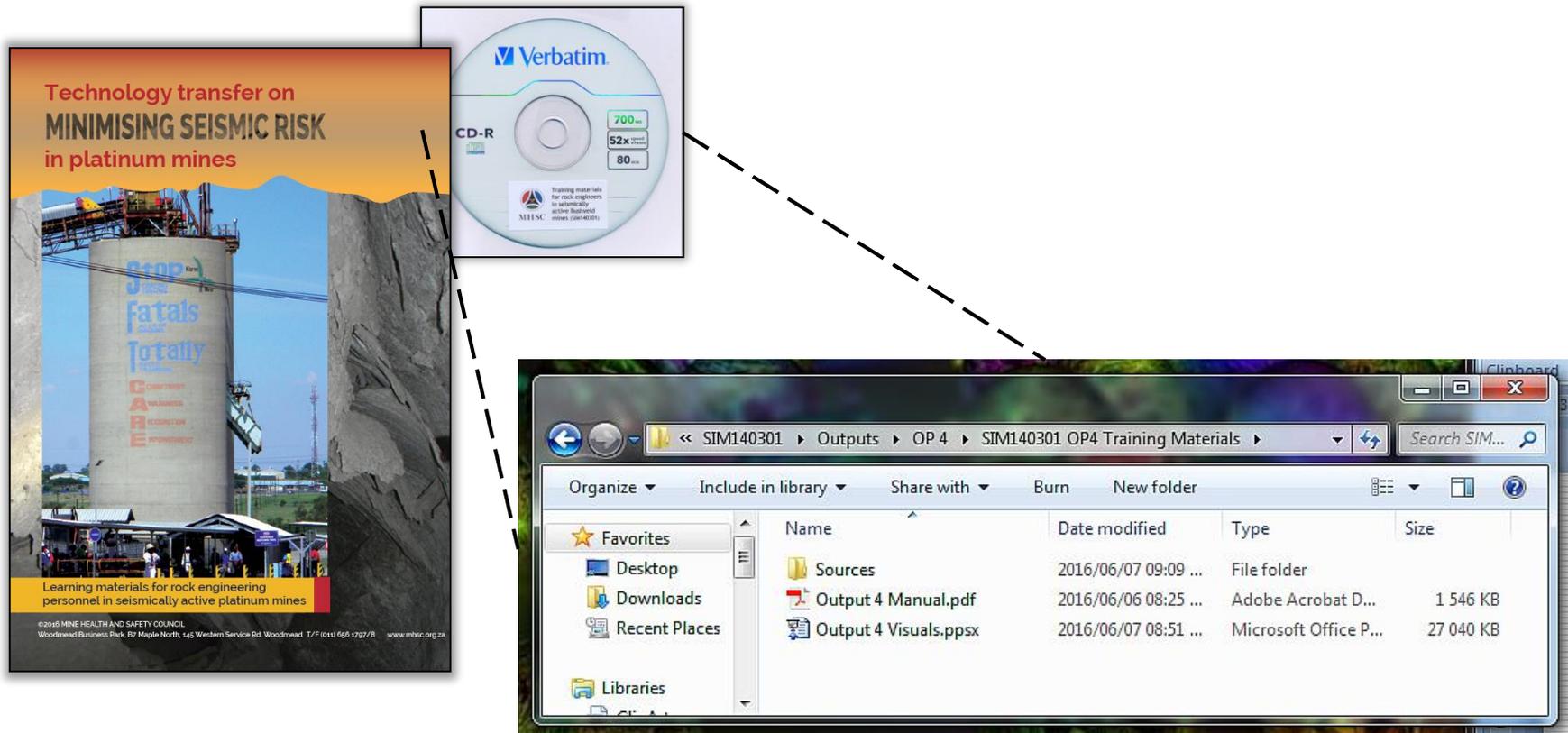
Jager & Ryder
3.4

Ryder & Jager
7.2

Visuals
50-51

10. Implementation of research outcomes

- **Research outcome 3:**
 - *CD with sources and references*

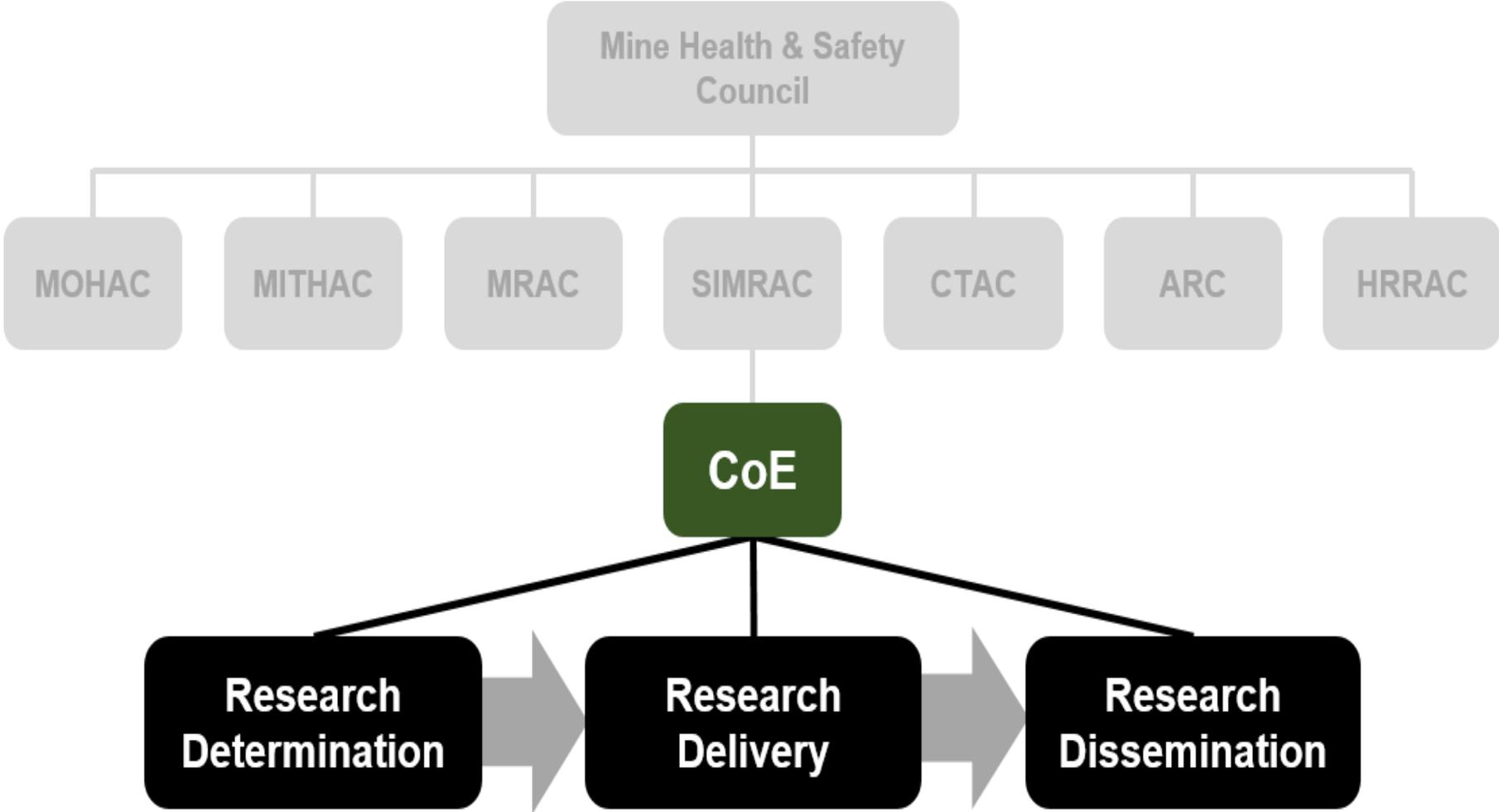


11. Research Conclusions

- **Summary:**

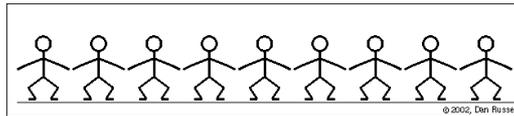
- *SIM140301: Technology Transfer project successfully completed*
- *Three independent output streams reached the target stakeholder mines*
- *Benefit of increased knowledge levels and awareness of rockburst risk in PGM mines*
- *Set new standard in state-of-the-art training methodology at stakeholder training centres.*

12. MHSC New Structure





MHSC



Any Questions?

Thank you

MHSC Disclaimer:

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