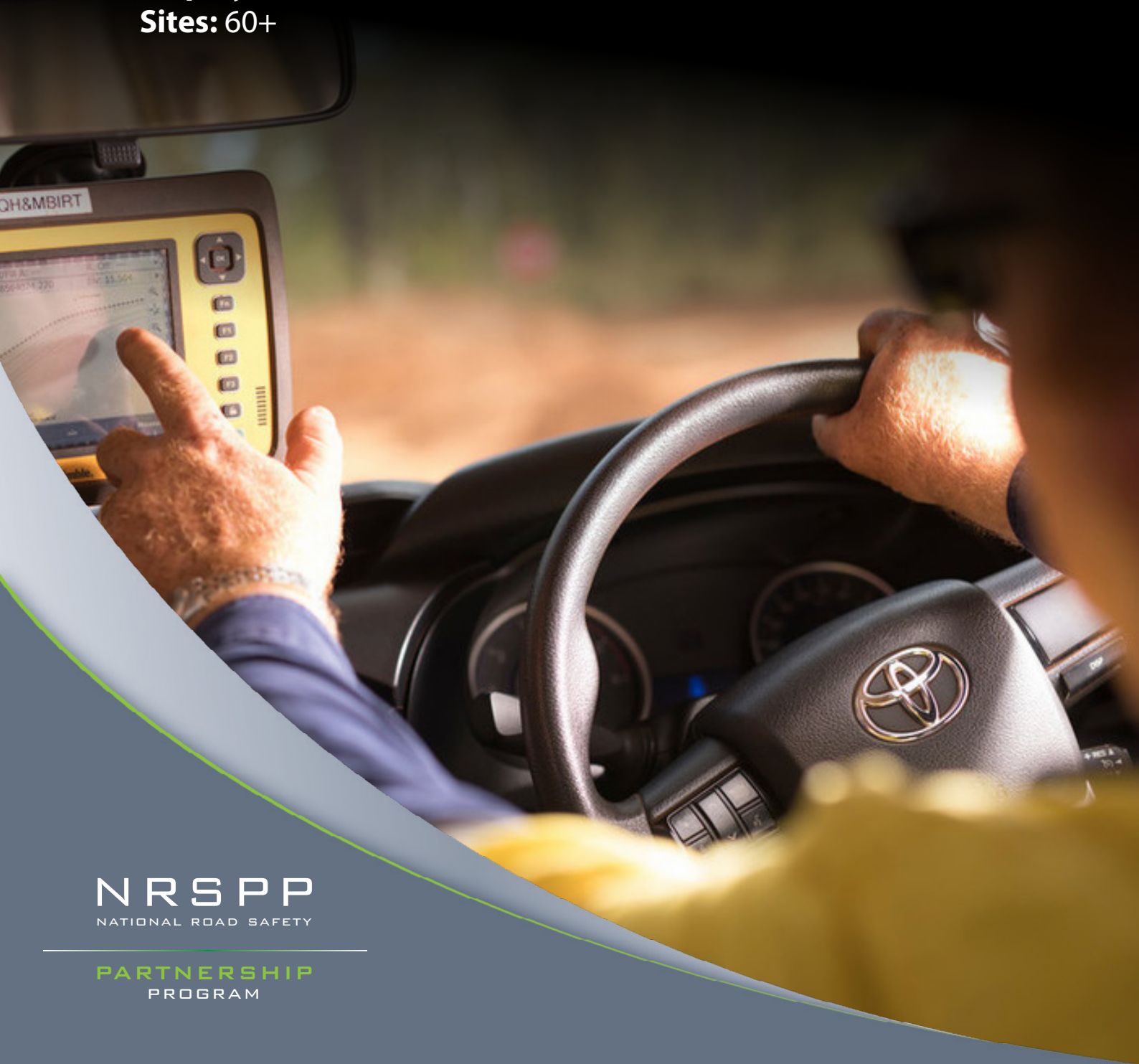


March 2018

Rio Tinto

The safety loop: CRM program, bow ties and preventing fatalities and serious injuries

Employees: 50,000+
Sites: 60+



NRSP
NATIONAL ROAD SAFETY

PARTNERSHIP
PROGRAM

PARTNERSHIP PROGRAM

Organisation: Rio Tinto
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The Rio Tinto logo is a red rectangle with the words "RioTinto" in white, sans-serif font.

Case Study:

How a linked CRM-bow tie approach can prevent fatalities and serious injuries

Key Outcomes:

- Creating a safety loop, that incorporates a critical risk management (CRM) program underpinned by the bow-tie analysis method, drives perpetual improvement in safety performance
- A layered verification-based CRM program helps highlight areas for improvement and engage frontline operations in improving and maximising their own safety
- The bow-tie method can be effective in narrowing an organisation's focus to key critical controls that have the most impact on safety performance on the ground
- Implementing a standardised system allows safety learnings to be shared globally virtually overnight, quickly turning safety failings into strengths
- CEO-level support and cascading safety accountability via each level of management drives a strong, self-reinforcing safety culture
- Empowering frontline operational staff to stop, or not start, work if it is unsafe engages the entire workforce in the safety process, resulting in better safety performance and improving the quality of safety data collected to drive improvements.

Synopsis:

Implementing a layered critical control verification program, underpinned by the bow tie analysis method, can create a strong safety loop that identifies weaknesses in an organisation's frontline safety controls, turning them into strengths while engaging everyone from the CEO to operators in preventing and reducing serious injuries and fatalities.

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Organisation Overview

Rio Tinto employs more than 50,000 people across the globe – and an equivalent number of contractors – working in 35 countries and six continents.

Pioneers in mining and metals, Rio Tinto has been in business for more than 140 years. It finds, mines, processes and markets mineral resources, with a product list that includes aluminium, copper, diamonds, gold, industrial minerals (borates, titanium dioxide and salt), iron ore, coal and uranium.

The company is strongly represented in Australia and North America, and also has significant businesses in Asia, Europe, Africa and South America.

Its Australian operations include the Argyle diamond mine in WA's remote East Kimberley; the Bell Bay aluminium smelter in Tasmania and Boyne aluminium smelters near Gladstone; bauxite mining on Cape York and in the Northern Territory; alumina refineries in Queensland; Australia's longest continually operated uranium mine, Energy Resources of Australia; one of the world's largest producers of seaborne salt, Dampier Salt; and vast iron ore operations in the Pilbara.

Rio Tinto's operations are underpinned by the values of safety, teamwork, respect, integrity and excellence. In regards to safety, the company aims to foster a culture where its people keep their safety, and that of their workmates, contractors and communities, top of mind.

It is committed to sharing and working with 'competitors' to maximise safety performance across the industry and believes in putting people at the centre of its safety strategy.

Safety Strategy

Over the past decade, Rio Tinto's all injury frequency rate (AIFR), a key measure of its safety performance, has reduced by about 85 per cent.

All Rio Tinto workers are required to ensure that safety controls are in place prior to undertaking a task and immediately stop the task if an uncontrolled hazard is identified.

In the continual tension between time, quality and convenience, Rio Tinto wants its people to not feel rushed to complete the job, but rather be alert to the hazards and empowered to stop if needed.

Rio Tinto's safety strategy focuses on three main areas, striving to eliminate fatalities, prevent catastrophic events, and reduce the number and severity of injuries.

Efforts to reduce injuries include specialist programs that aim to improve workplace conditions, raise awareness of hazards and risks, develop a better appreciation of severity focus, and improve contractor management, systems integration and learning from incidents.

Strong systems, monitoring and assurance activities underpin the focus on preventing catastrophic events, which often lie outside the control of individual operators, such as underground risks and energy explosions.

In regards to fatality elimination, Rio Tinto aims to ensure it has effective critical controls in place through its layered critical control verification program, referred to as CRM (critical risk management), as well as recognising that there are human factors at play, including human error.

This case study will focus primarily on Rio Tinto's critical control verification program, developed in partnership with Forwood Safety, with a particular emphasis on how it has tailored the popular 'bow-tie' analysis method to identify what fatality critical controls are required, assess their effectiveness and create a 'safety loop' to ensure failings become learnings. The case study then focusses on the application to vehicles and driving as their number one fatal risk.

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Kicking Safety Goals

Rio Tinto's goal is for everyone to go home safe and healthy at the end of each shift. Its approach to safety goes beyond compliance and seeks to achieve continual improvement.

Annually-audited global safety standards address key areas of risk and provide consistency in safety management and performance across its operations and projects.

All levels of the organisation are expected to engage with safety and are supported by effective fit-for-purpose management systems and internal controls that include monitoring and reporting against set standards. To achieve its safety goals, Rio Tinto:

- Reports and investigates all incidents, ensuring learnings are shared and implemented across the organisation.
- Actively involves employees and contractors in all areas of safety management.
- Implements safety performance standards and expectations for managing critical risks.
- Provides training to ensure employees and contractors understand the controls for managing risks.
- Measures and monitors performance against minimum safety standards.
- Maintains an appropriate safety assurance framework through a range of audits, reviews and verifications against its standards.
- Develops, implements and embeds a focus on process safety and fatality prevention programs.
- Establishes, implements and monitors critical control plans to manage key safety risks
- Expects its leaders to be visible and passionate champions for safety. They willingly accept accountability for the safety of everyone in their team.

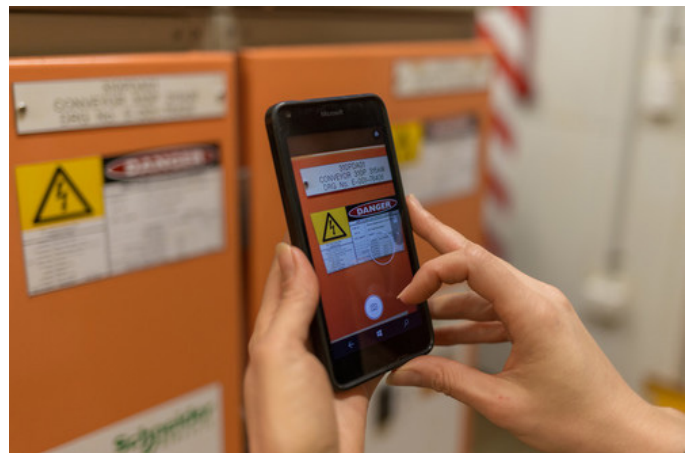
- Expects every employee to be committed to their own safety and the safety of their workmates, and consistently set high standards through their behaviour.

The CRM Journey

Rio Tinto's layered critical control verification program covers the fatality critical risk and every operational person, from general managers and supervisors to operators and contractors, at every Rio Tinto site.

The company's starting point in introducing its CRM program was through benchmarking with the Escondida operation in Chile, where Rio Tinto is a Joint Venture partner but it is managed by BHP. BHP's Chile experience had also showed how a complex site with a large labour force could implement and systemise a new approach.

Before roll out, Rio Tinto trialed its CRM program at three diverse locations to test its adaptability across a range of operating environments, such as mining, refining and smelters, while ensuring consistency of approach and data collection. Once the trial was complete and the design confirmed, Rio Tinto rolled out its critical control verification program rapidly across its global operations, with the speed of the roll out powered by an executive mandate, strong support from leaders and operators, and the power of a well-designed standardised system and supporting technology platform.



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CRM Roll Out

Rio Tinto's CRM program was rolled out in a standardised and consistent way across more than 60 operational sites and major projects, from exploration and rail to marine and legacy sites.

The program identified 22 core operational fatality risks, such as confined spaces, falls from heights, slope failure, contact with molten material and contact with electricity.

For each risk there are a number of critical controls required. Those controls range from engineering to administrative controls. Before a job goes ahead, operators verify that the critical control is in place by answering a series of yes/no questions, on a task-by-task basis.

In a layered process, supervisors also verify those critical controls are in place, on a shift-by-shift basis, and managers or superintendents routinely verify the design and implementation of the controls.

More than 1.4 million critical control verifications were done in 2017 across Rio Tinto's global network.

The focus is on maximising the effectiveness of the control and using learnings raising it in the hierarchy of controls wherever possible.

Automation and technological solutions to remove employees from the line of fire are also a constant imperative.

Having one, standardised system also allows Rio Tinto to have common metrics, goals and stage gates and share learnings quickly across safety leaders and internal social media channels, such as Yammer.

One of the most powerful features of the CRM is how Rio Tinto can translate a learning or improvement to a critical control with a simple change to a verification question. Once approved, it can happen overnight and be used around its global operations the next day.

Unravelling the Bow-Tie

One crucial link between Rio Tinto's critical risk management program and monitoring and controlling for critical controls has been its use of the bow-tie method.

The **bow-tie** method refers to a visual representation of the risks associated with a certain hazard and the controls that can be put in place to prevent or mitigate the risks. It takes its name from the shape of the diagram created, which looks like a bow-tie.

While the method was already being used across Rio Tinto, the organisation tweaked its use of bow-ties to focus more on the critical controls required to address the key risks identified through its CRM program.

Taking a more structured and disciplined approach, bringing the two elements together helped Rio Tinto narrow its focus on the few critical items that would make the most difference to safety at the frontline.

The company challenged itself to apply a more stringent definition of what is a control and used the bow-tie method to ensure it was identifying the right controls and to assess whether it had specific risks under control or whether it needed to improve the control of a given risk.

This more stringent, disciplined approach to using bow-ties at the 'front end' to identify controls, and then implement layers of verification on critical controls to ensure fatalities and injuries are prevented or reduced, is also being used more widely across a range of industries, including retail as well as mining and construction. Rio Tinto also uses bow-ties for its parallel process safety program.

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What is a critical control?

- An object or device, for example, a railing on the side of the road.
- A technical system, for example, an in-vehicle monitoring system.

What is a critical control?

- A direct human action, for example, a driver obeying the speed limit...that must be in place to prevent or mitigate a Potentially Fatal Incident (PFI). If a critical control is not there or fails the potential for a fatality is greatly increased.
- When we are talking about what is going wrong, we are talking about what critical controls are failing or were not in place for the PFI to occur. We need to know what our critical controls are so we can check they are in place and effective.
- If the critical control is not there we don't start the work, or if the work has already started we stop and fix it now.
- To save a life we must say no if the control is not there to complete the task.

Source: Rio Tinto Vehicles & Driving PFI presentation

On the ground outcomes

How Rio Tinto applies the bow-tie method, informed by its CRM program, on the ground can be demonstrated by examining an internal education campaign it undertook about its biggest safety risk, vehicles and driving.

A vehicles and driving review, completed as part of a research partnership with the University of Queensland, revealed that almost one-third of incidents at Rio Tinto are vehicle related. Examples of potentially fatal incidents (PFIs) recorded include drivers losing control of their vehicle and potentially colliding with an oncoming fuel tanker, vehicle rollovers, an underground vehicle driver losing control down an incline shaft, and an employee being struck by a lift truck.

Through analysing verifications completed as part of its CRM program, Rio Tinto identified three main issues relating to vehicles and driving, with 'driver fatigue' and 'road design and maintenance' each accounting for about one in six incidents and 'stop and give way at intersections' accounting for one in 10 incidents.

Rio Tinto identified that the majority of incidents took place 'in the pit' (44 per cent) and 'in and around the plant' (38 per cent); 18 per cent of vehicle related incidents happened 'outside the gate'.

Drilling down a step further, Rio Tinto was able to analyse where things were going wrong and what critical controls were failing. In the pit, the factors identified included segregation, or vehicle exclusion zones; road design and maintenance; operator competency, including giving way at intersections and unsecured loads; and fitness for work, that is fatigue.

Segregation was also an issue for 'in and around plant' PFIs, along with mobile equipment maintenance and signage and demarcation issues.

Critical controls that failed most 'outside the gate' relate to fatigue, people not following road rules, drivers not taking evasive action, and management of loads. The data Rio Tinto reviewed to identify these critical control failures also told it that most of its 'outside the gate' PFIs related to:

- Vehicles running off the road
- Vehicle roll overs
- Vehicle hits vehicle
- Vehicle hits person/animal.

Although in most cases people are not being permanently injured or killed, Rio Tinto recognises that the potential for a fatality is real.

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Closing the Loop

Applying those findings through the bow-tie method (see diagram) shows visually and quickly what the issues are and what is working.

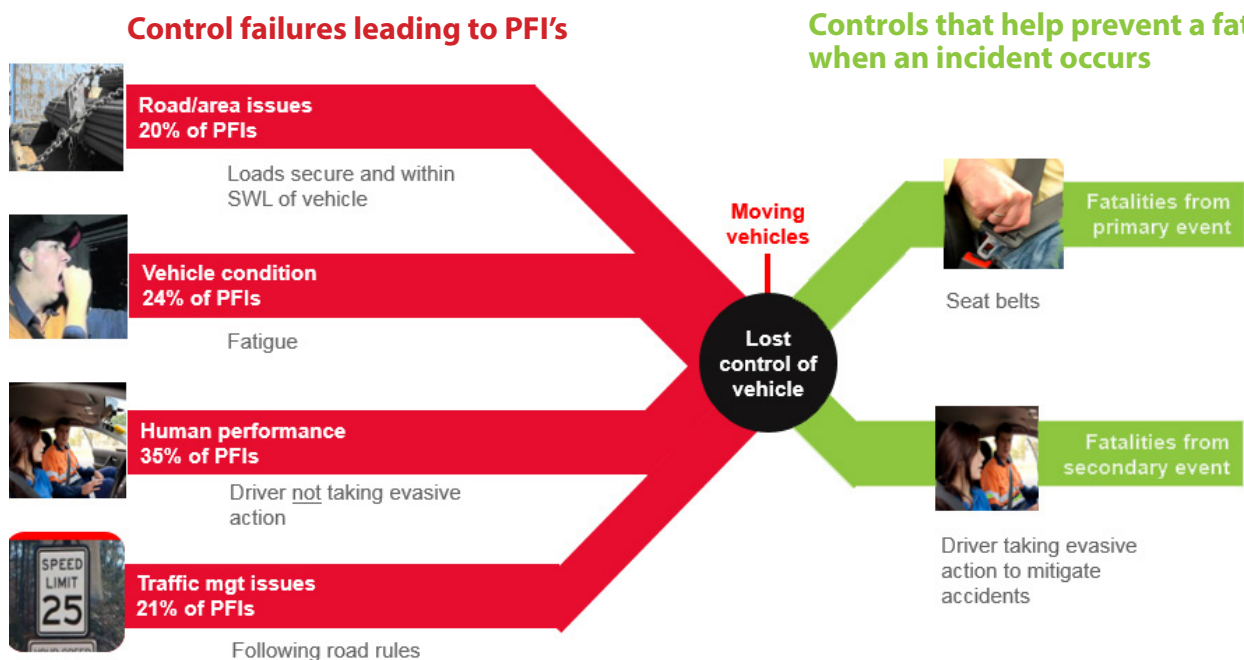
In this case, Rio Tinto analysed all critical control field verification data from open cut mines over an eight month period and combined it with data from all vehicle and driving incidents over a 16-month period. As part of the review, each individual incident PFI report was read.

Taking a look at the resulting bow-tie diagram, the red controls on the left show what is failing, demonstrating that the highest number of PFIs are caused by 'human performance', typically where a driver has not taking or not being able to take evasive action to try and avoid an incident.

The green controls on the right show what is working – use of seat belts and operators being in the moment and taking evasive action are helping prevent fatalities. Interestingly, this example highlighted that drivers not taking evasive action is causing PFIs but drivers who do take evasive action are helping to prevent fatalities.

The learnings from this bow tie show the need for increased focus on how drivers can be present and anticipate and control these factors. The risks drivers themselves can control include wearing a seat belt, speed, managing personal fatigue, and vehicle condition (via pre-start checklists).

In addition, factors Rio Tinto can control include ensuring vehicles and in vehicle monitoring systems are maintained; educating employees around fatigue and mental wellbeing.



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The Safety Loop

Rio Tinto uses the bow-tie method as an initial tool to highlight how risk unfolds in its business and measure the critical controls being used to manage that risk. The strength of the bow-tie approach is as that initial identification tool, allowing companies to visually represent how specific risks are being managed and examine if they have the right controls in place.

The next critical step, as identified by Rio Tinto's approach, is using incident data and control verifications to 'close the loop'. The critical controls identified are tracked through the critical control verification process, which verifies effectiveness of those controls in the field, and through the incident review process.

The results of this process are fed back into the CRM to validate the effectiveness of current controls to prove they are effective or to highlight the need to devise better controls. Any new controls result in the relevant bow tie being updated, and so the loop continues.

At Rio Tinto, control verification includes daily physical checks in the field by 6,500 frontline operational leaders.

These checks are recorded in a centralised global database, highlighting any non-compliances so any potential weak areas are identified and can be rectified. Other operational staff, like truck drivers, also do checks before they start tasks which may pose a fatality risk.

In combination with analysing incident data to help identify trends, verification data highlights specific issues, allowing Rio Tinto to implement an education campaign or modify the verification questions it asks at the frontline to monitor its effectiveness.

Eyes on the Ground

The combination of on-the-ground frontline checks and a database that all Rio Tinto safety leaders around the world can access brings global data together with local action. If any Rio Tinto personnel finds a gap in a control, it must be fixed there and then. Work cannot commence or a truck cannot be driven until it is fixed.

General managers are ultimately responsible for safety, and that responsibility then cascades to their managers. Those managers are discussing direct with site superintendents or supervisors key safety areas to be focused on in their operations.

Superintendents or supervisors then share relevant information with their teams and conversely operations share with their leaders.

This 'cascade effect' reinforces a strong safety culture and expectations within the organisation.

Operators themselves are also supported and authorised to not start work or stop work if it's not safe, and to seek help from leaders to ensure controls are in place. Rio Tinto is also encouraging its people to 'embrace the red', reinforcing an attitude that identifying a non-conformance is a positive.



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Results and Impact

Rio Tinto has already recorded more than 1 million control verifications per year since rolling out its CRM program, with more than 25,000 verifications completed across Rio Tinto's global operations each week.

The organisation believes it is too early in its CRM implementation to quantify results of the program, however the level of safety awareness and of critical controls at the frontline has significantly improved as has the targeted focus on measures needed to prevent fatalities and serious injuries.

The CRM-bow tie safety loop has also added discipline to Rio Tinto's safety processes and the quantity of verifications has resulted in significant improvements on the ground. Some verifications are paper based and logged later in the shift, but increasingly data collection is moving into real time online via a mobile app Rio Tinto and tied to its reporting system.

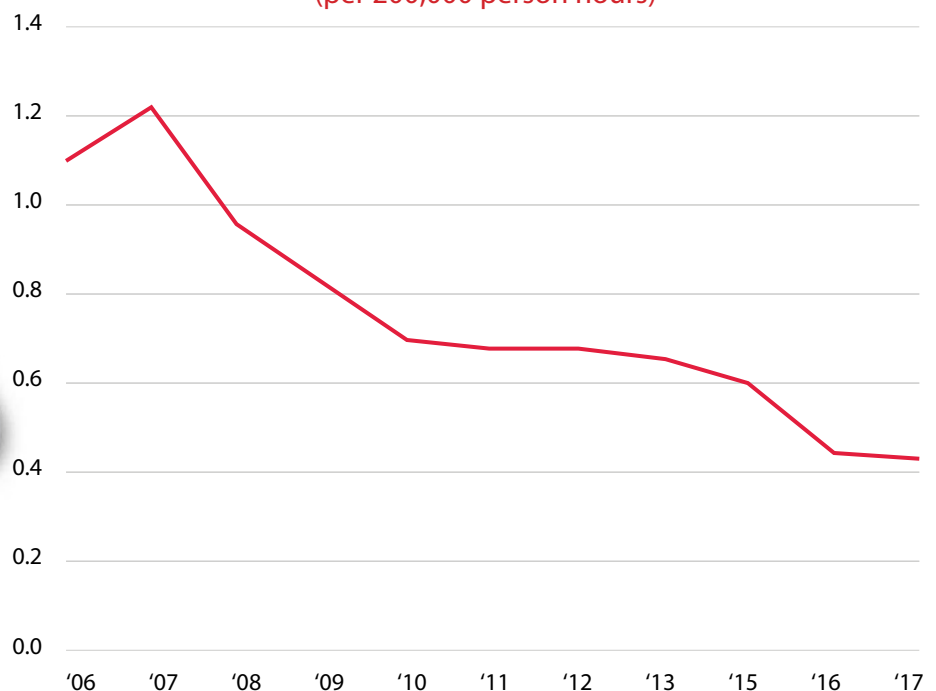
Rio Tinto can analyse verifications across sites, using GPS location signatures; times of the day; across tasks; and across the variability among operators, supervisors and general managers, to examine specific risks and controls.

This data allows the company to delve deeper into patterns, such as which controls fail or are missing, the time of day or week the verifications take place and which leaders are conducting verifications. Corrective action can then be taken to ensure it has strong coverage of control verification, by site location, leader, risk and job type.



Source: CRM mobile app provided by Forwood Safety.

Rio Tinto's All Injury Frequency Rate
(per 200,000 person hours)



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Lessons and Learnings

Rio Tinto has managed to reach the frontline and engage in the safety discussion the people actually exposed to the risk – they are the ones doing on-the-ground checks and verifications. That means, if the process is followed, every visible and controllable risk is being addressed before work commences.

It also provides a rich data set about the effectiveness of specific controls, allowing Rio Tinto to highlight and address gaps. Collecting standardised content also enables Rio Tinto to share and mobilise learnings quickly, by updating verification questions, across its global network.



To 'bring people with you', it's also important they understand why a safety focus is important — to prevent fatalities and injuries — and that using a standardised model makes it easier and faster to share learnings.

Rio Tinto's experience also shows support from the top, from the CEO down, is critical in improving safety. It also drove, in Rio Tinto's case, fast implementation of the CRM program. Such high-level support creates safety engagement

across the organisation and contributes to a culture where Rio Tinto's people recognise verification checklists as a tool for them to use to help keep themselves and their colleagues safe.

Leveraging technology makes getting data into a CRM program easier and faster and allows organisations to keep control of system design and content. At Rio Tinto, technology around the CRM program means using the mobile app to capture data.

Organisations need to be patient and give their safety strategy time. Large businesses can't change course easily but regardless of business size it takes time to roll out a safety strategy, embed it and get results. The roll out may be completed in weeks or months, but cultural change and improvements can take years.

While capability is a consideration, Rio Tinto believes the approach it has taken is not limited to larger organisations; any business can take a person-centred approach to safety that includes multiple levels of verification to reduce and prevent injuries and fatalities.

Keep in mind though, Rio Tinto cautions, that while a very important tool, initiatives like a critical control verification program are just that – a tool. A business still needs to ensure it has the systems and culture in place that supports and complements all the pillars of its safety strategy.



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Seven Critical Control Program Tips

- **Don't invent — just implement.** Or as the team likes to call it, adopt don't adapt. Resist building your own. Instead of building a bespoke or proprietary system, build proprietary safety leaders and champions who can deliver it.
- **Reduce Complexity, don't multiply it.** The great challenges for operators and leaders are the legacy systems in place. No one wants to be seen to have dropped an old process but it is the discipline needed during or after the rollout.
- **Make it easier.** The fundamental question to ask at every step is how will this make it easier for a night-shift operator or superintendent on a weekend with new staff or skeleton crew? How will it work in the toughest conditions and locations? So therefore:
- **Ask the operators what is important.** As an operator told us, "at least you are asking the right questions. For CRM is about binary decision making. Checking what can kill you if you do not have the controls in place." Such critical risk analysis provides an opportunity for operators to tell you what is really important. Putting verifications in the hands of the operator also enables a conversation about how to make tasks easier and safer. Their solutions will often be quick and simple to implement.
- **Faster rollout = faster learnings.** Rather than rolling out CRM relatively slowly in a staged manner, it was done quickly group-wide. The keys were having a centralised support team and metrics ready, enabled by technology. Interestingly, and it may seem counter-intuitive, rolling it out all at once at great pace also accelerated learning. That is because everyone would share their experiences, their concerns and their solutions via safety leader peers and the online social media and communication tools we used. So a problem or risk or concern in Madagascar could be shared and solved with peers in Canada thanks to the commonality of approach.
- **Metrics and minds.** A metric report of compliance and non-compliance can tell you a lot, but it can only tell you so much. The dashboard can't really tell you as much as the qualitative value of a good toolbox talk, and it can't necessarily tell the difference between a verification done by the seasoned hand on Wednesday and the verification done by an apprentice working late hours on a Saturday. That is why leadership in the field is vital to having the informed safety conversation, recognising the human factors at play.
- **Believe it.** Senior leadership and HSE practitioners have to believe CRM works, for if they don't the frontline won't either and it will be ineffective. Strong active executive sponsorship, from the CEO down, sets the tone and provides the imperative for behaviours to change. Holding your reports accountable for the adoption and effectiveness is crucial. If the CEO is asking informed questions of their reports, they will ask their general managers, who will ask their people.

Source: Minesafe International 2017 Address, Joanne Farrell – Rio Tinto Group Executive Health, Safety & Environment and Managing Director Australia