Resources Regulator
Department of Regional NSW

Investigation report

Report into the serious injury of a worker at Myuna Colliery

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Executive summary

A 45-year-old mine worker suffered serious injuries when he became pinned between the conveyor boom of a Joy 12CM12 continuous miner and a rib about 12.16am on 5 February 2021. The incident occurred in an underground coal mine known as Myuna Colliery, in Lake Macquarie, NSW. The mine is operated by Centennial Myuna Pty Limited.

The worker (who was injured) was assisting a continuous miner operator and another worker install roof bolts using the continuous miner. The worker was standing on the right-side platform of the continuous miner. The crew was working in a closed heading where an intersection was being formed. The continuous miner needed to be moved into the centre of the heading so a replacement bolt cassette could be loaded. The worker was aware that the continuous miner needed to be repositioned, but was not aware of the reason. The continuous miner was not fitted with a proximity detection system (PDS).

The worker stepped off the platform and positioned himself behind the continuous miner. The investigation was unable to verify his exact movements at this time, however, it is most likely to have been around the time that the continuous miner operator began repositioning the continuous miner. The continuous miner operator did not expect the worker to step off the platform and was unaware that he had done so.

The continuous miner trammed a short distance in a generally rearward direction (outbye) and then forward (inbye). The conveyor boom attached to the rear of the continuous miner was angled to the right while the continuous miner was being repositioned. As the continuous miner trammed forward, the rear right side of its conveyor boom moved toward where the worker was standing adjacent to the right rib. The boom struck the worker's upper body and pinned him against the rib. The continuous miner operator heard the injured worker scream and moved the continuous miner, thereby releasing him.

The injured worker was assisted from the incident scene by colleagues and transported to the surface of the mine where he was treated by ambulance officers. There were complications with the injured worker's first aid treatment and his extraction from the mine. The injured worker was not initially given pain relief and an Oxy-Viva unit deployed to him contained an empty oxygen cylinder. The transport vehicle was driven slowly due to poor road conditions and the significant pain that the worker was experiencing. As a result, it took double the time it would normally take to exit the mine.

The worker suffered serious injuries, including:

- serious lower left arm fracture, requiring surgery
- unilateral renal agenesis (loss of a kidney)
- rib fractures
- spinal injuries
- shoulder injury
- cardiac injuries
- psychological injuries.

Investigation findings

The investigation determined there were multiple factors that contributed to the incident:

- Lack of effective communication between the continuous miner operator and the worker.
  - Lack of situational awareness by the continuous miner operator and the worker.
  - The worker failed to follow the safe work location rules.
  - The continuous miner operator failed to maintain an effective lookout while tramming the continuous miner.

  - The conveyor boom of the continuous miner was angled to the right in circumstances where the worker believed that it would be centred while the continuous miner was being moved.
- The relevant risk to health and safety was death or serious injury due to a collision between a continuous miner and a worker.
- The mine operator identified the risk before the incident.
- To control the risk, the mine operator primarily relied on:
  - safe work location rules
  - safe work procedures
  - trained and competent workers
  - planned task observations.
- The injured worker and the continuous miner operator were trained and determined to be competent to operate continuous miners and other mobile plant and to have a sufficient understanding of safe work procedures at the mine.

Recommendations

Mine operators

Mine operators have a duty to identify hazards and manage risks to health and safety in accordance with the provisions of the *Work Health and Safety Act 2011* and related legislation. It is recommended that mine operators:

Proximity detection systems

- implement higher order engineering controls (like PDS) in combination with lower order administrative controls (including safe work location rules and training) to manage risk arising from continuous miners, where reasonably practicable, having regard to the following:
  - PDS technology for mobile plant used in underground coal mines has advanced significantly in recent years and concerns held by some mine operators in the past about the reliability of PDS may no longer be valid.
  - PDS has been used successfully on continuous miners in other jurisdictions and found to complement lower order administrative controls (including safe work location rules and training).
  - MDG 2007 is not an impediment to adopting PDS on continuous miners. Where appropriate SIL ratings are unachievable for a PDS, mine operators should use other risk mitigation methods to satisfy functional safety requirements.
  - The cost of PDS is generally not grossly disproportionate to eliminating or minimising the risk of interactions between continuous miners and workers.
- recognise that early planning is essential when fitting PDS to existing continuous miners. PDS must be considered as part of the overhaul planning process.
- review existing risk assessments concerning interactions between continuous miners and workers having regard to the previously mentioned matters.

Administrative controls

- ensure safe work location rules and exclusion zones are adequate
- ensure safe work location rules are presented in a logical and consistent manner and understood by the workforce

- ensure key terms are defined and explained.

Communication

- provide adequate training to workers on effective communication techniques when working in noisy and dark environments
- reinforce the need for workers to use effective communication when working in and around mobile plant.

First aid and emergency response

- review emergency plans and training processes to ensure that they adequately reflect the following:
  - NSW Ambulance Service advice about the appropriate location to treat injured workers.
  - Instruction on how information about an injured worker's injuries and condition is effectively communicated to emergency services, including the provision of updated information.
- in accordance with clause 92 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022, consult with emergency services agencies about the content of the mine's emergency plan. This consultation should include making provision for emergency services to attend underground areas of mines to respond to injured workers.
- review its inspection and audit programs to ensure that all first aid equipment is adequate and fully functional.

Workers

Workers have a duty to take care for their own health and safety and of their co-workers. They must also comply as far as they are reasonably able with any work instructions given by mine operators to ensure worker safety and compliance with the *Work Health and Safety Act 2011* and related legislation. It is recommended that workers ensure:

Communication

- that all workers involved in a work activity are actively included in discussions about the activity before commencing
- all workers understand how the work activity will be undertaken
- that effective communication occurs before moving mobile plant
- positive communications are established confirming how, where and why the mobile plant is to be moved
- environmental factors, such as noisy and dark work environments, are considered.

Situational awareness

- situational awareness is maintained at all times
- adequate separation distances from moving mobile plant are maintained
- mobile plant operators maintain effective lookout when moving equipment by scanning and monitoring the work environment.

Safe work location rules

- safe work location rules and exclusion zones are followed and consideration is given to changes that affect safe work locations and exclusion zones when mobile plant is moved.

Table of Contents

1. Purpose of the report

This report describes the mining workplace incident investigation conducted by the NSW Resources Regulator into the cause and circumstances of an incident in which a worker suffered serious injuries at Myuna Colliery on 5 February 2021.

2. Investigation overview

2.1. Major Safety Investigations

The Regulator investigates critical workplace incidents in the NSW mining, petroleum, and extractives industries. The Regulator carries out a detailed analysis of incidents and report its findings to enhance industry safety and to give effect to its compliance and enforcement approach.

2.2. Legislative authority to investigate

Investigators are appointed as government officials under the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and are deemed to be inspectors for the purposes of *the Work Health and Safety Act 2011*. The Regulator has also delegated some additional functions to investigators, including exercising the power to obtain information and documents for the purposes of monitoring compliance with these Acts.

2.3. Regulator response

The incident was reported to the Regulator on 5 February 2021. The Regulator deployed mine safety inspectors and investigators to the mine. An investigation commenced.

On 10 March 2021, the Regulator published an Investigation Information Release (IIR21-03) to provide information concerning the incident and recommendations to the mining industry.

3. Terminology

The investigation found that some terms relating to proximity detection systems (PDS) are used interchangeably and that the term itself is sometimes used to encompass three levels of control:

1. **Awareness** – the system alerts the operator of a potential interaction
2. **Detection** – the system alerts the operator of a potential interaction and advises an appropriate response
3. **Collision avoidance** – the system takes control of the mobile plant to prevent a collision occurring.
4. Unless specified otherwise in this report, references to PDS describe the highest of the above levels – collision avoidance.

4. The incident

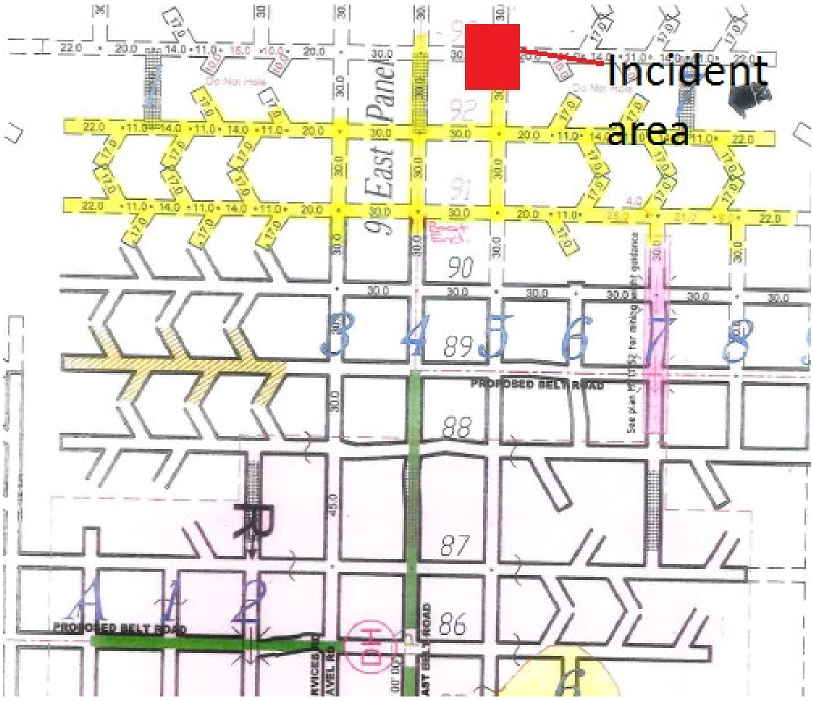
4.1. The mine

Myuna Colliery is an underground coal mine at Wangi Wangi, about 25 km south-west of Newcastle, NSW. The mine's workings are under Lake Macquarie. The mine operator uses conventional underground bord and pillar mining methods to extract coal.

4.2. The incident location

The incident occurred in the Myuna Colliery Fassifern Seam 9 East Panel, Heading 5 cut through 93. An intersection was in the process of being formed at that location when the incident occurred.

Figure 1 - Excerpt from 9 East Panel Plan



4.3. Parties involved

4.3.1. Mine operator and holder

The nominated operator of the mine and the person conducting the business or undertaking (PCBU) within which the worker and others were working at the time of the incident is Centennial Myuna Pty Limited. The mine operator is a wholly owned subsidiary of Centennial Coal Company Limited (CCCL).

Mining activity at the incident location is authorised by mining lease 1632. The mine operator is the holder of this authorisation.

All workers involved in the incident were employed by the mine operator.

4.3.2. Original equipment manufacturer (OEM)

The mobile plant involved in the incident is a Joy 12CM12 continuous miner. It was manufactured by Joy Manufacturing Company Pty Ltd, which is now known as Joy Global Australia Pty Ltd (Joy).

4.3.3. The worker

The worker (injured worker) was 45 years of age at the time of the incident. He began employment with the mine operator on 6 January 2014 but had worked as a contractor at the mine for a short period before that. He was employed as a multi-skilled mine worker. He was assessed as competent to operate continuous miners, shuttle cars and load haul dumps. The worker had worked at several other underground coal mines since 2010.

4.3.4. Continuous miner operator

The operator of the continuous miner began employment as a multi-skilled mine worker at the mine in 2017. He began working in the underground coal mining industry around 2010. The majority of his experience operating continuous miners was gained at the mine, although he had operated continuous miners at another site.

4.3.5. The other worker

The other worker present at the time of the incident was standing on the left side platform of the continuous miner. He began employment as a multi-skilled mine worker at the mine in 2014. He had about 40 years' underground coal mining experience at the time of the incident.

4.4. Mobile plant involved

4.4.1. Overview

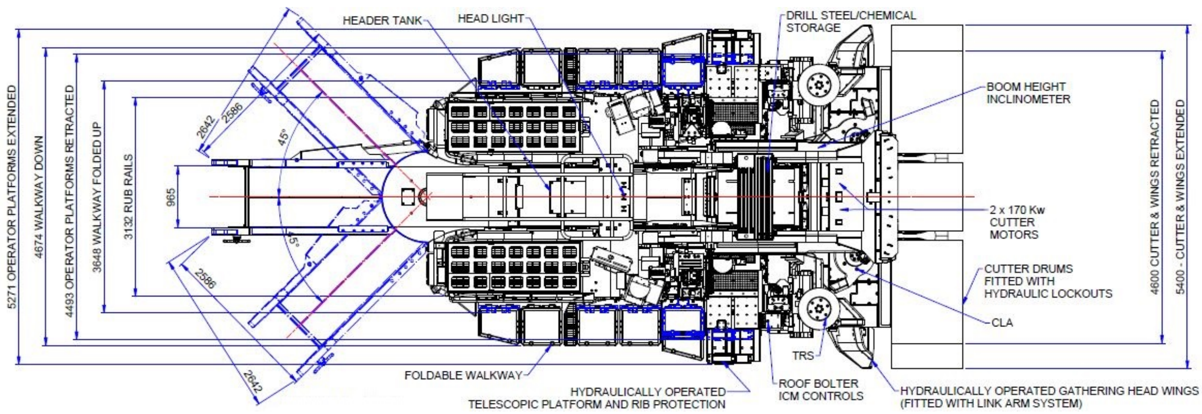
The continuous miner involved in the incident was a Joy 12CM12, which was manufactured in 2009. It was assigned the mine identifier CM313. CM313 had operated at other CCCL-owned mines before it was moved to the mine. CM313 was equipped with a cutter head, roof and rib bolting systems, a conveyor boom and operator platforms. It was able to be operated via remote control and trammed in forward and reverse directions via 2 continuous metal track circuits. Each track circuit was able to operate independently, allowing CM313 to slew in both clockwise and anticlockwise directions.

The specifications of CM313 are set out in the following table:

Table 1: CM313 specifications

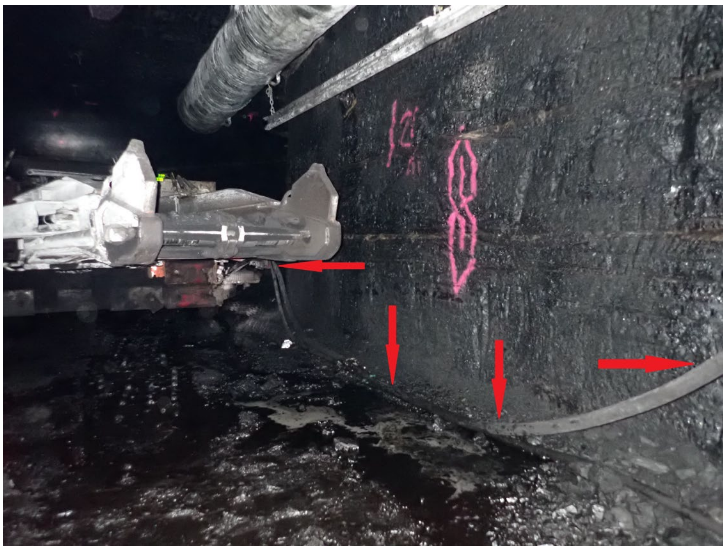
CM313 specifications	
Overall length	11.83 metres
Length excluding boom	8.33 metres
Length of boom	3.5 metres
Width (platforms extended)	5.26 metres
Weight	78 tonnes (approximate)

Figure 1a- Excerpt from general arrangement diagram (supplied by the mine operator)



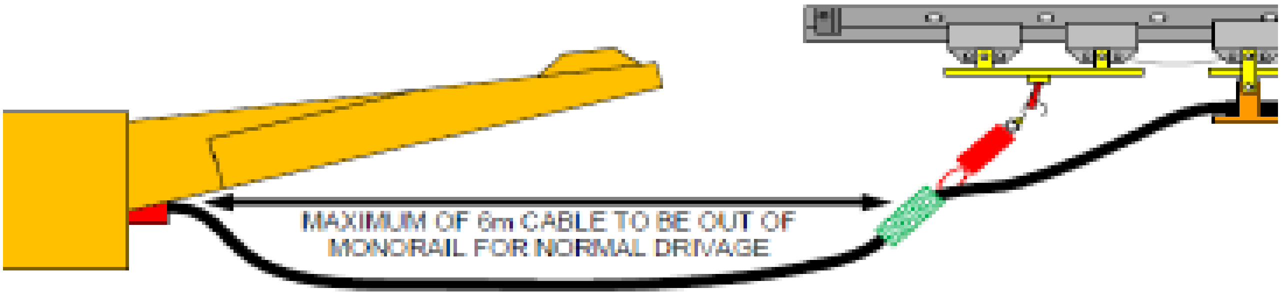
CM313 was electrically powered. Power was supplied through a flexible cable that joined to CM313 at its rear right hand corner.

Figure 2 - Trailing electrical cable fixed to miner



The length of the cable was managed with the assistance of a monorail system as shown in Figure 3.

Figure 3 – Excerpt from Centennial Myuna cable training presentation



4.4.2. Overhaul of CM313

In March 2019, an initial scope of work for the overhaul of CM313 was developed by the mine operator and Joy. A formal agreement was reached on 18 June 2019. The overhaul began shortly after and was completed in December 2019. As discussed later in this report, the timing of this overhaul was significant in terms of the practicability of installing a proximity detection system on CM313 before the incident. The work performed during the overhaul included:

- converting CM313 to operate as a wide head, single pass miner
- fitting hydraulic extendable platforms with rib protection
- attaching a Komatsu conveyor boom
- installing bolting platforms and roof supports for those platforms.

4.4.3. Introduction to site

The mine operator's introduction to site and commissioning processes for CM313 were completed in January 2020. It began operating in the mine in February 2020. The commissioning process included a pre-delivery inspection, electrical review, explosion protection inspection and a mechanical audit.

4.5. Lead up to the incident

4.5.1. Work crew

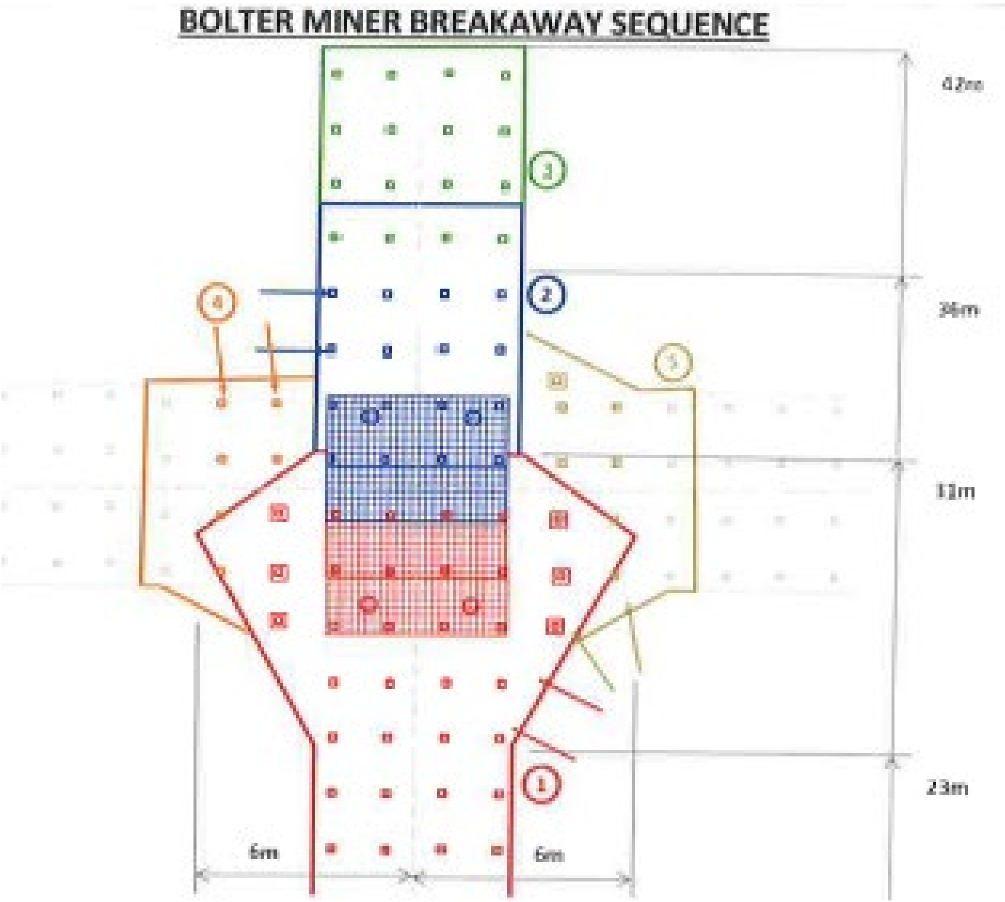
About 10pm on Thursday 4 February 2021, the crew started their shift. They attended briefings at the surface of the mine that were conducted by the undermanager and deputy. Following the briefings, the workers travelled underground to the 9 East Panel. A short time later they moved to their assigned work locations in the panel.

4.5.2. Commencement of work

The workers went to 5 Heading, inbye of 92 cut through. The injured worker was tasked to operate a shuttle car. The previous crew had started forming up a niche (or hammer) on the left and right sides of the heading at what would become the intersection of 5 Heading and 93 cut through (the work area). The workers were tasked with continuing the formation of the intersection. The conditions at the work area were relatively flat and dry.

The mining sequence used to form intersections at the mine is shown in Figure 4.

Figure 1 - Excerpt from mine's support rules



CM313's operator inspected CM313 and the other workers inspected the shuttle cars they would operate during the shift.

Another worker was allocated rousty duties that involved ensuring that the mining crews had sufficient supplies of work materials. The rousty inspected CM313 in the presence of CM313's operator and the other worker. He identified that the left side bolting cassette was depleted and informed CM313's operator that he would obtain a replacement cassette. Significantly, as events transpired later in the shift, the injured worker was not present during this conversation.

While cutting coal, an issue arose on the feeder that required repair by an electrician. Had the issue at the feeder not arisen, the workers would have continued to cut coal until the cutting sequence shown in red in Figure 4 was complete. However, to advance production while the feeder was not in operation, the deputy (supervisor) instructed the workers to install roof bolts in the work area. Before starting this work, CM313's operator used CM313 to remove loose coal from the floor and loaded it into the shuttle car, which was being operated by the worker (who became injured). He parked the shuttle car at the feeder.

While the worker was near the feeder, other workers had a conversation about where and how they would install bolts in the right-side niche. They identified there was only one bolt left in the left side bolt cassette and were aware that the cassette was to be changed out. Significantly, again as events transpired later in the shift, this was not communicated to the worker (who became injured).

CM313's operator trammed the front of CM313 into the right-side niche where it was parked. The boom was angled to the right at 21 degrees from its centre position, resulting in the boom being centred along the roadway while the front of CM313 was angled into the right-side niche. The angle of the boom relative to CM313 is shown in Figure 7. It did not change at any time throughout the incident.

The other worker and CM313's operator began operating the left and right-side bolting rigs on CM313 respectively. The worker returned to the work area and stood behind CM313's operator on the right platform of CM313. The worker assisted by passing bolts. CM313's operator installed one bolt on the right side and the other worker installed 2 bolts on the left side.

4.6. Material conflict in the evidence

The investigation found a conflict in the information provided by the workers about what occurred next. CM313's operator stated he said words to the effect of "we'll get the left hand cassette changed". The (injured) worker stated that the words the continuous operator used were "last bolt", which signalled to him that the bolting cycle was complete. The worker stated that he said, "going cable" to inform the other workers he was leaving the platform of CM313. He also shook his cap lamp from side to side as a signal that he was leaving the platform. The other workers told investigators they did not hear or see any indication from the worker that he was about to leave the platform and said they did not expect him to do so in circumstances where the left side bolt cassette was to be changed.

Investigators were not able to resolve the conflict in the information, however, the following circumstances of the incident were established by evidence including data downloaded from CM313 that was extrapolated with Komatsu and Simtars (Safety in mines testing and research station). Simtars prepared the imagery shown in Figures 7 and 8 of this report. (The Regulator has removed some incidental items from these figures for the purposes of this report.)

4.7. Circumstances of incident

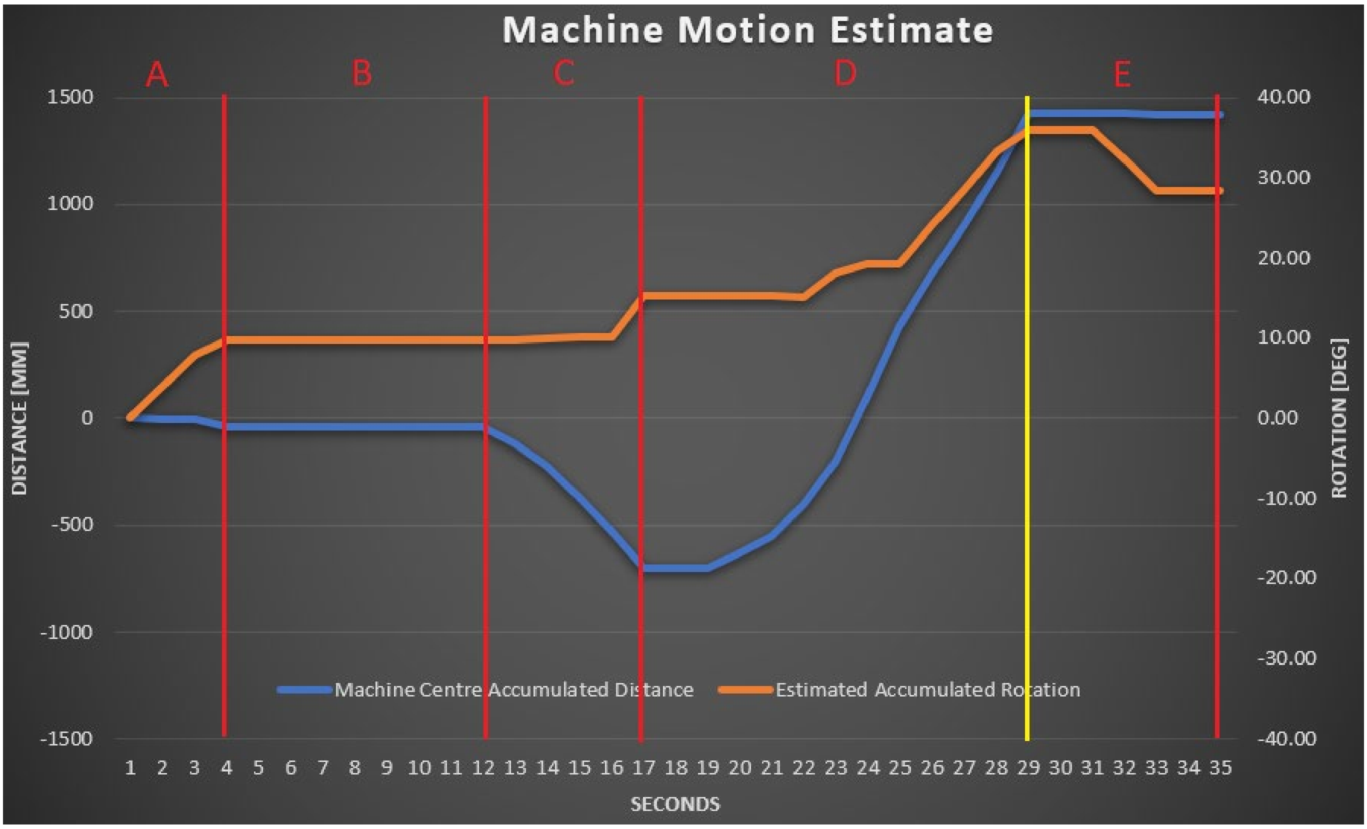
CM313's operator and the other worker lowered CM313's temporary roof supports and retreated the bolting rigs to their stowed positions. CM313's diversion valve was activated by adjusting a lever adjacent to the right side platform of CM313. The activation of the valve resulted in the necessary energy being supplied to CM313's tracks, enabling movement of the continuous miner.

Figure 5 - Location of diversion valve above right side platform on CM313

CM313's operator began tramming CM313 in reverse from the right-side niche at 12.16am. He intended to move CM313 from the niche and centre it in the heading to facilitate the replacement of the empty left side bolt cassette. As a matter of practicality, when a bolt cassette is changed, the continuous miner needs to be centred in the roadway with its boom angled to the right to provide access to the left side of the miner. This requirement is captured in the mine operator's procedures.

Figure 6 is a graphical representation of the data extrapolated from CM313's onboard control system. The movement data shown in the graph relates to CM313's centre mass and is not necessarily representative of the movement of its extremities. The seconds count along the horizontal axis begins at 12.16am. The left axis relates to the movement of CM313, which is shown by the blue line. Decreases in values relate to rearward movement and increases in values relate to forward movement. The right vertical axis relates to the rotation of the machine shown by the orange line. Increases in values represent counter-clockwise rotation and decreases represent clockwise rotation. The vertical lines and lettering on the graph have been added by the Regulator to assist with the description of the incident. The yellow line in Figure 6 shows the point the worker was impacted by the boom.

Figure 2 - Machine motion estimate prepared by Komatsu (adapted by the Regulator)



The following table summarises the movement depicted in Figure 6:

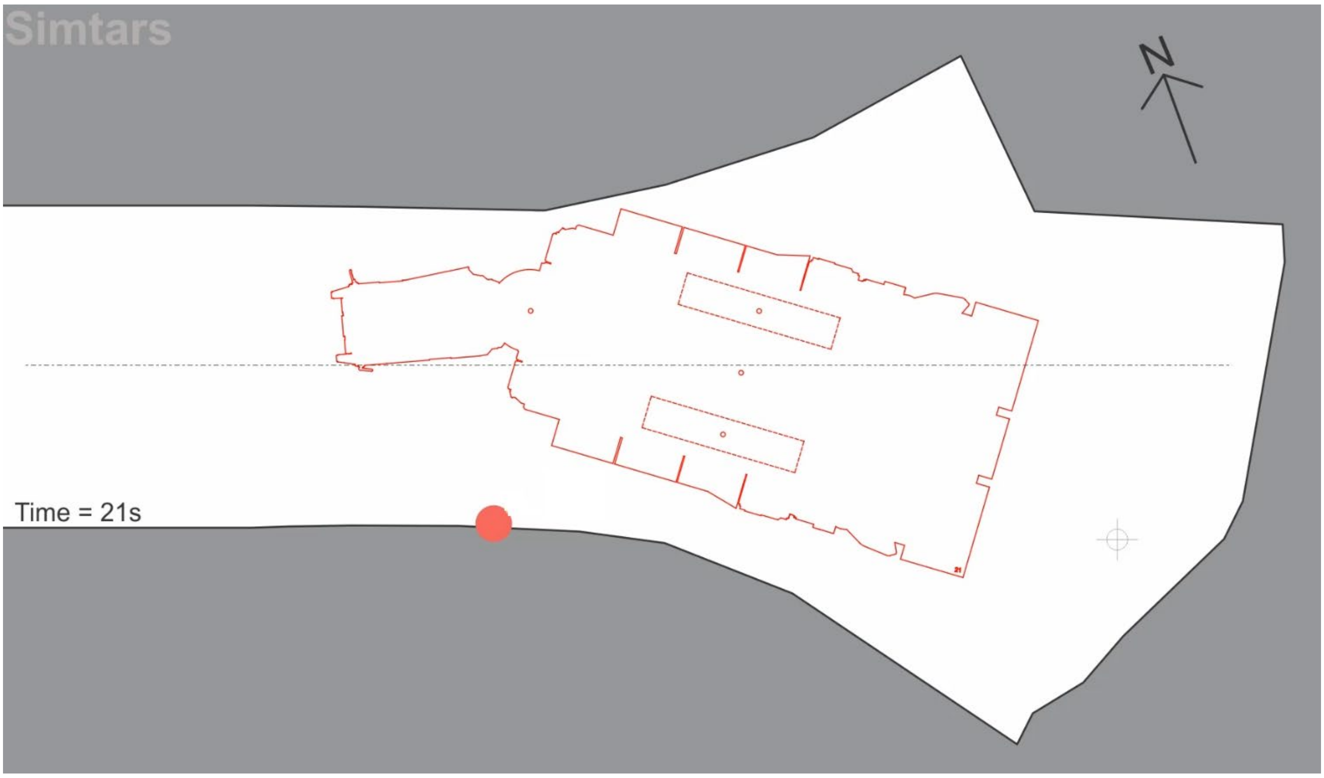
PHASE	DESCRIPTION
A	CM313 rotates anti-clockwise 9.82 degrees and moves rearward by 41 mm.
B	CM313 is stationary.
C	CM313 moves rearward by 698 mm. There is a slight anticlockwise rotation of 5.17 degrees at the end of this phase.
D	CM313 is stationary for two seconds. It then advances 1427 mm. It rotates in an anticlockwise direction as it moves forward, with the most significant rotation occurring in the 4 seconds before impact. CM313's movement during this phase is described in further detail below.
E	CM313 rotates in a clockwise direction.

Around the time that CM313 began moving out of the niche, the (injured) worker stepped off the right platform. Investigators established that this occurred in Phase A or B. The worker said he left the platform of CM313 about 90 seconds to 2 minutes before any movement by CM313. The investigation was unable to confirm this, however, it cannot be excluded as a possibility. The worker stated he stepped off CM313 to manage the cable that was trailing behind it.

CM313's operator and the other worker remained on the platforms of CM313 as it moved. CM313's operator said he did not see the (injured) worker in between the activation of the diversion valve and the incident. The other worker was focusing on the roof area to see if it would be possible to install an additional bolt before the cassette was changed. He caught a glance of the worker stepping off CM313 but did not see him again until he was pinned against the rib.

As CM313 moved rearward out of the niche, it moved generally closer to the left rib.

Figure 7 – CM313's position at the completion of its rearward movement (marker shows position where the (injured) worker became pinned)

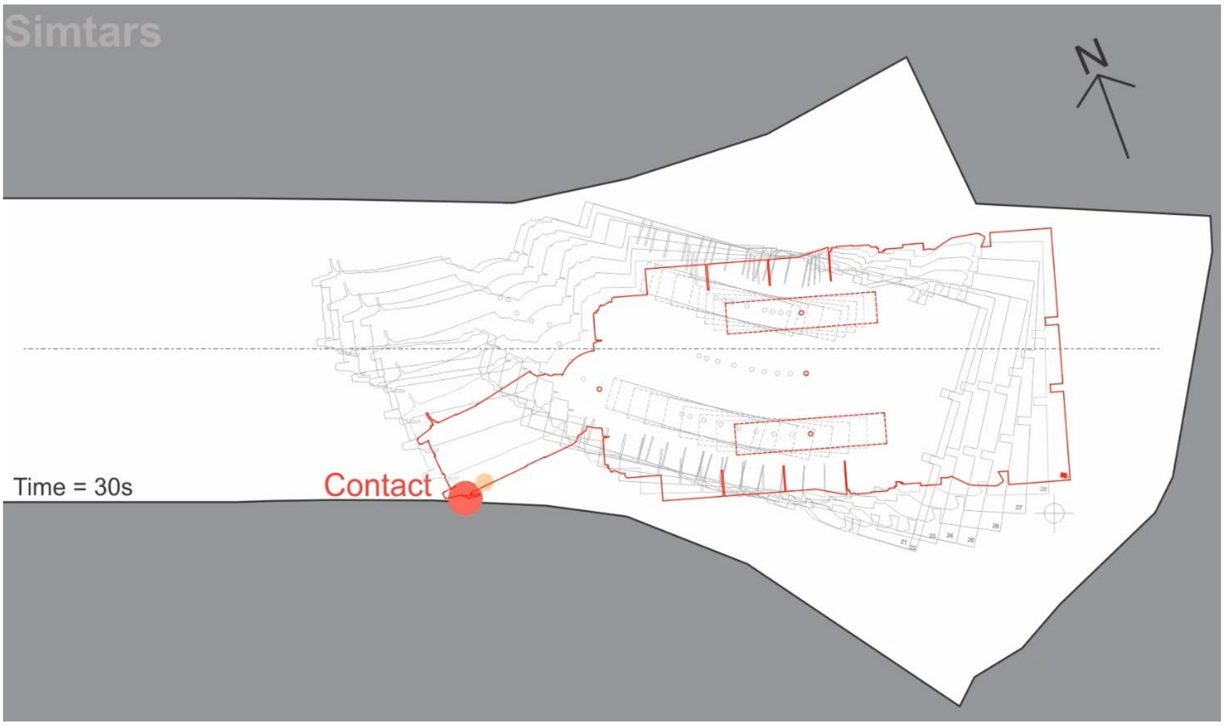


The (injured) worker's movements while CM313 was being repositioned remains unclear. He said while CM313 was retreating, he went to the position where he later became pinned (shown by the red marker in Figure 7). He said as CM313 retreated, he pulled a section of cable back that was about 6 metres along the ground from this point (adjacent to the right rib). The investigation did not identify any evidence to support this statement and it was inconsistent with objective CM313 data establishing that CM313 retreated a total of 698 mm from the niche, making it unlikely that there would have been 6 metres of cable to take up.

The worker said after pulling the first section of the cable back, he walked forward to the location of the red marker shown in Figure 7 in order to take hold of another section of cable. The worker said CM313 was moving rearward when he did this. The investigation did not find any evidence to support this statement, as CM313 retreated for a total of 5 seconds (Phase C).

After completing its rear movement, CM313 was stationary for 2 seconds (start of Phase D). CM313's operator began tramming it forward to further centre the machine. CM313 moved forward and rotated counter-clockwise for about 8 seconds before the incident. As shown in Figure 8 below, there was a considerable lateral movement of CM313's boom as it moved toward the right rib. In the 5 seconds before the impact, the rear right side of the boom moved laterally by 1853 mm and forward by 2116 mm.

Figure 8 - CM313 forward movement during Phase D



The injured worker said CM313's boom could have been as far as 10 metres forward of the position where he was hit at the time that he bent down to pick up the cable. This was inconsistent with evidence that the CM313's cutter head was about 1800 mm from the face at the time of impact, meaning that CM313 could not have been positioned any further forward than this distance (1800 mm). Additionally, the width of the road where the injured worker was positioned was 5500 mm. As Figure 8 illustrates, the rear right side of the boom was positioned near the centre of the roadway when it began moving toward the right rib.

The injured worker said he did not see CM313 move forward at any stage during the above sequence (i.e. during phases A to E). Investigators found, as shown in Figure 6, any rear movement by CM313 ceased 12 seconds before the incident.

The injured worker was facing slightly inbye and towards the continuous miner when he stood up after bending down. He said he was holding a section of cable at that time. As he stood up, he said he saw the rear right corner of CM313's boom moving towards him and about to hit his upper left side. He moved his left arm across his body to try and protect himself, when the rear right corner of the boom hit his left side and pinned him against the rib.

Figure 10 – A mines inspector standing in the approximate spot where the injured worker just before being hit by boom

The injured worker screamed out in pain and vomited. His screams were heard by the other workers. CM313's operator rotated CM313 in a clockwise direction, which caused CM313's boom to move away from the right rib releasing the injured worker (Phase E). CM313 did not move forward or rearward during this manoeuvre. The injured worker was pinned against the rib for several seconds. When he was released, the injured worker fell to the ground and saw that he had an obvious deformity to his lower left arm.

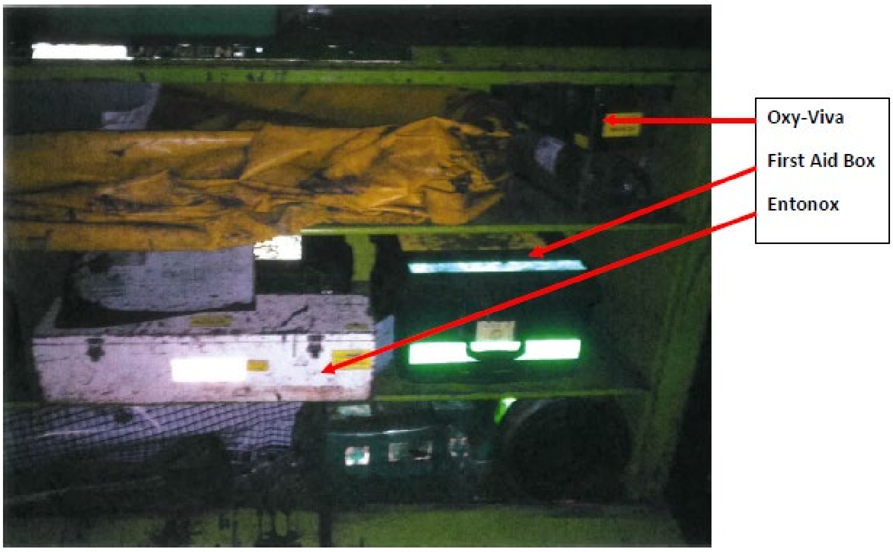
5. The emergency response

CM313's operator immediately assisted the worker while the other worker raised the alarm. CM313's operator assessed the worker for any further injuries other than his fractured left arm. No further injuries were seen by CM313's operator nor described by the worker who was in immense pain. CM313's operator physically supported the injured worker and they began walking towards the crib room for assistance. The worker was placed in a transport vehicle and taken to the crib room.

CM313's operator told another worker, who was speaking to the control room operator, what had occurred. The control room operator requested assistance from the NSW Ambulance Service. It appears that some useful information about the incident and the worker's condition may not have been relayed to the ambulance service's control room operator. This is discussed in more detail in section 8.

A worker went to the emergency pod in the panel to obtain Entonox; a pain relief gas that is stored in a cylinder and administered through a mask. He reached into the pod and mistakenly took hold of an Oxy-Viva unit instead of an Entonox unit. He returned to the transport vehicle where the injured worker was seated. He handed the Oxy-Viva unit to the other workers providing first aid to the injured worker. Nobody raised any concerns at this time about the fact that Oxy-Viva rather than Entonox had been obtained.

Figure 11 - View of Oxy-Viva and Entonox units in an emergency pod



Several workers began transporting the injured worker out of the mine in the transport vehicle. After leaving the crib room, the workers identified that the cylinder attached to the Oxy-Viva unit was empty. The driver of the transport vehicle was aware that there were multiple rough sections of roadway along the exit and this would increase the pain and discomfort of the injured worker. The driver slowed the transport vehicle to minimise these effects. This nearly doubled the time it took to get the injured worker back to the surface. The transport vehicle left the crib room at 12.28am and arrived at the surface at 1.59am.

When the transport vehicle was about halfway through its journey, its driver stopped at the bottom of the Fassifern Drift. They took an Entonox unit from an emergency pod at that location and gave it to the injured worker. This appeared to have provided some limited pain relief. His colleagues did not see any changes in the condition of the injured worker while he was being extracted from the mine and did not give any updates to the control room about his condition.

On arrival on the surface, the injured worker was treated by ambulance officers who had been waiting at the mine for almost one hour. The injured worker was taken to John Hunter Hospital.

6. Injuries suffered by the worker

The worker suffered multiple injuries because of the incident, including:

- a serious lower left arm fracture that required surgery
- unilateral renal agenesis (loss of a kidney)
- rib fractures
- spinal injuries
- shoulder injury requiring surgery
- cardiac injuries
- psychological injuries.

The injured worker continues to experience a range of life-changing health issues stemming from the incident. He was receiving ongoing treatment from multiple specialists at the time of publication.

7. Investigation findings

7.1. CM313 functionality

The investigation determined that the incident was not caused by a machine malfunction or any unplanned movement by CM313. This finding is supported by a range of evidence including:

- worker accounts
- records obtained from the mine operator
- functional testing
- analysis of data downloaded from CM313
- testing of the remote control unit that was connected to CM313 when the incident occurred.

7.2. Causes of the incident

The investigation determined that the incident was caused by a combination of the following factors:

- Ineffective communication between the workers.
- The communication that occurred between CM313's operator and the injured worker was ineffective. Neither had a clear understanding of what the other intended to do. Environmental factors, such as the use of drilling and bolting machinery, ventilation systems and ear protection, made effective verbal communication in the underground mining environment very difficult. The injured worker's attempt to use his cap lamp to communicate also failed to effectively signal to CM313's operator that he was leaving CM313.
- The effect of this flawed communication was that CM313's operator was unaware of the movements of the injured worker and the injured worker was unaware of the precise how, where and why CM313 would be tramming.

7.2.1. Failure to maintain situational awareness

The following facts demonstrate that the workers involved in the incident did not have an adequate understanding of what was happening around them in the lead-up to the incident:

1. The injured worker perceived that the conveyor boom of CM313 was further away from him than it was during Phase D.
2. CM313's operator was unaware that the injured worker had left the platform of the continuous miner and did not know where he was.
3. The other worker saw that the injured worker had stepped off CM313's right platform but did not notify CM313's operator of this, nor watch to see where he went.

Significant factors underpinning the failures described in points 2 and 3 were that, in the mind of CM313's operator, there was no need for the worker to leave the right platform (and he did not expect him to do so) and both he and the other worker considered the worker to be very safe and not somebody who would put himself in a dangerous position.

7.2.2. Failure to observe safe work location rules

The mine's safe work location rules provide that the area between the side of the boom and the rib are no-standing zones. The investigation was unable to determine whether or not the worker was in a no-standing zone other than during the final seconds before the incident. The investigation established that the worker was positioned between the boom and the rib at least for those final few seconds immediately before the incident.

7.2.3. Failure by CM313's operator to maintain an effective lookout

CM313's operator did not see the worker after he left the platform of the miner. A significant factor underpinning this failure was that CM313's operator was of the mistaken belief that the worker was standing behind him on the platform of the miner and had no reason to leave it. Notwithstanding this, it was incumbent on CM313's operator to ensure that no-one was in an unsafe work location around CM313 while it was being trammed. Additionally, CM313's operator should have had a greater awareness regarding the proximity of the conveyor boom to the right rib.

7.2.4. Location of boom

CM313's conveyor boom was angled toward the right rib as it was being repositioned in the heading before the incident. It can be inferred that CM313's operator maintained it in this position as it would need to be angled to the right when the left side cassette was changed. The result was that when CM313 trammed forward, the conveyor boom was much closer to the right rib than it would have been if the boom was centred.

The injured worker said he assumed that CM313's operator would centre the conveyor boom before CM313 was moved. This was based on the injured worker's belief that this was a requirement that applied at the mine when continuous miners are trammed rearward. This resulted in the injured worker being much closer to the boom than he thought he was in the seconds before the incident. Had the injured worker known that the left side bolt cassette was to be changed out, he may have had awareness that the boom was to remain angled to the right.

There were no specific rules in place at the mine setting out what position the conveyor boom of a continuous miner should be in while it is being repositioned in a closed heading. This is because of a need to provide continuous miner operators with the flexibility to position the conveyor boom as they see fit to prevent it from contacting the ribs.

7.3. Risk to health and safety

The investigation identified that workers at the mine were exposed to the risk of death or serious injury by being struck or pinned by a continuous miner because of standing in an unsafe location.

7.4. Identification and assessment of the risk

7.4.1. Mine operator

The mine operator identified the risk of a worker being struck by a continuous miner well before the incident occurred. It had undertaken various risk assessments between 2010 and 2020.

Each of the risk assessments identified the risk of interactions between underground mobile plant and workers in some form. Collectively the risk assessments identified the following controls:

- Safe standing zones and work procedures.
- Trained and competent operators, including completion of a hazard awareness program.
- Supervision.
- Audible warning devices and lighting on continuous miners.
- High visibility clothing.
- Functional safety design of controller (dead man/tilt switch operation).
- Slow tramming speed of continuous miners.
- Machinery maintenance program and mine inspection system.
- Underground transport management plan.
- Strata management plan.
- Fit-for-purpose equipment.

7.4.2. Original equipment manufacturer (OEM)

On 10 December 2019, Komatsu prepared a risk management plan to communicate the hazards and controls associated with operation of the overhauled CM313 to the mine operator. The plan assumed the existence of effective safe work location rules at the mine. The controls that Komatsu recommended the mine operator consider to reduce the risk of crush injuries included:

- the use of cap lamps
- isolation rules
- audible alarms and reversing lights.

The risk assessment did not identify PDS as a suitable control.

7.4.3. Workers

The workers each completed a personal risk assessment before the incident using the mine operator's 'Stop, Look, Assess and Manage' (SLAM) process. However, the SLAM completed by the injured worker was not able to be found following the incident.

The controls identified by the workers in the SLAMs that were recovered included the following (as relevant):

- safe work zones
- cable awareness
- positive communications
- spotters
- housekeeping on continuous miner.

7.5. Implemented risk controls

At the time of the incident, the mine operator had implemented a series of controls to eliminate or mitigate the risk of workers being struck by continuous miners. They included the following:

7.5.1. Safe work location rules

Procedural deficiencies set out following in this section are not considered to be a substantial cause of the risk to which the injured worker was exposed for the reasons set out above at section 7.2 'Causes of incident' and because most workers generally understood that the following were no standing zones while CM313 was being repositioned in a closed heading:

- anywhere between the conveyor boom and the rib; and
- within 2 metres of the rear of the conveyor boom.

7.5.1.1. Established safe work location rules at the mine

At the time of the incident, the mine operator had implemented the following safe work location rules at the mine:

- S070 T050 No Standing Zone procedure dated 2 April 2012 (NSZ procedure)
- 'Myuna Collieries - No Standing Zones' plan (No. MY10916 – Revision 2) reviewed 3 July 2017 (the plan).

Most of the diagrams that defined safe work location zones in the NSZ procedure were also contained in a similar form in the plan. The plan was displayed in prominent locations in the mine at the time of the incident, including the crib room in the panel where the incident occurred.

The NSZ procedure described the following safe work location zones:

- Control Zone – 'Designated area where people can pass or work when the continuous miner is operational, the pump is running.'

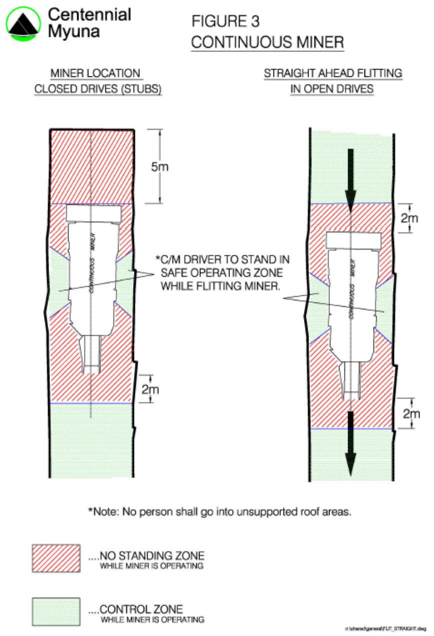
- No Standing Zone – 'Area where people cannot pass or work unless appropriate isolation procedures for the continuous miner have been carried out.'

The NSZ procedure did not describe 'no entry zones'. While the plan does refer to 'no entry zones', it did not define the safe work location zones that were depicted in it. The mine operator stated that the term 'no entry zones' should be given 'its ordinary every day meaning'. The mine operator's training materials also refer to 'no entry zones'.

7.5.1.2. Safe work location zones when repositioning a miner in a drive

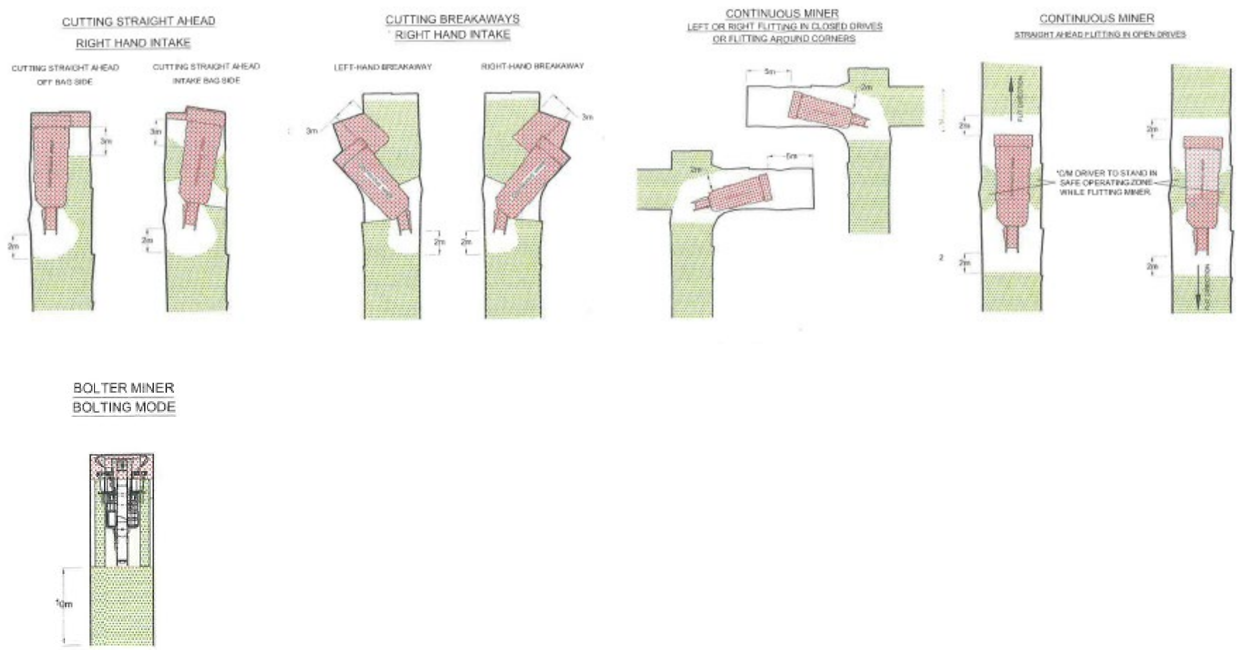
The mine operator stated the following diagram in the NSZ procedure sets out the safe work location zone rules that apply 'when repositioning a continuous mining machine in a drive'.

Figure 12 - Excerpt from Centennial Myuna S070 T050 No Standing Zone Procedure



There was no corresponding illustration of the above 'Miner location closed drive stubs' in the plan. This position existed despite most workers at the mine being familiar with the plan but some not being familiar with the NSZ procedure and whether it was still in effect.

Figure 13 - Excerpt from 'Myuna Collieries - No Standing Zones' plan



7.5.1.3. Terminology used in the safe work location rules

The NSZ procedure and the plan each describe the safe work location zones that apply when continuous miners are in, 'cutting' and 'flitting' modes. Additionally, the plan refers to a 'bolting' mode, which is not referred to in the NSZ procedure. The terms 'cutting', 'flitting' and 'bolting' are not defined in the safe work location rules or any related document. The failure to define 'flitting' made it difficult for some workers to describe which of the safe work location rules applied when a continuous miner was being repositioned within a heading by reference to these documents. However, most workers considered that 'flitting' referred to moving a continuous miner a considerable distance; for example, moving from one heading to another. This was consistent with information provided by the mine operator to the Regulator. Workers generally referred to smaller movements of continuous miners as 'tramming'.

7.5.1.4. Understanding of safe work location rules

Workers at the mine provided a range of different views about what the safe work location rules were when a continuous miner was being repositioned from a niche or breakaway into the centre of a heading.

Most workers agreed the cutting and bolting mode diagrams had no relevance to the task of repositioning CM313 within the heading. However, some of the workers were confused about whether the flitting diagrams had application to the task because of the confusion around the term 'flitting'. Some workers felt that the diagrams in the plan did not sufficiently describe the task that was being performed at the time of the incident.

Notwithstanding the above issues, most workers generally understood that the following were no standing zones while CM313 was being repositioned in a closed heading:

- Anywhere between the conveyor boom and the rib; and
- Within 2 metres of the rear of the conveyor boom.

7.5.1.5. Other relevant guidance in the NSZ procedure

The NSZ procedure sets out several other requirements in relation to activity around continuous miners that were relevant to the incident:

- The operator shall have a view of all other personnel involved in the flit during flitting.
- During flitting operations, crew members will be under the direction of CM313's operator.

7.5.1.6. Observations regarding effectiveness of safe work location rules

On the date of the incident, the mine operator's safe work location rules proved ineffective in preventing the interaction between the boom of CM313 and the injured worker. As an administrative control, there effectiveness was wholly reliant upon workers properly understanding and complying with them.

While the specific manner in which the safe work location rules failed in this case was unable to be determined, because of the conflicting versions given by the, it is apparent that immediately before the incident, the injured worker was in an unsafe location having regard to the proximity of the boom of CM313 to him.

The investigation identified the following:

- Most workers were familiar with the NSZ plan but some of the workers were not familiar with the NSZ procedure and whether it still applied.
- The mine operator's safe work location rules did not provide clear information about the location of no standing zones when a continuous miner was being repositioned within a closed heading.
- Most workers interviewed indicated they were unaware of any circumstances when safe standing rules were breached.
- Several workers were, or may have been, aware of circumstances when no standing zone rules were breached but were unable to describe particular instances.

- The mine operator stated it was unaware of any circumstances in which no standing zone rules were breached in the 12 months before the incident.
- Notwithstanding procedural deficiencies set out above, most workers generally understood that anywhere between the conveyor boom and the rib and within 2 metres of the rear of the conveyor boom constituted no standing zones if CM313 was being repositioned in a closed heading.

7.5.2. Safe work procedures – including positive communication

The investigation identified a range of other procedures that were relevant to the work being undertaken at the time of the incident. They include procedures covering the safe operation of the continuous miner, strata support installation, unloading and changing cassettes on a continuous miner and cable management.

7.5.2.1. Observations regarding effectiveness of procedures

The investigation identified the following:

- All of the workers interviewed demonstrated there was a strong emphasis on the need to establish positive communications at the mine.
- The failure by CM313's operator and the injured worker to establish positive communications before the incident was a departure from the usual practices and procedures used at the mine.
- While the procedures set out what position a boom should be in when a bolt cassette is changed out, they do not define what position the boom should be in while a continuous miner is being repositioned in a heading.

7.5.3. Trained and competent workers

Each of the workers was trained and assessed by the mine operator as competent to perform the work they were undertaking at the time of the incident. The workers had undertaken 3 days of induction training, a mine hazard awareness program and annual whole-of-mine refresher training. The training materials included the following warning in relation to continuous miners.

'The machine is over 10 metres in length but the tracks are 2.5 metres long. Small movement of the tracks results in a large movement of machine components'.

7.5.4. Planned task observations

7.5.4.1. Description

The mine operator tasked the section deputy on each shift to complete a planned task observation of their crews. The observations are performed while the crews undertook a variety of tasks associated with the operation of continuous miners. The mine operator stated the process was used to 'remind workers of the risks and controls when working near continuous miners'.

The investigation reviewed all planned task observations conducted at the mine in the 12 months before the incident.

7.5.4.2. Observations regarding effectiveness of planned task observations

The investigation identified that there:

- was a strong focus on compliance with no standing zone rules when the planned task observations were undertaken
- no instances of non-compliance with no-standing rules being recorded in the planned task observations.

7.5.5. CM313 safety systems

The following table provides a summary of the key safety systems that were fitted to CM313 to minimise the risk of workers being pinned by the boom of a continuous miner.

SAFETY SYSTEM	DESCRIPTION	OBSERVATIONS REGARDING EFFECTIVENSS OF SFETY SYSTEM
Audible alarms	Operate upon start up and when the continuous miner is reversing. Alarms were found to be operational during functional testing.	No effect. The injured worker was already aware that CM313 was being repositioned and it was moving forward when the incident occurred.
Reversing light	Bright light that shines rearward when CM313 is moved in a rearward direction. Light was found to be operational during functional testing.	No effect. The injured worker was already aware that CM313 was being repositioned and it was moving forward when the incident occurred.
Continuous miner hydraulic pump diversion valve	When activated, the diversion valve prevents the tracks of CM313 from moving.	No effect. The injured worker was aware that CM313 was moving before the incident.

Figure 3 - Reversing light on CM313 displayed during functional testing

7.6. Practicability of absent control – proximity detection

Investigators considered whether it was reasonably practicable for the mine operator to have installed proximity detection systems on CM313 before the incident.

7.6.1. Consideration by mine operator

The mine operator explained it had not installed PDS on any continuous miners at the mine before the incident on the basis that:

- operational risk assessments completed on continuous miner operations did not identify the requirement for the need of proximity detections systems
- notwithstanding the above, the mine operator stated proximity detection was being considered on a Centennial group wide basis.

7.6.2. Information considered by mine operator and CCCL

The mine operator and CCCL considered various information about the practicability of installing proximity detection equipment on underground mobile plant before the incident including the following:

7.6.2.1. MDG 2007 – Published July 2013

CCCL was part of an industry working group on collision management systems in underground coal mines. The group was responsible for producing Mine Design Guideline 2007 – Guideline for the selection and implementation of collision management systems. MDG2007, which is still in effect, identifies as its purpose:

To provide information to assist in applying an appropriate methodology to define, select and implement a collision management system suitable for the mine and may be used to review the system in operation.

MDG 2007 asserts that collision management systems need to be designed, implemented, and operated with 'appropriate safety integrity'. This can be achieved by applying a Safety Integrity Level (SIL) rating or alternatively by providing the following to the machine operator:

- Assurance of what functional safety standard has been used.
- Identification of safety critical systems and components of those systems.
- Documentation of what tasks need to be undertaken to maintain system integrity across the lifecycle of the system.

MDG 2007 requires mine operators to complete risk assessments to ensure that the risks associated with the use of collision management systems throughout its life cycle phases are as low as reasonably practicable.

7.6.2.2. ACARP Project C24010 Collision Awareness – Capability of Underground Mine Vehicle Proximity Detection Systems – Published 6 February 2018

This project was undertaken by Simtars. The purpose of the project was to independently assess proximity detection systems using a range of vehicle to person scenarios in the underground coal mining environment. One of the findings of the project was:

………some of the suppliers had problems with offering reliable technology and proven solutions to address the different developed scenarios. During testing suppliers also questioned the practicality of some of the scenarios when their systems did not perform as expected. This indicates a difference between mining industry performance expectations of proximity detection systems and what the suppliers are providing to the mining industry.

7.6.2.3. Trial of PDS at Myuna Colliery – January 2014

The mine operator participated in the trial of a PDS (awareness system only) at the mine, which involved the installation of technologies in each workers' integrated communications cap lamp and on two shuttle cars. The trial identified several limitations regarding the effectiveness of the PDS trialled at that time.

7.6.2.4. Timing of installation of PDS

The mine operator stated that, due to the nature or the process, installation of a 'Proximity Ready System' only occur during overhaul at Komatsu's workshops. This is consistent with information provided by proximity detection system providers.

7.6.3. Information provided by Joy Global/Komatsu

Joy stated it did not supply a standard PDS on any of its underground mining equipment sold in Australia. This is although PDS is available on Joy equipment sold in the United States. It states its experience has been that mine operators in Australia prefer a PDS solution that can be fully integrated across all of its mobile plant and operations, not just on Joy and Komatsu equipment. It stated it was always willing to work with mine operators and PDS suppliers to provide the necessary interfaces with its equipment, something it has done on several occasions.

7.6.4. Information supplied by proximity detection system providers

The investigation engaged with 2 leading PDS providers to obtain information about the level of development of PDS technologies and the uptake of PDS in the underground coal mining industry. The information provided by each of the providers was consistent. The following is a summary of the information obtained:

7.6.4.1. Operation of PDS

Each PDS has its own technologies and systems but there are some commonalities about their design and operation. Flame proof generators are mounted on the extremities of the mobile plant. The generators create an electro-magnetic field. Cap lamps are fitted with a coil which can detect the electro-magnetic fields and send a message to the PDS to cause it to create an alarm, slow or stop the mobile plant. The size and shape of each field or zone is configurable depending on the mine operator's requirements.

7.6.4.2. Rollout of PDS

Because of the close proximity in which underground coal mining mobile plant operates it is generally not feasible to operate PDS on a single piece of mobile plant. As an example, if a detection zone was created around the boom of a continuous miner, a detection would occur each time a shuttle car approached the continuous miner to be loaded. It is possible to create a silent zone around certain parts of the shuttle car that prevents it from causing a detection when it approaches a continuous miner. If there were multiple shuttle cars operating in proximity to the continuous miner, each would need to be fitted with the technology to create a silent zone. These types of factors need to be considered across each operating panel in a mine.

PDS providers stated it was only practicable to install PDS on underground mobile plant during an overhaul when the plant was brought to the surface. This is because:

- there is a significant amount of welding work required to install PDS that cannot be performed in an explosive environment
- it is necessary to strip the mobile plant back in order to fit the necessary components.

Given that continuous miners are overhauled approximately every 4 to 5 years, a significant period of lead time is available to plan, install and commission PDS across all mobile plant in a mine.

7.6.4.3. Functional safety requirements of MDG2007

It has been noted by PDS providers that some mine operators perceive the functional safety requirements prescribed by MDG 2007 as an impediment or disincentive to obtaining PDS. PDS providers have not been able to obtain a sufficient SIL rating for their systems because of some practicalities around their software systems and the nature of the underground mining environment. Notwithstanding this, consistent with MDG 2007, they have been able to incorporate other risk mitigation methods to demonstrate to mine operators that their systems are functionally safe. PDS providers highlight that their systems are designed to complement existing controls, such as safe work location rules, and not replace them.

PDS providers have observed that, notwithstanding their efforts, some operators state that they are looking for a SIL rated PDS in order to meet the requirements of MDG 2007. This suggests that there is a level of misunderstanding about these requirements, as alternative methods of demonstrating functional safety to comply with MDG 2007 (other than a SIL rating) are clearly available.

7.6.4.4. Reliability of PDS

There has been a significant increase in the reliability of PDS in recent years. Although providers publicly state the detection zones are accurate to a distance of 50 cm, these zones are likely to be in the vicinity of 20 to 30 cm.

7.6.4.5. Costs of PDS

The investigation assessed the costs associated with the acquisition of PDS on continuous miners. Acquisition costs may include:

- system purchase and install
- original equipment manufacturer costs where the PDS needs to be configured to control the continuous miner
- acquiring PDS compatible cap lamps or retro fitting existing cap lamps with bolt on detection units
- training and commissioning.

The specific costs associated with the acquisition of PDS have not been detailed in this report to maintain commercial confidences. However, the investigation determined these costs were not disproportionate to eliminating or minimising the risk of interactions between continuous miners and workers in terms of section 18 of the *Work Health and Safety Act 2011*.

7.6.4.6. Observations regarding the installation of PDS on CM313

The investigation identified the following:

- PDS technology has advanced significantly in recent years.
- It is almost certain that had today's standard of PDS been effectively implemented on CM313, the technology would have shut it down before its boom injured the worker.
- PDS has been successfully implemented on continuous miners in South Africa and United States where their use is required by legislation. They have not been implemented in NSW.
- Given that is only practicable to install PDS on continuous miners during an overhaul, consideration regarding the practicability of installing PDS on CM313 needs to be considered by reference to the circumstances that existed during the planning phase of its last overhaul in March 2019 when the scope of this overhaul was developed.

7.7. Actions taken post incident

The mine operator has undertaken several measures since the incident occurred to reduce the relevant risk. They include:

- conducting a review of its operational risk assessments for the safe operation of continuous miners.
- updating the S070 T029 Safe Operation – Continuous Miner procedure to include the following additional requirements:
  - When an operator is required to enter or exit CM313 through a designated no standing zone he must establish positive communications with CM313 driver and confirm that the 'pump on CM313 is off' or 'CM313 is in bolting mode' before entering the no standing zone.
  - Workers must be aware of the environmental conditions and stand in appropriate position that remains clear of the no standing zones at all times.
  - Conducting refresher training in relation to safe work location rules around continuous miners.
  - Conducting a review of its existing engineering controls, including PDS, with Komatsu.
  - Installing a proximity ready system on a continuous miner during its current overhaul and engaging a PDS provider to install a 'Field Electromagnetic Detection system'. It states that this will enable the continuous miner to be 'DS ready when the technology is proven'. The mine operator is proposing to conduct a trial of the system involving its day shift crew when the overhauled continuous miner returns to the mine.

— Installing a mode lighting system on each of its continuous miners during their scheduled 5 yearly overhaul. The mode lighting assists workers by signalling when the operational mode of a continuous miner is changed.

The mine operator did not make any other changes to its safe work location rules, including the zones referred to in them.

8. Emergency response

The investigation examined the mine operator's emergency response to the incident.

8.1. Emergency management plan

The mine operator had implemented the Myuna Colliery Emergency Management Plan (EMP) at the mine before the incident. The EMP provided for the establishment of a manned control room that was in operation at the time of the incident.

8.1.1. First aid and emergency response training

The mine operator facilitates a range of first aid and emergency response training, including:

- first aid training - All workers were provided the opportunity to undertake the 'Apply First Aid' qualification on a voluntary basis. The training was facilitated by NSW Mines Rescue
- oxy-viva and Entonox training – All workers were required to undergo annual training provided by the mine operator in relation to the use of Oxy-Viva (oxygen therapy) and Entonox (pain relief) units
- Mines Rescue members – The mine maintains 19 Mines Rescue Brigadesmen. Brigadesmen undertake periodic training with NSW Mines Rescue that includes training in first aid and responding to emergencies.

The investigation determined that each of the responders was sufficiently trained to fulfill the role that they undertook in the provision of first aid to, and extraction of, the worker.

Worker	Apply First Aid	Oxy-Viva/Entonox	Mines Rescue Brigadesmen
Responder A	Yes	Yes	No
Responder B	No	Yes	No
Responder C	No	Yes	Yes
Transport vehicle driver	No	Yes	No
CM313's operator	Yes	Yes	Yes
Deputy	Yes	Yes	Yes
Responder D	Yes	Yes	Yes

8.2. Inspection of Oxy-Viva and Entonox units

The mine operator implemented an inspection program for first aid equipment at the mine, including Oxy-Viva and Entonox units. The program included the following inspection regime which the investigation determined had been followed:

- Weekly inspections by each panel deputy.
- Three monthly inspections to ensure that the equipment was in place and in working order.
- Annual inspections by an external provider to ensure that the equipment was in the required functioning order.

The investigation determined that the most likely reason that the oxygen bottle was empty when it was deployed to the injured worker was the cylinder being left in the open position following testing and a lever inside the unit being left slightly open, thereby permitting oxygen to slowly deplete from the system. Other possible, but less likely reasons, are that the bottle was depleted during testing or may have been mistakenly turned on.

8.3. NSW Ambulance response

The following key information about the injured worker's extraction from the mine and the ambulance response was obtained during the investigation:

Time	Event
12.16 am	Incident occurred.
12.18 am	A responder contacted the mine's control room operator and advised the worker 'was squashed against rib and boom'. He further advised the worker was on his way out of the mine and that the worker had a significant arm deformity but was breathing and conscious. He told the control room operator the worker was pinned but did not say how long the worker was pinned for.
12.20 am	A call to the NSW Ambulance Service was initiated by the mine's room operator. He advised the worker was squashed against the rib. Ambulance operator said: "We would normally say don't move him but obviously that's not a safe area to be in so they're trying to bring him up".
12.28 am	Deputy told the mine control room operator that the worker was pinned between the boom and the rib. This information was not communicated to the ambulance operator.
12.56 am	NSW Ambulance unit 4244 arrived at the mine (road vehicle).
01.34 am	Deputy told the control room operator that the worker vomited after incident. It was unclear if this information was communicated to the ambulance officers in attendance.
02.15 am	NSW Ambulance officers began treating the worker.
02.21 am	NSW Ambulance left the mine with the injured worker on board.
03.03 am	The injured worker arrives at John Hunter Hospital.

NSW Ambulance representatives stated the information provided by the mine operator about the worker's crush injury was unclear. They indicated that if further information was provided about the worker's condition, a higher level response may have been assigned. This may have included using air transport. It should be noted that the mine's control room operator states he had a face-to-face conversation with the 2 ambulance officers after they arrived at the mine. He said he provided some additional information to them, which included that the worker was pinned by the boom of CM313.

Ambulance representatives said it was unlikely that the lower priority ambulance response caused the injured worker's condition to become worse. They stated the treatment of crush injuries required heart monitoring and administrating intravenous medication to counter the release of toxins. They also stated the treatment for kidney injuries was to flush them using an intravenous line. It was further stated that good conditions were required to insert an intravenous line and ambulance officers would not have been able to initiate that in an underground coal mine setting.

The ambulance officers stated the worker's ambulance treatment would not have involved the administration of oxygen. They stated the inability by the responding workers to administer oxygen to the worker would not have caused his condition to become worse. The failure to provide adequate pain relief caused the injured worker unnecessary pain and distress.

8.3.1.1. Observations regarding emergency response

The investigation established the following in relation to the emergency response to the incident:

- The responding workers all considered that the most effective response was to transport the injured worker to the surface as soon as possible. There was no consideration given to having ambulance officers treat the worker at the incident site, having regard to the time it would have taken to transport ambulance officers to the incident scene and the limited treatment options that were available to ambulance officers in an underground setting.

- The workers who responded to the injured worker received appropriate training and those that made key decisions about first aid and the emergency response had undergone advanced training as NSW Mines Rescue Brigadesmen.
- The provision of an Oxy-Viva unit to the transport vehicle rather than Entonox unit was based on a human error that arose in an urgent situation. There was no evidence of failings in the mine's systems or training that caused this to occur. The units were quite distinctive in appearance and there was nothing identified in the manner in which the units were stored or labelled which contributed to the error.
- Some important information about the incident was not provided to the ambulance operator, including the possibility that the worker may have sustained internal injuries and that he had vomited. This was likely to be a result of information being relayed from one person to another. However, information was passed by the control room operator to the ambulance operator that the worker had been 'squashed.' It was likely that the control room operator also informed the ambulance officers in attendance that the worker was pinned.
- The poor state of the road on the exit to the mine and the failure to provide the worker with pain relief, resulted in the worker's extraction from the mine being prolonged and extremely painful.
- There is no evidence of any failings by the mine operator relating to the storage and inspection of Oxy-Viva causing the unit that was deployed to the worker to be empty.

9. Recommendations

9.1. Mine operators

Mine operators have a duty to identify hazards and manage risks to health and safety in accordance with the provisions of the *Work Health and Safety Act 2011* and related legislation. It is recommended that mine operators:

9.1.1. Proximity detection systems

- Implement higher order engineering controls (like PDS) in combination with lower order administrative controls (including safe work location rules and training) to manage risk arising from continuous miners, where reasonably practicable, having regard to the following:
  - PDS technology for mobile plant used in underground coal mines has advanced significantly in recent years and concerns held by some mine operators in the past about the reliability of PDS may no longer be valid.
  - PDS has been used successfully on continuous miners in other jurisdictions and found to complement lower order administrative controls (including safe work location rules and training).
  - MDG 2007 is not an impediment to adopting PDS on continuous miners. Where appropriate SIL ratings are unachievable for a PDS, mine operators should use other risk mitigation methods to satisfy functional safety requirements.
  - The cost of PDS is generally not grossly disproportionate to eliminating or minimising the risk of interactions between continuous miners and workers.
  - Recognise that early planning is essential when fitting PDS to existing continuous miners. PDS must be considered as part of the overhaul planning process.
  - Review existing risk assessments concerning interactions between continuous miners and workers having regard to the previously mentioned matters.

9.1.2. Administrative controls

- ensure safe work location rules and exclusion zones are adequate
- ensure safe work location rules are presented in a logical and consistent manner and understood by the workforce
- ensure key terms are defined and explained.

9.1.3. Communication

- provide adequate training to workers on effective communication techniques when working in noisy and dark environments
- reinforce the need for workers to use effective communication when working in and around mobile plant.

9.1.4. First aid and emergency response

Review emergency plans and training processes to ensure they adequately reflect the following:

- NSW Ambulance Service advice about the appropriate location to treat injured workers.
- Instruction on how information about an injured worker's injuries and condition is effectively communicated to emergency services, including the provision of updated information.
- In accordance with Clause 89 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022, consult with emergency services agencies about the content of the mine's emergency plan. This consultation should include making provision for emergency services to attend underground areas of mines to respond to injured workers.
- Review inspection and audit programs to ensure first aid equipment is adequate and fully functional.

9.2. Workers

Workers have a duty to take care for their own health and safety and of their co-workers. They must also comply as far as they are reasonably able with any work instructions given by mine operators to ensure worker safety and compliance with the *Work Health and Safety Act 2011* and related legislation. It is recommended that workers ensure:

9.2.1. Communication

- that all workers involved in a work activity are actively included in discussions about the activity before commencing
- all workers understand how the work activity will be undertaken
- that effective communication occurs before moving mobile plant
- positive communication are established confirming how, where and why the mobile plant is to be moved
- environmental factors, such as noisy and dark work environments, are considered.

9.2.2. Situational awareness

- situational awareness is maintained at all times
- adequate separation distances from moving mobile plant are maintained
- mobile plant operators maintain effective lookout when moving equipment by scanning and monitoring of the work environment.

9.2.3. Safe work location rules

- safe work location rules and exclusion zones are followed and consideration given to changes that affect safe work locations and exclusion zones when mobile plant is moved.