ACARP PROJECT C17032
PUBLISHED 01/05/09

TYREGATE: A "WORLD FIRST" RISK MANAGEMENT DECISION SUPPORT TOOL FOR EARTHMOVER TYRES AND RIMS

Guldidar Kizil
MINERALS INDUSTRY SAFETY AND HEALTH CENTRE (MISHC), THE UNIVERSITY OF QUEENSLAND

Tilman Rasche
QUEENSLAND DEPARTMENT OF EMPLOYMENT, ECONOMIC DEVELOPMENT AND INNOVATION, DIVISION OF MINES AND ENERGY

ACARP

DISCLAIMER

No person, corporation or other organisation ("person") should rely on the contents of this report and each should obtain independent advice from a qualified person with respect to the information contained in this report. Australian Coal Research Limited, its directors, servants and agents (collectively "ACR") is not responsible for the consequences of any action taken by any person in reliance upon the information set out in this report, for the accuracy or veracity of any information contained in this report or for any error or omission in this report. ACR expressly disclaims any and all liability and responsibility to any person in respect of anything done or omitted to be done in respect of the information set out in this report, any inaccuracy in this report or the consequences of any action by any person in reliance, whether wholly or partly, upon the whole or any part of the contents of this report.

ACARP PROJECT C17032

TYREgate:

A "*World First*" Risk Management Decision Support Tool for Earthmover Tyres and Rims

http://www.mirmgate.com/tyregate

May 2009

Dr Guldidar V. Kizil
Senior Research Officer
Minerals Industry Safety and Health Centre (MISHC), The University of Queensland

Mr Tilman Rasche
Senior Inspector of Mines
Queensland Department of Employment, Economic Development and Innovation,
Division of Mines and Energy

ACKNOWLEDGEMENTS

The authors of this report would like to acknowledge the following industry personnel, companies and organisations:

- Australian Coal Association Research Program (ACARP) for giving the opportunity to carry out this project,
- Project monitors as follows:
    - Mr Tony Egan (Xstrata Coal), and
    - Mr Keith Smith (ACARP)

  for their guidance, strong support and assistance during the project execution,
- BHP Billiton for providing a permission to utilise the Incident Cause Analysis Method (ICAM) for the accident/incident data analysis and TYREgate website presentation
- Klinge & Co for their on-going commitment, support and invaluable contributions towards TYREgate establishment.

The ACARP project supervisor Mr Keith Smith and project industry monitor Mr Tony Egan from Xstrata Coal both expressed their views that this had been a most satisfying and exciting project which had produced a very usable outcome. They congratulated the project team.

EXECUTIVE SUMMARY

This report introduces the recently developed online and publicly accessible **TYREgate: Tyres and Rims Risk Management Decision Support Tool (http://www.mirmgate.com/tyregate)** and describes its unique and innovative features. At present, the authors believe that TYREgate is a *world's first* earthmover tyre and rim related searchable **Causal Factors Database** which provides the mining industry with a unique, up-to-date and complete source of information on earthmover tyre and rim safety and maintenance improvements.

TYREgate's main deliverable is its unique and innovative search methodology which allows managers, decision makers and other users with limited time to access dynamically generated, graphically displayed accident, incident and risk management 'near real time' data by using a ***"3 Click"*** approach.

What are my major risk factors? *(Click 1)*

Where can I find the causes of these factors? *(Click 2)*

Why did these specific accidents occur? *(Click 3)*

How can I mitigate the risks at my own operation? *(Checklists)*

Searching is not only limited to the *"3 Click"* approach. Proven search techniques such as keywords can still be used within TYREgate offering another layer of flexibility. An innovative ***"Advanced keyword search"*** option allows users to further refine their search results by using a search on the current set of results or from all incident data.

One of the key features of TYREgate is that a search in progress (during *"3 Click"* search process or at the final step, on search the results page) can be filtered by the *"Year"* and / or the *"Country"* to refine and highlight relevant resources.

TYREgate's ability to provide dynamically generated, downloadable ***"TYREgate Checklists"*** that contain industry adopted hazard mitigation practices is seen as a particularly powerful feature.

TYREgate closely aligns with the vision of the Earth Moving Equipment Safety Round Table (EMESRT) Vision as follows:

> *"A global industry free of fatalities, injuries and occupational illnesses associated with operating and maintaining exploration and mining equipment"*.

EMESRT was formally established in 2006 by a group of major mining companies from around the world. EMESRT has developed 15 Design Philosophies (DPs) including "*Tires & Rims"* for key issues that impact on the human factors design of earth moving equipment. The EMESRT DPs are available on the web via the *"Minerals Industry Risk Management Gateway"* website which is known as MIRMgate (http://www.mirmgate.com), the pre-eminent search engine for risk management.

EMESRT resource materials form an integral part of MIRMgate and TYREgate has been developed to

provide seamless integration with the online EMESRT *"Tires & Rims"* Design Philosophy (DP) (http://www.mirmgate.com/tires_and_rims.asp).

The aim of a DP is to provide information to assist with equipment design so that risks are reduced to an acceptable level. TYREgate adds considerable value to information and methodology that EMESRT has developed in a number of subject areas, specifically the EMESRT *"Tires & Rims"* DP.

TYREgate builds on a previous ACARP project C15046, "**Review and Analysis of Tyre Related Accidents and Incidents – a Study with Recommendations to Improve Tyre & Rim Maintenance and Operational Safety of Rubber Tyred Equipment**" *(Rasche T & Klinge T 2006)*. The *"Incident Cause Analysis Method (ICAM)"* was utilised to analyse the accident / incident data. The ICAM methodology provides a logical framework for the analysis of incident and accident causation. and supports the notion that most incidents and accidents are caused rarely by a single act or condition, but rather by a number of factors working together.

Without the root cause review, safety improvements around tyre and rim maintenance and their use will continue to remain reactive rather than proactive and are likely to continue their focus on less effective means such as procedural 'fixes' rather than solutions addressing the root cause of the mishap (such as the design of the equipment).

The project has successfully achieved its objectives but also went beyond these objectives and in addition, developed a smart, sophisticated data entry tool (within the budget allocated), dynamically generated, 'near real time' ***"TYREgate Checklists"***, a comprehensive ***"TYREgate User Guide"*** (See Appendix 1) and a ***"TYREgate Questionnaire"***. To achieve full integration with the EMESRT *"Tires and Rims"* DP, and to introduce the ***"Filter data by Year and/or by Country"*** option, the original database, developed by the ACARP C15046, was expanded to include ***"EMESRT Risk", "Year"*** and ***"Country"*** categories. Furthermore, a ***"TYREgate Media Release"*** was prepared and submitted to a wide range of well known mining journals, e-journals and e-newsletters to raise awareness of this invaluable tool.

A key point of TYREgate is that it forms the "pilot" for like projects towards creation of reliable databanks that will be of assistance across a range of design or safety projects.

The immediate take-up and usage of TYREgate has demonstrated the industry need for such databases.

Feedback to date has shown that TYREgate is an elegant solution to capturing, analysing and reporting on a range of diverse data related to tyre and rim related accidents and incidents. Furthermore, general feedback on TYREgate and specific comments on its intuitive graphical interface and ability to provide the user with specific hazard based *"TYREgate Checklists"* have demonstrated the opportunity to expand TYREgate's methodology to other areas of safety research and communication. To that end, Australian Coal Association Program (ACARP) has provided funds for the 2009 development of ***"ISOgate: Isolation Risk Management Decision Support Tool"***, a new Causal Factors Database aiming at presentation, analysis and reporting of *'isolation'* related accident and incidents. ISOgate will be linked to the EMESRT *"Isolation of energy, including parking"* Design Philosophy.

TYREgate is a publicly accessible global accident/incident information database and reporting system. TYREgate and the 2009 development of ISOgate will be the first “2” cornerstones of a new series of leading practice decision making databases for the minerals industry.

The authors firmly believe that it is vital for this work to be supported and continued into the future. Based on the proven TYREgate methodology, they aim to establish a series of causal factors databases to address major mining risks to provide the mining industry with better and more objective decision making information.

The following report introduces TYREgate from the ground level up and discusses TYREgate Key Features and system functionality. This project is a successful collaboration between the Minerals Industry Safety and Health Centre (MISHC) - The University of Queensland, the Queensland Department of Employment, Economic Development and Innovation – Division of Mines and Energy, and Klinge & Co (a mining industry service provider, contractor and consultant specialising in earthmover tyre and rim management systems).

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

This report introduces ***"TYREgate: Risk Management Decision Support Tool"*** carried out under the **Improved Health and Safety Program** category of the 2007 ACARP call for Research Proposals, Open Cut Mining Priorities section, namely '*General improvement to the safety of mining and maintenance operations through novel procedural, operating, or equipment changes'*.

Incidents and accidents related to tyre and rim maintenance and operation continue to occur within the industry. Because of the energies involved, such mishaps can easily result in serious injury or even fatal outcomes. Even near misses, if properly assessed for their true risk potential can often be classified as '*high potential'* events.

While there are a number of documents available that provide sound advice on tyre and rim maintenance and application, these may not provide the background on why, and for what reasons, in order of priority, certain actions are required. Also, this advice is often only aimed at the tyre maintenance service provider, which may or may not address the true root cause such as issues with product design which lie outside the service providers' scope of influence.

To address these issues, an online and publicly accessible ***"TYREgate: Tyres & Rims Risk Management Decision Support Tool"*** has been established.

TYREgate is built on a previously gathered, reviewed and analysed, comprehensive database of publications of available incidents and accidents (Rasche T & Klinge T, 2007). The *"Incident Cause Analysis Method (ICAM)"* was utilised to analyse the data. Section 2 provides further information on TYREgate and its background.

TYREgate allows searching via an innovative graphing scheme. The graphs are dynamically created to allow ease of access to root and contributing causes of tyres and rims related accident and incident data. The unique ***"3 Click"*** graph searching scheme is explained in Section 5.

To assist the industry in better prioritising its approach to safe tyre maintenance, TYREgate provides the minerals sector and its stakeholders such as tyre and rim manufacturers and service providers, with an objective up-to-date 'all in one' analysis and summary of its incident and accident experience, and an insight into the real root and contributing causes (acts and conditions, design issues etc.) that need to be addressed proactively to improve the safety of tyre and rim maintenance, and application in the field. *"TYREgate Checklists"* is a powerful TYREgate feature that not only contains accident and incident data but also Australian and global industry adopted risk mitigation practices. More information about the *"TYREgate Checklists"* is given in Section 3.

The Minerals Industry Risk Management Gateway (MIRMgate - http://www.mirmgate.com) portal is utilised to make this invaluable information widely available not only to the general mining community worldwide but also to tyre maintenance and management personnel and Original Equipment Manufacturers (OEMs). The MIRMgate home page and link to the TYREgate portal is shown in Figure 1.

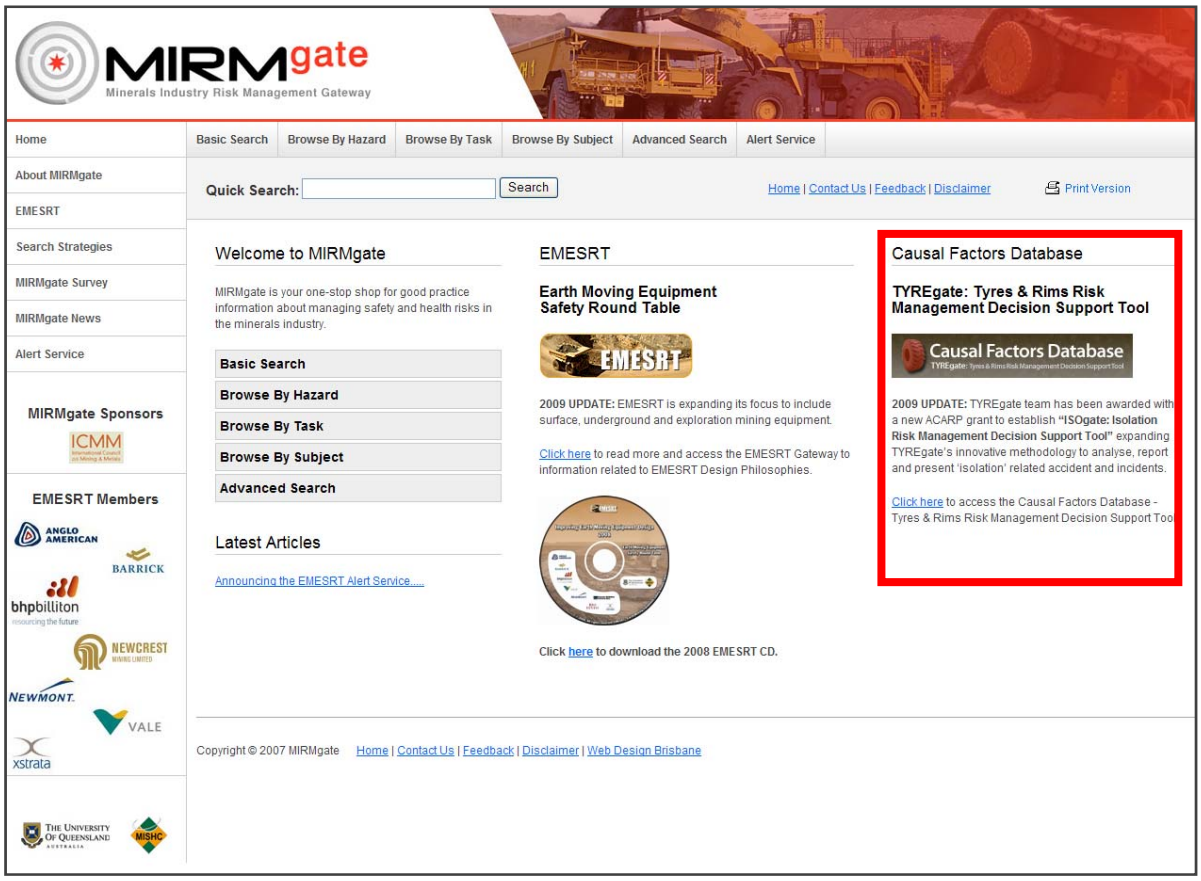


Figure 1. MIRMgate home page and TYREgate portal link through MIRMgate.

1.1 TYREgate Key Deliverables

A key point of this project is that TYREgate forms the ***"pilot"*** model for a range of other like databases covering high risk activities and delivering high quality information, e.g. causal factors, probability and consequence information as well as recommendations which will enable industry to move closer to its vision of an injury free workplace. Now that the TYREgate system is designed and its methodology is proven, the approach is transferable to other areas of major risks in the mining industry.

The deliverables sought and now achieved are:

- A user friendly presentation via industry endorsed MIRMgate portal,
- Ongoing population of an industry best practice database (tyres & rims including accidents and incidents),
- A record of industry developments in Australia and the rest of the world through reporting of incidents /accidents including technological initiatives,
- Assistance in the creation of Industry Safety Alerts where applicable,
- An annual project report,

- The representation of a ***"Pilot Model"*** towards the development of several other causal factor databases to assist industry, in the medium to longer term[1], and
- Added value to information and methodology that EMESRT is developing in the topic area of *"Tires and Rims"*.

The following Section 2 provides project background information.

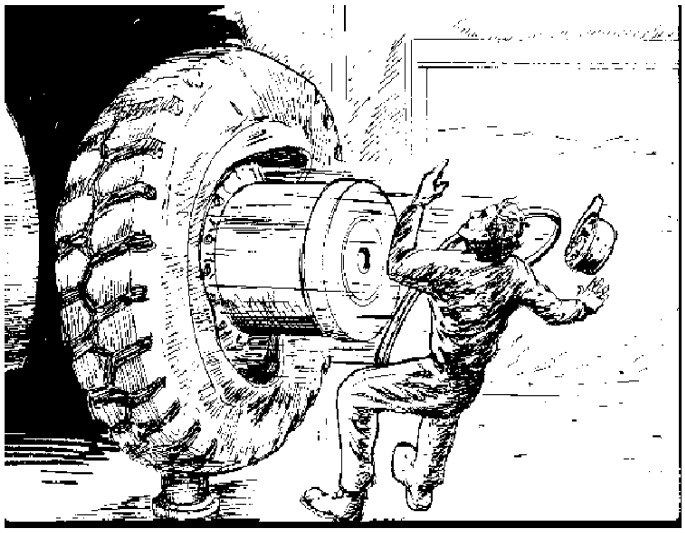
[1] In December 2008, ACARP awarded the authors with further research funds to develop *'ISOGate: Isolation Risk Management Decision Support Tool'*, an isolation related accident and incident Causal Factors Database.

2.0 BACKGROUND

TYREgate builds on a 2006/07 ACARP project C15046, initiated by Klinge & Co., known as ***"Review and Analysis of Tyre Related Accidents and Incidents – a Study with Recommendations to Improve Tyre & Rim Maintenance and Operational Safety of Rubber Tyred Equipment".*** This project presented a "first" milestone analysis of tyre and rim related accidents and incidents data.

The ACARP project C 15046 was triggered by a tyre fatality at a north Queensland mine in February 2004, and resulted ultimately in the design of TYREgate, a web-based tyres and rims accident and incident "Causal Factors Database". The database centered around the gathering, recording and analytical breakdown of publicly available incident and accident data to deliver a list of recommendations to industry for "Health and Safety" improvements of tyre and rim maintenance and service work, operations, general management approaches of tyre and rim related work and assets, and training recommendations.

This project based its findings on a total of 82 publicly available incident reports occurring between 1989 and 2006 (largely from the Australasian, American, & Canadian region), 30 of which resulted in single or multiple fatalities. During a 4 year period alone (2003-2006), the authors became aware of at least six fatalities related to tyre and rim maintenance work in the Australasian region. This unfortunately corresponds well with estimated (minimum) one to two deaths per year across the Australian, American and Canadian region, based on the current accident experience.



Failure of rim/locking mechanisms during wheel maintenance is one of the highest cause of all tyre maintenance fatalities (U.S. Department of Labor, *Tire and Rim Safety Awareness Program*, in *Instruction Guide Series, MSHA IG 60.* 1996, U.S. Department of Labor, Mine Safety and Health Administration)

In 2008, the authors became aware of at least one reported tyre related death overseas and one case here in Australia so far[2].

The ACARP project C15046, completed in 2007, developed a Tyre Related Accident and Incidents Database, based on the BHP Billiton "Incident Cause Analysis Method (ICAM)" approach, and provided with

- a detailed and comprehensive analysis of tyre and rim related incidents and,
- their root causes - acts and conditions that have led to incidents and accidents of tyre service and operational personnel;

and delivered a report.

[2] While the cases were reported in the press, no detail has been made available so far that warrants inclusion and update to the TYREgate database.

An important aim of the TYREgate project was to design a comprehensive database of publications of available incidents and accidents, and utilise the Minerals Industry Risk Management Gateway (MIRMgate - http://www.mirmgate.com) portal to provide access to the database.

This project has not only utilised this existing database and provided online access to this complete source of information, but has also further developed the database content and made the invaluable information available to the database users.

The following Section 3 provides project objectives and outlines project achievements to date.

3.0 TYREGATE OBJECTIVES

The main objectives of this project were as follows:

- Establish an online, searchable "Causal Factors Database" accessible via MIRMgate, based on the tyre related accidents and incidents database developed by the ACARP project C15046,
- By doing so, create a 'first point of contact' for information about tyre and rim related incidents, accidents and recommendations for safety improvements across the industry, and
- Populate the "Causal Factors Database" periodically for continuing development of the industry best practice tyres and rims related accidents and incidents database, and
- Prepare a written report on the outcome of the project.

3.1 Achievements to Date

The project not only successfully achieved the objectives listed above but also went beyond these objectives and developed:

- a smart, sophisticated data entry tool within the allocated budget;
- dynamically generated, 'near real time' ***"TYREgate Checklists";***
- a comprehensive ***"TYREgate User Guide"*** (See Appendix 1); and
- a ***"TYREgate Questionnaire"***.

To achieve full integration with EMESRT ***"Tires and Rims"*** Design Philosophy and to provide ***"Filter data by Year and/or by Country"*** option, the original database developed by the ACARP C15046, was further expanded.

In addition, a ***"TYREgate Media Release"*** was prepared and submitted to a wide range of well known mining journals, e-journals and e-newsletters. To date, progress relating to article publications is given below:

- Online e-journals & e-newsletters
  - MIRMgate News: *published in Dec 2008 issue*
  - International Longwall News (ILN): *published on Feb 9th, 2009*
  - Sustainable Minerals Institute (SMI) Newsletter: *published in Mar 2009 issue*
  - Global "Mining Monthly" magazine: *published in Mar 2009 edition*
  - Australian Mining online journal (http://www.miningaustralia.com.au/Article/The-gateway-to-tyre-safety/468840.aspx): *published on Feb 25th, 2009*
  - 24/7 Queensland Resources Council (QRC) quarterly Safety and Health Newsletter: *published in Nov 2008 issue*
  - UQ Update: *The University of Queensland UQ newsletter requested an article regarding TYREgate to publish*
  - AUSIMM Newsletter: *to be published in Sep 2009 edition*

Apart from those mentioned above, the authors became aware that the Department of Primary Industries (DPI) "Mine Safety Update January 2009" e-newsletter included an article about TYREgate, "***TYREgate opens the door to improved tyre safety"***.

"Queensland Mines and Quarries Safety Performance and Health Report 1 July 2007 to 30 June 2008", published in December 2008, includes an article about TYREgate: "***Earthmover tyre and rim safety – TYREgate launch***".

4.0 METHODOLOGY FOR TYREGATE DEVELOPMENT

The project has built on the previously mentioned ACARP project C15046 and took a staged approach as outlined below:

Stage 1: Establishment of an online, searchable *"Causal Factors Database"*

A. Development of an online searchable causal factors database design model within the MIRMgate framework
B. Development and implementation of search functionality
C. Development of new web pages & logo
D. Establishment of a "pilot" model
E. Integration with the MIRMgate EMESRT *"Tires and Rims"* Design Philosophy
F. Test / trial / adjustment of webpage(s) & search functions where applicable
G. Launch of the new publicly accessible system via MIRMgate

Stage 2: Database Population

A. Ongoing collection of data, data analysis based on the ICAM approach and its addition to the system

Stage 3: System Maintenance/User Feedback

A. Routine system maintenance
B. Communication of developments to MIRMgate users
C. Collection of user feedback regarding the online searchable database

Stage 4: Information Dissemination

Promotion of the project and its outcomes at industry conference(s).

Stage 5: Final Report Preparation

Write up of the final report.

The above listed stages are addressed in the following sections:

- The development of TYREgate is outlined;
- Its key features including the innovative *"3 Click"* graph searching scheme and other unique system search functionalities are detailed;
- The link between TYREgate and MIRMgate EMESRT *"Tires and Rims"* Design Philosophy (DP) is explained;
- *"TYREgate Checklists"* are introduced;
- Ongoing population of the database as well as yearly (2008) reporting on tyre and rim related incidents, new developments and improvement initiatives is described.

5.0 STATE OF THE ART

Tyres, rims and wheel assemblies are safety critical items which must be maintained and operated correctly to provide a safe working environment. **TYREgate** is a **"Risk Management Decision Support Tool"** that allows users to access and analyse a large and diverse range of tyre and rim related incidents and accidents, in 'near real time'. Results are presented in a range of dynamically created intuitive graphical formats and reports. The following Figure 2 provides a general overview of the TYREgate site.

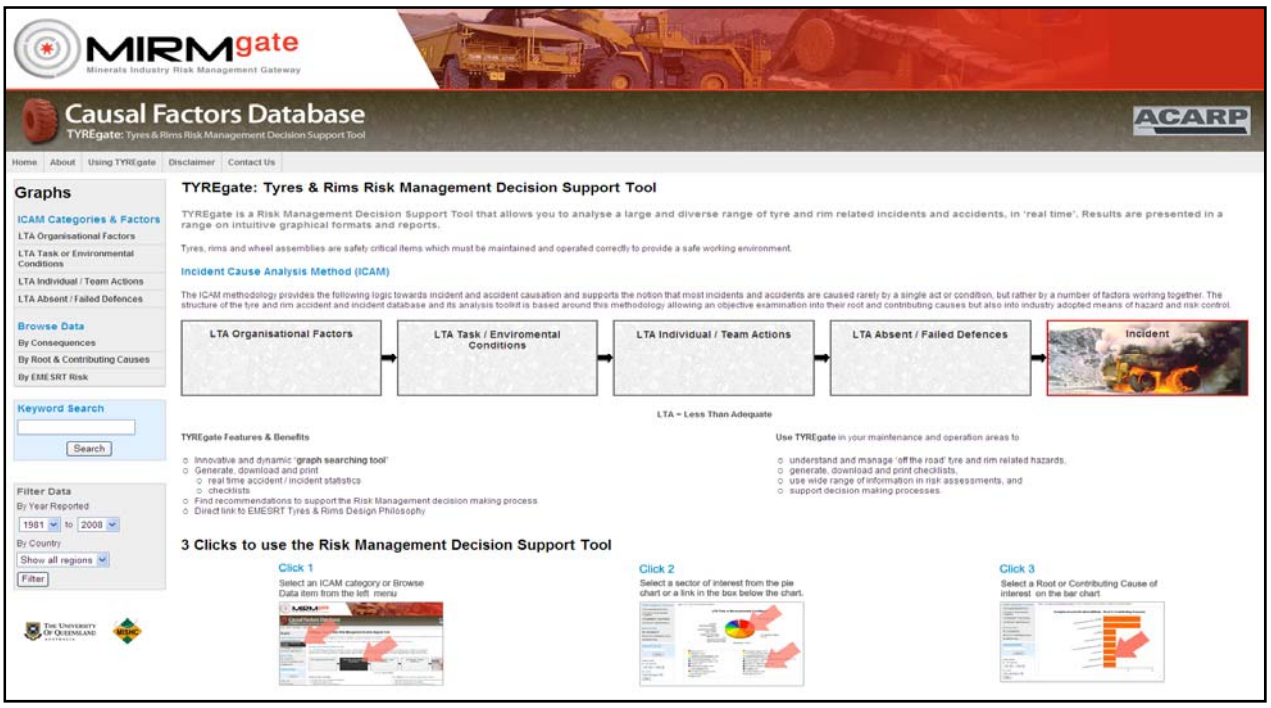


Figure 2. TYREgate: Tyres and Rims Risk Management Decision Support Tool home page.

TYREgate provides a range of information, potential solutions and flags opportunities that can be used to improve safety of tyre and rim maintenance and use of rubber tyred equipment at any mine site, or related operation or service. In particular, TYREgate is expected to provide tyre maintenance tooling and tyre maintenance service providers with sound observations to advance safety in this safety critical area of tyre and rim usage.

The TYREgate database and search tool will also be of assistance to designers, manufacturers, importers and suppliers of plant which under the Queensland Coal Mining Safety and Health Act Section 44 *(Queensland Coal Mining Safety and Health Act 1999)* and the Mining & Quarrying Act Section 41 *(Queensland Mining and Quarrying Safety and Health Act 1999)* are obliged to *'… to ensure the plant is designed so that, when used properly, the risk to persons from the use of the plant is at an acceptable level'.*

As such, this project is a *'first'* in that it makes available reliable probability and consequence data, together with recommendations on industry adopted tyre and rim safety improvement strategies.

Such databases and initiatives so far have only been pursued in the nuclear, aviation or petrochemical sector domain (eg OREDA – Offshore reliability data (Sintef, *OREDA Handbook* 1997) - as such this

project can be seen as the *'pilot'* and leading example for the minerals industry worldwide to provide high quality decision making information.

The project is also closely aligned with the Earth Moving Equipment Safety Round Table (EMESRT) *"Tires & Rims"* Design Philosophy (DP) in that many of the previous studies' recommendations are considered for inclusion in a design brief aiming at enhancing safety, maintenance and operational aspects of working with tyres and rims, and equipment to carry out such work.

TYREgate's unique and innovative features are described below.

5.1 TYREgate: Unique Features

TYREgate has been developed with the above points in mind and is currently online and accessible through MIRMgate.

A. World's 1st searchable Causal Factors Database

At present, the authors believe that TYREgate is a *world's first* earthmover tyre and rim related searchable causal factors database which provides the mining industry with a unique and complete source of information towards earthmover tyre and rim safety and maintenance improvements.

B. ICAM approach on TYREgate incident and accident analysis

Incident Cause Analysis Method (ICAM) provides the logical framework for the analysis of incident and accident causation and supports the notion that most incidents and accidents are caused rarely by a single act or condition, but rather by a number of factors working together. See Figure 3. The structure of the tyre and rim accident and incident database and its analysis toolkit is based around this methodology. This allows an objective examination not only into their root and contributing causes but also into industry adopted means of hazard and risk control.

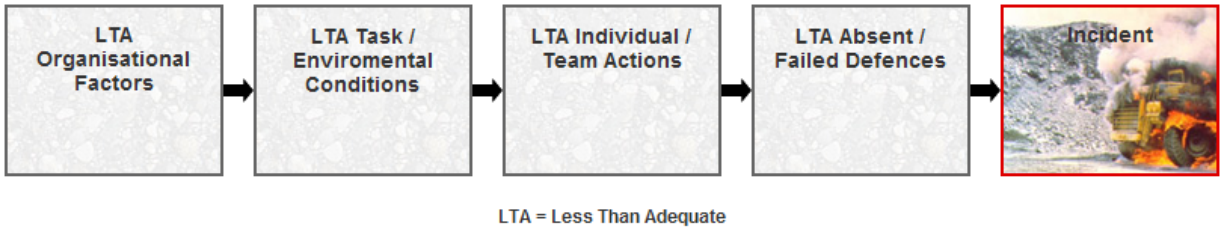


Figure 3. Incident Cause Analysis Method (ICAM).

C. Integration with MIRMgate EMESRT web portal

EMESRT resource materials form an integral part of MIRMgate and the TYREgate has been developed to provide seamless integration with the EMESRT *"Tires & Rims"* Design Philosophy (DP). EMESRT and the EMESRT DPs are introduced below. The process followed to integrate TYREgate with the MIRMgate EMESRT *"Tires and Rims"* DP is also explained.

a) EMESRT Introduction

The Earth Moving Equipment Safety Round Table (EMESRT) was formally established in 2006 by a group of major mining companies from around the world as follows: Anglo American, Barrick, BHP Billiton, Freeport-McMoRan, Newmont, Rio Tinto, Vale and Xstrata *(EMESRT 2008)*. The goal of EMESRT is to accelerate development and adoption of leading practice designs for earth moving equipment to minimise the risk to Health and Safety through a process of Original Equipment Manufacturers (OEM) and user engagement. Member companies for 2009 are Anglo American, Barrick, BHP Billiton, Newcrest, Newmont, Vale and Xstrata *(EMESRT 2009)*.

This ACARP project closely aligns with the EMESRT Vision, and adds considerable value to information and methodology that EMESRT is developing in a number of subject areas, specifically the EMESRT *"Tires & Rims"* Design Philosophy (DP).

EMESRT Vision:

"A global industry free of fatalities, injuries and occupational illnesses associated with operating and maintaining exploration and mining equipment".

EMESRT has developed 15 Design Philosophies (DPs) for key issues that impact on the human factors design of earth moving equipment. The aim of a DP is to provide information to assist with equipment design so that risks are reduced to an acceptable level.

The EMESRT DPs are available on the web via the Minerals Industry Risk Management Gateway website which is known as MIRMgate. Each DP has its own web page which can be accessed by clicking on the relevant DP. The MIRMgate EMESRT web portal can be found at http://www.mirmgate.com/emesrt.asp. Figure 4 highlights the 15 EMESRT DPs including EMESRT ***"Tires and Rims"*** DP that are accessible online.

b) MIRMgate EMESRT Design Philosophies (DPs)

Each EMESRT DP provides information about the *"Objective"* and *"General Outcome"* to be achieved, the *"Risks to be mitigated"* and *"Examples of industry attempts to mitigate risks"*. MIRMgate users can discover information related to each DP covering *"Risks to be mitigated"* and *"Industry attempts to mitigate risks"* by simply clicking on highlighted text or the corresponding images. The EMESRT *"Tires & Rims"* DP can be accessed at http://www.mirmgate.com/tires_and_rims.asp. See Figure 5. The information discovered by following this process presents as a list of MIRMgate search results derived from a pre-determined search using relevant keywords. This process is designed to move the user directly to high quality, reliable information about each DP without the need to actively search the MIRMgate system.

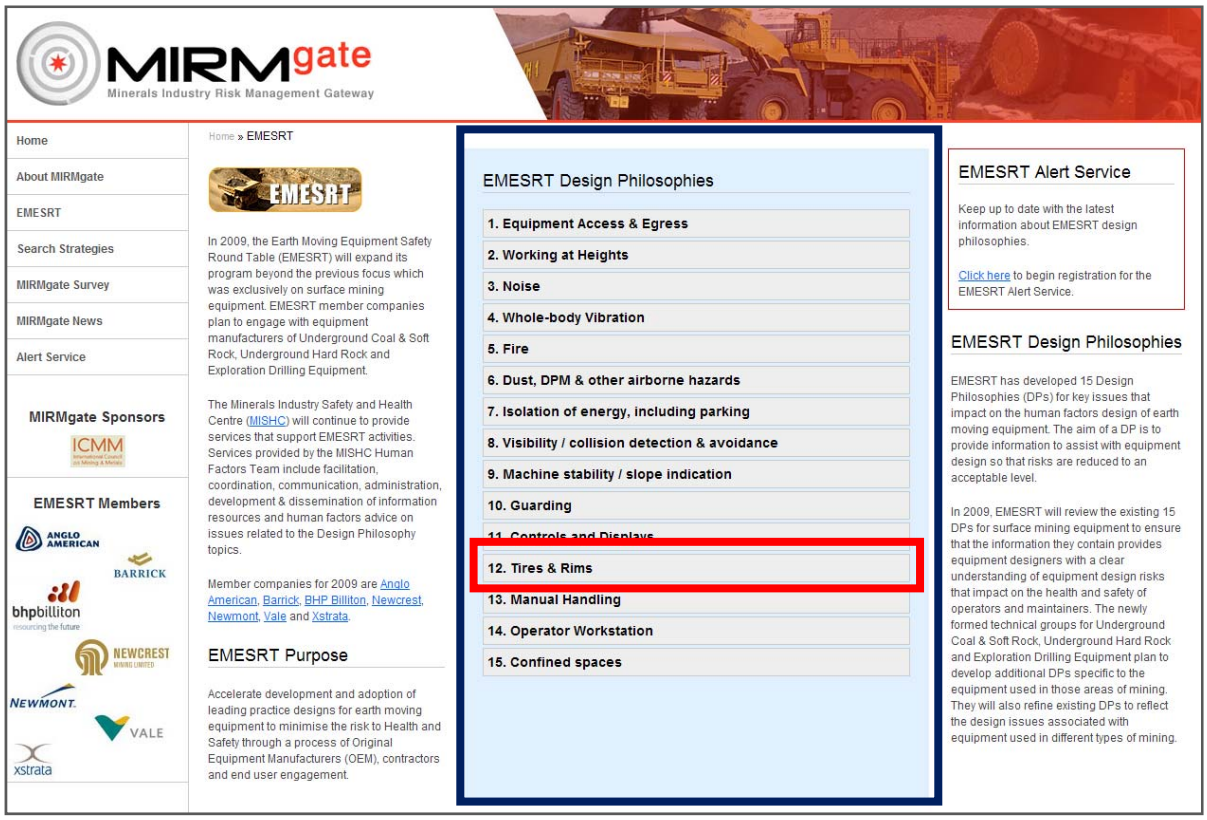


Figure 4. MIRMgate EMESRT home page.

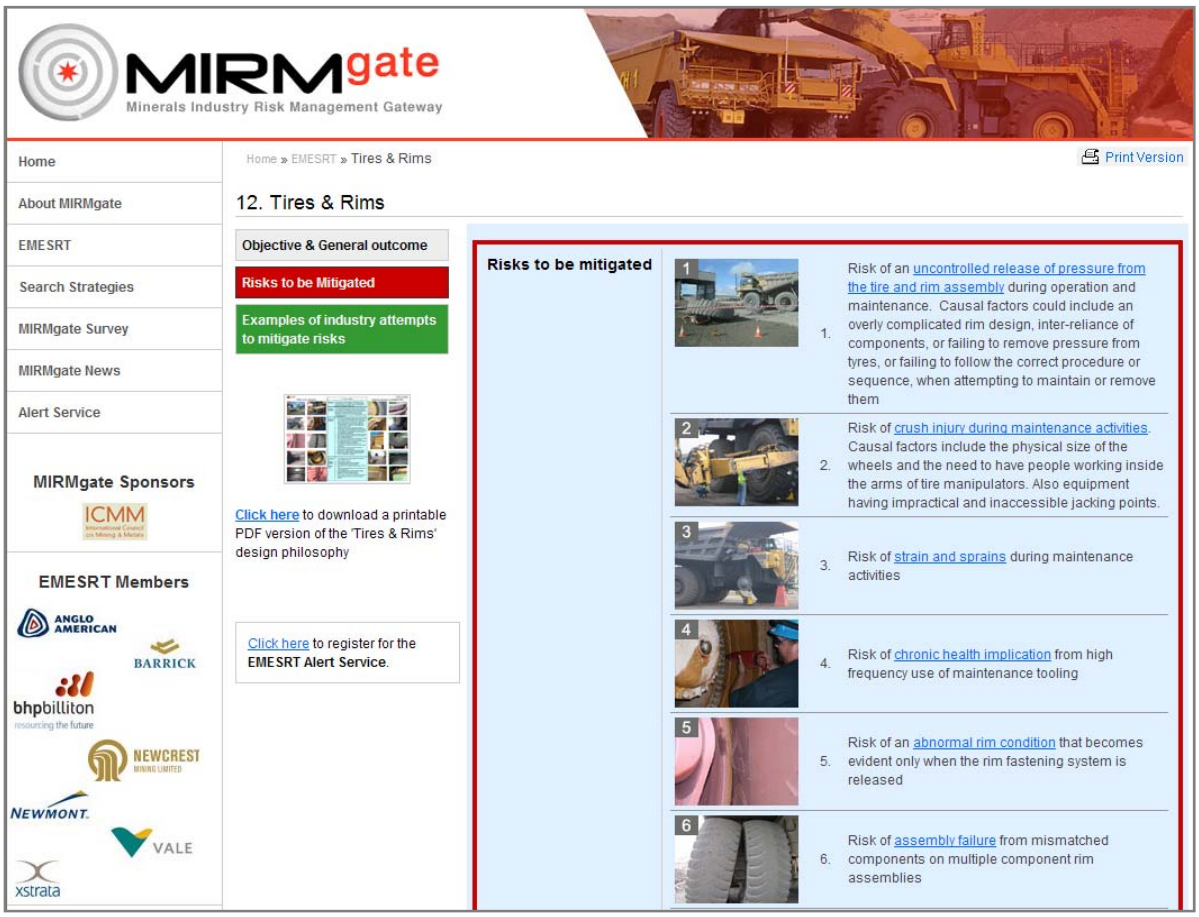


Figure 5. MIRMgate EMESRT *"Tires & Rims"* Design Philosophy (DP) home page.

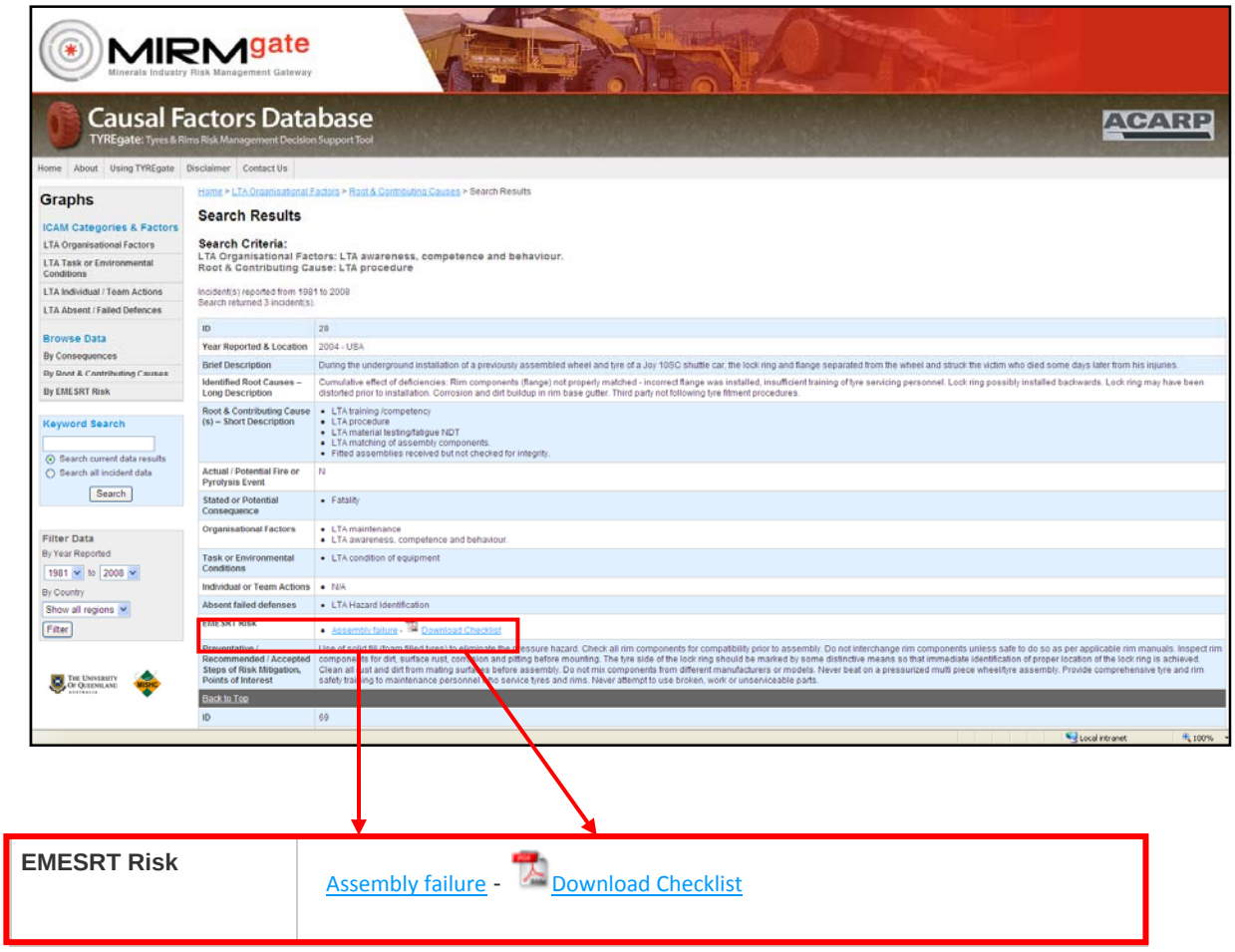
c) TYREgate link with the EMESRT "Tires and Rims" Design Philosophy (DP)

To integrate the two sites, TYREgate database has been further developed and a new element, *"EMESRT Risk"*, has been included. The *"EMESRT Risk"* categories represent the risks as identified by the EMESRT and presented in the EMESRT *"Tires & Rims*" DP *"Risks to be mitigated"* section. See Figure 5. The "Risks to be mitigated" section documents the significant and common Earth Moving Equipment (EME) risks that are evident at mine sites and could be improved through human factors engineering by the Original Equipment Manufacturers (OEMs).

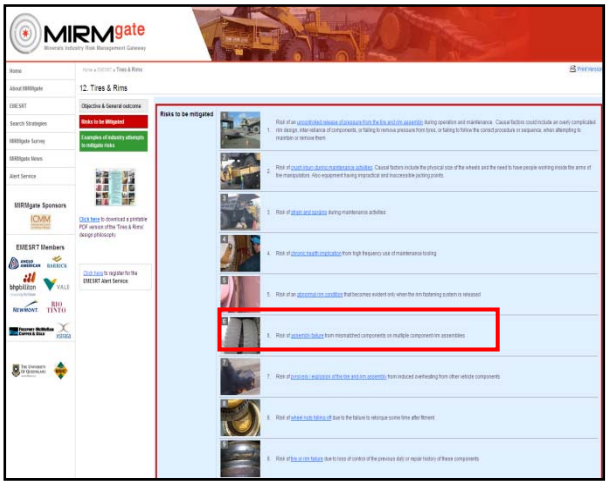
Each accident / incident analysis within TYREgate database has been assigned with relevant "EMESRT Risk(s)" category to enable the users to browse TYREgate *by EMESRT Risk*. TYREgate not only provides its users with the option to ***"Browse by EMESRT Risk"***, but also allows the users direct access to the EMESRT *"Tires and Rims"* DP by a hyperlink created through the ***EMESRT Risk(s)*** presented on TYREgate search results page as shown below in Figure 6. Another unique feature of MIRMgate, the ***"TYREgate Checklists"*** is designed to provide information specifically related to relevant EMESRT Risk category. Figure 6 also shows the *"Download Checklist*" hyperlink presented on the search results page. More information on the *"TYREgate Checklists"* is provided in the section 5.1.D.

The seamless integration with the EMESRT site, specifically to the *"Tires and Rims"* DP was one of the major goals of TYREgate and demonstrates the power of this pilot project to link with already existing systems.

TYREgate "Search Results" page



EMESRT *"Tires & Rims"* DP: *Assembly failure* **TYREgate Checklist: *Assembly failure***



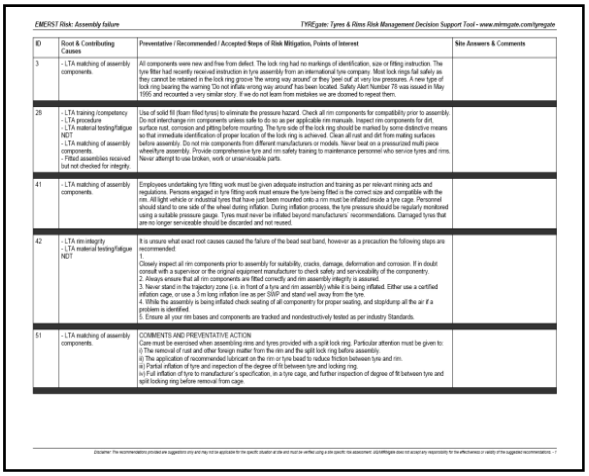


Figure 6. TYREgate link to MIRMgate EMESRT *"Tires and Rims"* Design Philosophy and *"TYREgate Checklist"*.

D. TYREgate Checklists

The *"TYREgate Checklists"* include comments and what approaches have been taken by the industry to mitigate the particular hazard(s) and resultant risk thereby allowing the user to check his/her own site's safety and health management system for industry solutions. The Checklists are provided at the end of a search result and are considered the last step in the search procedure. *"TYREgate Checklists"* are dynamically created and are downloadable.

The *"TYREgate Checklists"* contain three sections as follows:

a. Root and contributing factors
b. Preventative / Recommended / Accepted Steps of Risk Mitigation, Points of Interest
c. Site comments

More information about the *"TYREgate Checklists"* can be found in Section 6.4.

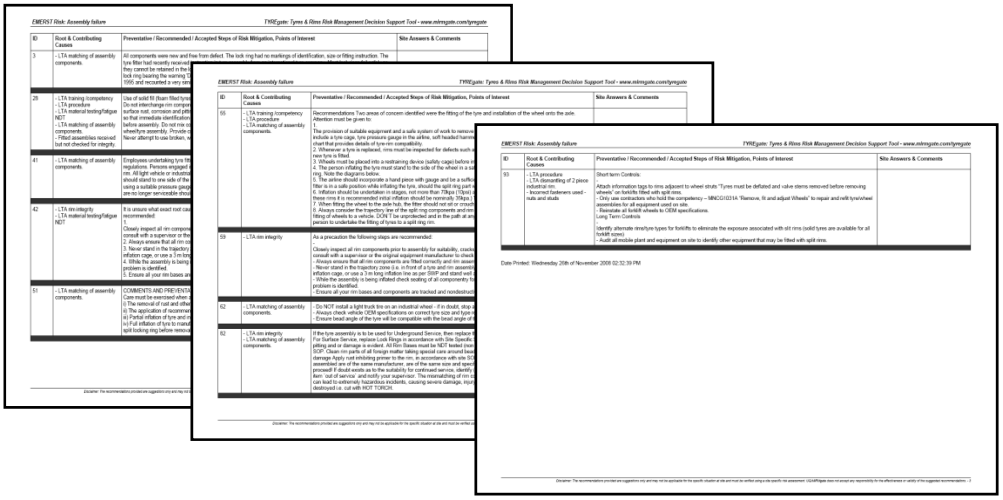


Figure 7. Example *"TYREgate Checklists"*

6.0 TYREGATE: UNIQUE & INNOVATIVE SEARCH CAPABILITY

6.1 Searchable by" ICAM" categories

By searching through the ICAM factors allows users to easily search and filter data. The ICAM categories include:

- LTA *(Less Than Adequate)* Organisational Factors,
- LTA Task/Environmental Conditions,
- LTA Individual / Team Actions, and
- LTA Absent/Failed Defences.

The following Figure 8 highlights the four ICAM categories available on the website. By clicking any one of the ICAM categories, users will be taken to a graph that has been generated real time from database records detailing the factors that contribute to the accident.

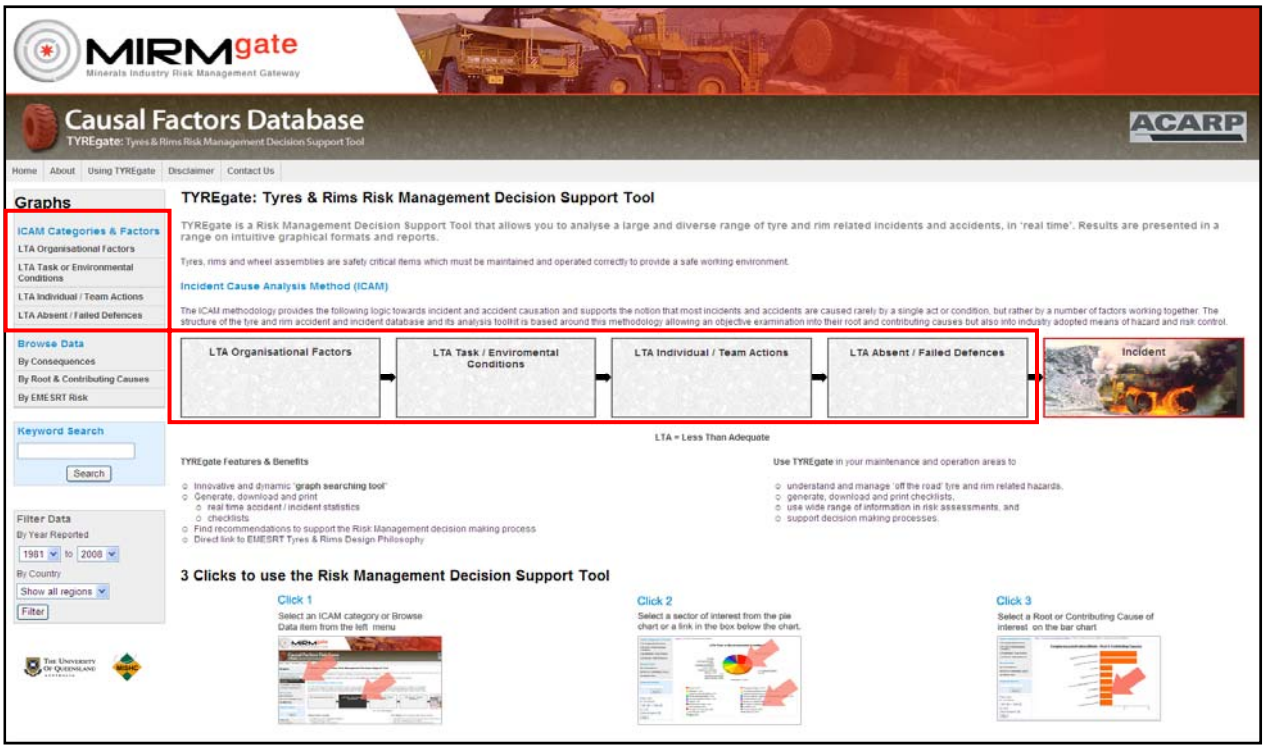
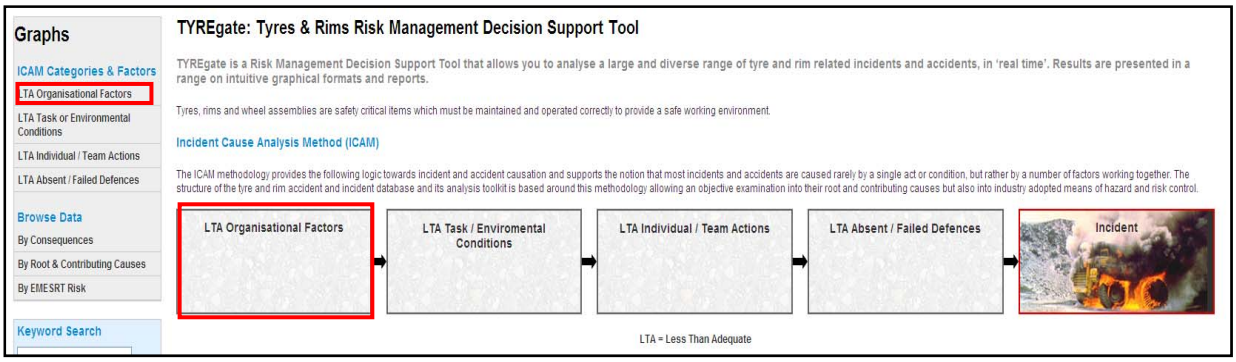


Figure 8. ICAM categories.

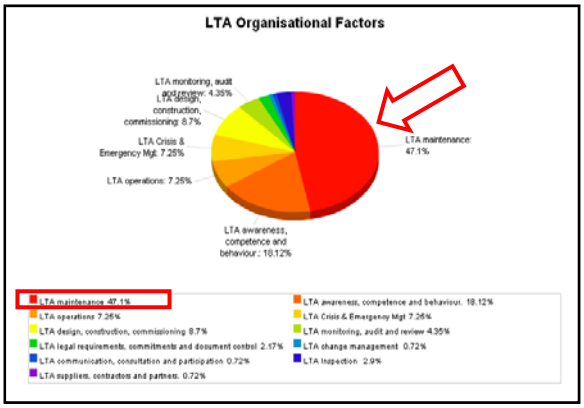
6.2 "3 Click" Approach

The ***"3 Click"*** approach is one of the more innovative features of TYREgate, within 3 steps users are taken through a series of charts containing a wealth of information facilitating fast and easy access to specific causal data. These charts and statistics are generated real time. The ***"3 Click"*** approach is pictorially described in Figure 9.

Click 1



Click 2



Click 3

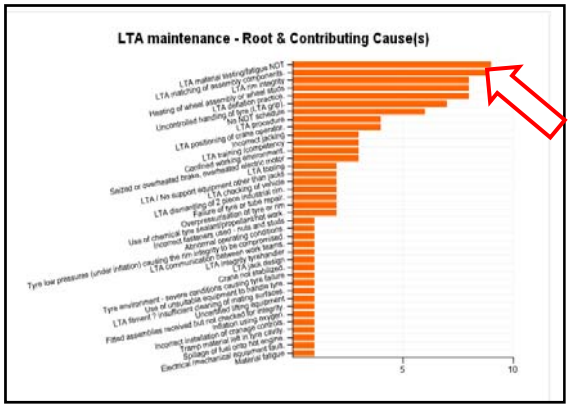


Figure 9. *"3 Click"* approach.

Clicking on any of the ICAM boxes ***(Click 1)*** will take the user to a graph providing the first level of information and relevant factors. For instance, clicking on 'LTA Organizational Factors' will provide a pie chart that shows where, from an organizational point of view, weaknesses exist. Clicking on the individual slices of the chart ***(Click 2)***, users then advance to root and contributing causes, displayed as a paretograph. By clicking on individual bars of the paretograph ***(Click 3)***, users are then (and only then) provided with detailed written information about the underlying incidents and accidents. Furthermore, it is at this level that *"TYREgate Checklists"* for specific hazard(s) are available. The ***"TYREgate Checklists"*** provide managers with a series of risk mitigation steps they can use to manage the risks they have identified. More information about the Checklists can be found in Section 6.4.

6.3 "3 Click" Browse Data options

Rather than searching through specific ICAM factors, users are also given a choice to browse by either *Consequence* (eg. Fatality), *Root and Contributing Causes* (eg. Less than adequate matching of assembly components) or by *EMESRT Risk* (eg. Crush injury during maintenance accident). This search capability provides another method of searching the TYREgate database allowing users to sort through data more efficiently. This alternate approach also follows the ***"3 Click"*** guideline where a user can reach specifics through a 3 step process of sorting information.

Browsing by *"EMESRT Risk"* in particular was one of the major goals of the project where the information generated through the EMESRT could be linked back with TYREgate.

Figure 10 shows the *"Browse Data"* options on TYREgate home page.

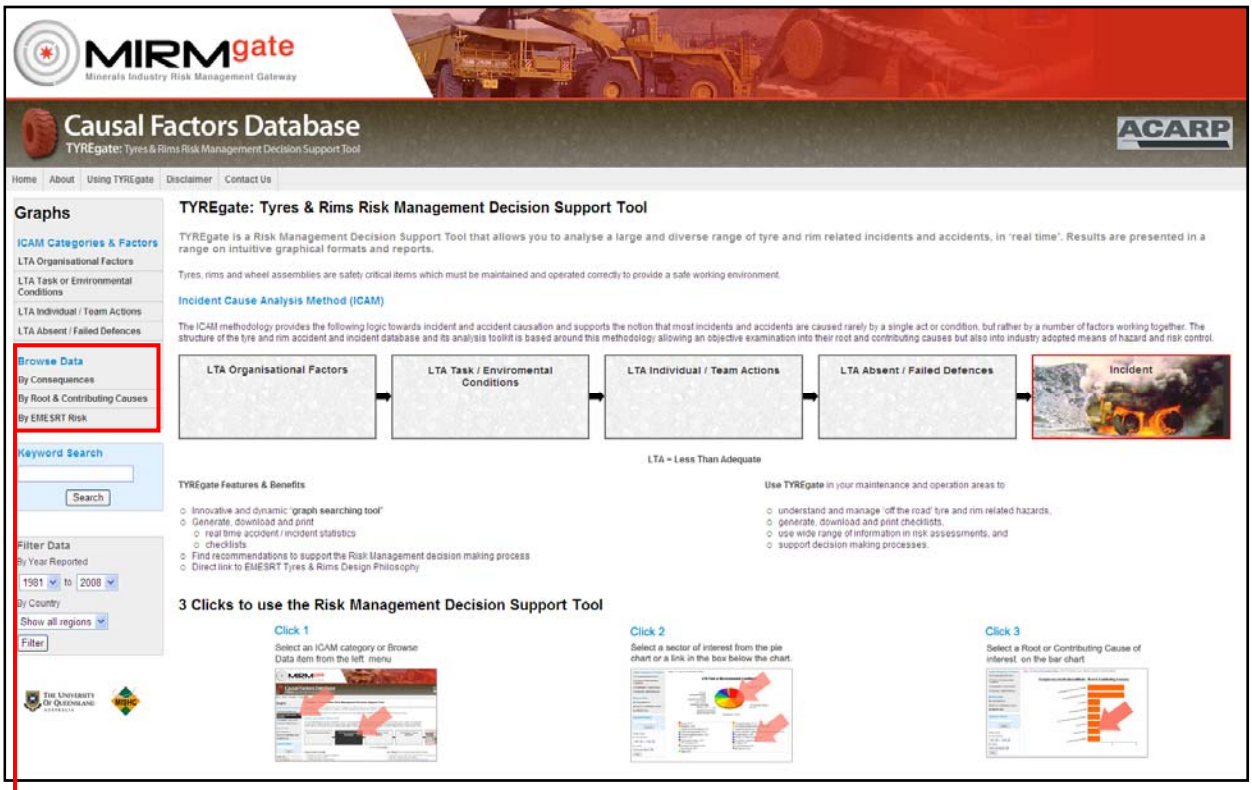
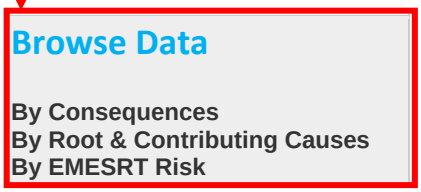


Figure 10. *"Browse Data"* options.



The *"Browse Data"* options are introduced below. For more information on browsing by category please refer to Appendix Section 3.

A. 'By Consequences'

Browsing data ***'By Consequences'*** allows users to understand the risk factors involved in the occurrence of an accident where the final outcomes can be quite serious. This can allow tyre maintenance and management personnel, Original Equipment Manufacturers (OEMs) and general mining community worldwide to implement strategies to reduce the risks of the more common root or contributing causes that may lead to the potential accidents. To browse data by consequences, click on *'By Consequences'* below the Browse Data heading. See Figure 10.

B. 'By Root and Contributing Causes'

Browsing data ***'by Root or Contributing Causes'*** allows users to filter results using causes. This allows easy identification of highly occurring causal factors that can be mitigated using the checklists. To browse data by Causes, click on 'By Root & Contributing Causes' below the Browse Data heading. See Figure 10.

C. 'By EMESRT Risk'

TYREgate has been fully integrated with the *"EMESRT Tires and Rims Design Philosophy (DP)"* as demonstrated in Figure 6. This functionality allows TYREgate users to navigate away to EMESRT Design Philosophies within the MIRMgate website where significant work in Design Philosophies has already been undertaken by the EMESRT (EMESRT 2009). TYREgate in this way can be thought of as a powerful tool to search within EMESRT Design Philosophies and as a complimentary tool for effective risk mitigation.

To browse data by EMESRT Risk, click on ***'by EMESRT Risk'*** below the Browse Data heading as shown in Figure 10. This option follows the unique and innovative TYREgate ***"3 Click"*** search guideline.

6.4 Special Features

A. Filter Data by Year and Country

One of the key features of TYREgate is that a commenced search (during ***"3 Click"*** search process or at final step, on search results page) can be filtered by the *"Year"* and / or the *"Country"* to refine and highlight relevant resources. Both points can be helpful in implementing risk mitigation strategies that are useful to specific areas or to gain a perspective of how causal data has changed over time. The filtering tool is located on the left hand side of the TYREgate menu as shown in Figure 11 and can be accessed at any time. As one of TYREgate's key innovative approach is its unique search functionality, the addition of easy to use search filters bring users one step closer to the perfect search system. For more information on filtering data please refer to Appendix Section 4.2.

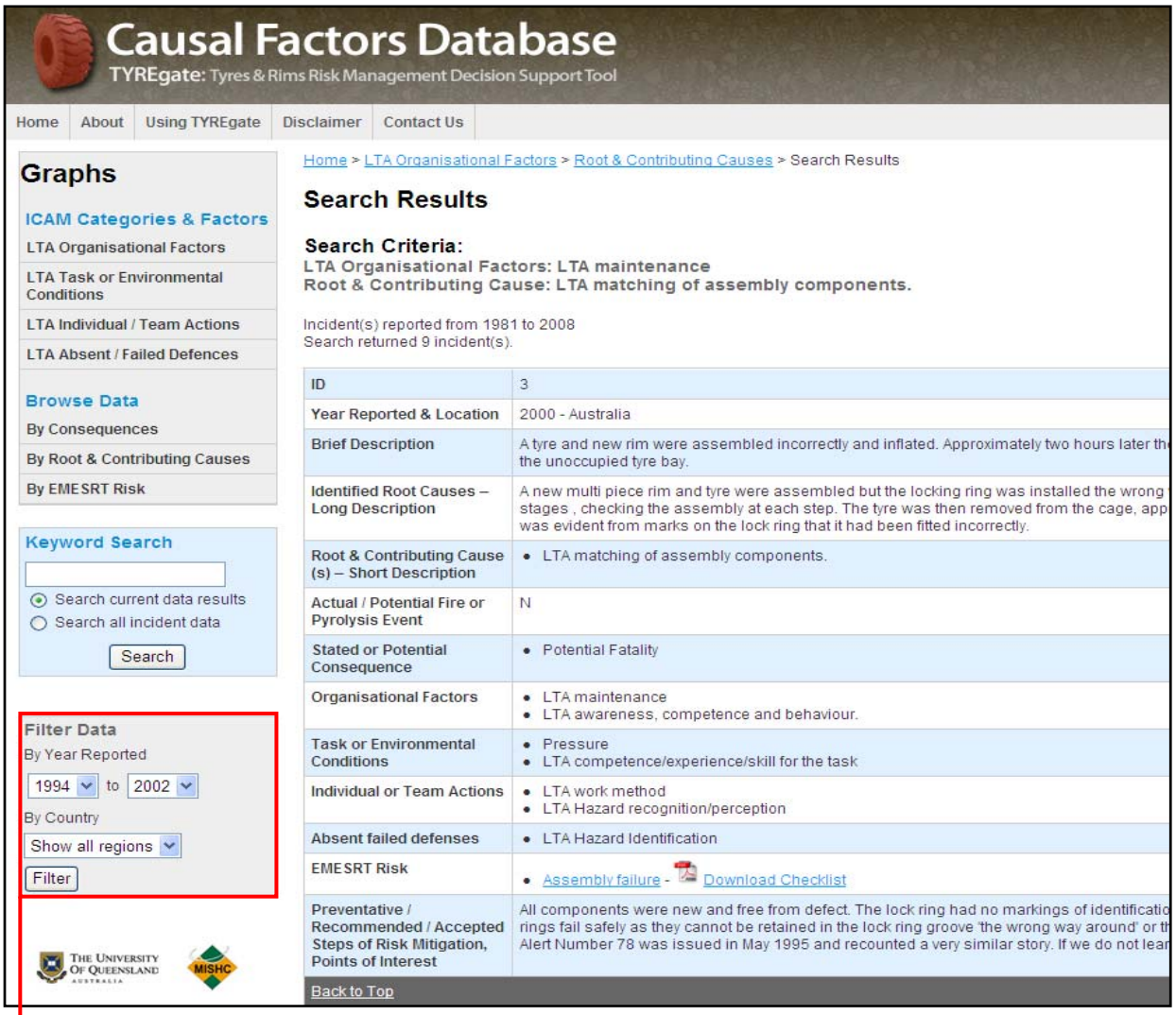
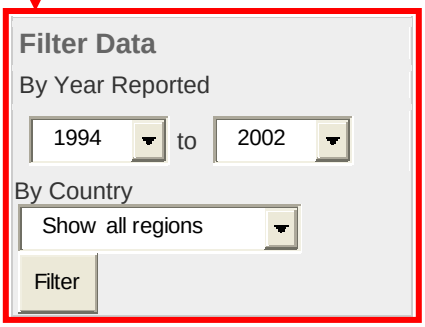


Figure 11. Filter Data by *"Year"* and *"Country"*.



B. Generate, download and print dynamically created Graphs & Checklists

a) Graph Search Results

Any report or graph generated can be printed off with the click of one button. Once again, one of the goals of TYREgate is ease of access to information and by allowing users to print data found within

TYREgate without having to go through the process of formatting information. The print feature also relates to *"TYREgate Checklists"* which are discussed in more detail in the following section.

All data can be printed by clicking the top right corner button.

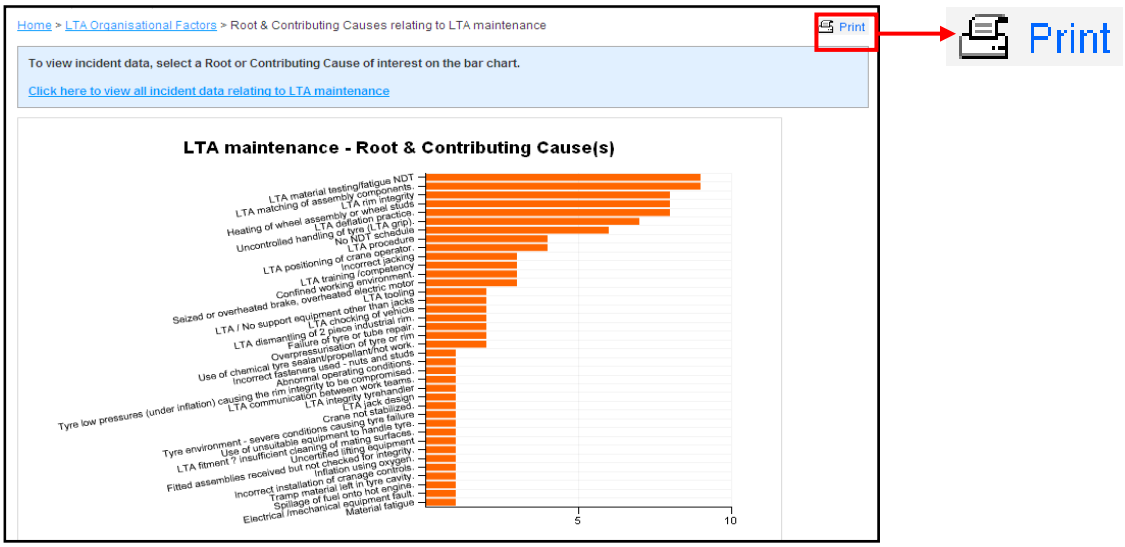


Figure 12. Data *"Print"* option.

b) TYREgate Checklists

TYREgate Checklist(s) is generated for each record of data in their relevant "EMESRT Risk" categories and they are found at the end of the search process where the user may ask himself / herself ***"How can I mitigate the risks at my own operation?"*** Users are then able to print these Checklists and take them into the field or boardroom and able to discuss where the major risks might occur and how to prevent them from causing accidents. An example Checklist is shown in Section 5.1.D, see Figure 7. More about the Checklists and how to access them are contained in Appendix Section 2.4.

C. *Direct link to* EMESRT *"Tires & Rims"* Design Philosophy (DP)

TYREgate has been fully integrated with the EMESRT *"Tires and Rims"* DP as explained in detail in Section 5.1.C and demonstrated pictorially in Figure 6. While TYREgate allows access to the analysed accident /incident data, based on ICAM approach, MIRMgate provides access to the original accident / incident data such as Safety Alerts, Safety Bulletins, and Accident Investigation Reports.

The direct link between the two systems enables TYREgate users access to online MIRMgate EMESRT *"Tires and Rims"* DP, and Australian and global accident / incident data through hyperlinked risk terms as identified within the *"Risks to be Mitigated"* section of the DP.

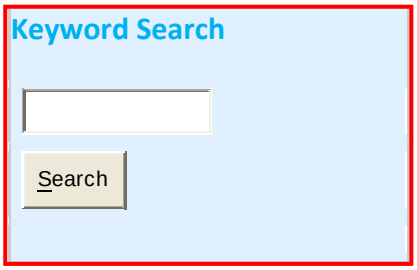
D. *Keyword Search and Advanced Search Techniques to refine search*

Searching is not limited to the *"3 Click"* approach. Searching though conventional techniques such as keywords can still be used within TYREgate offering another layer of flexibility.

Results can be either refined or searched in a number of other ways. Keyword search and advanced

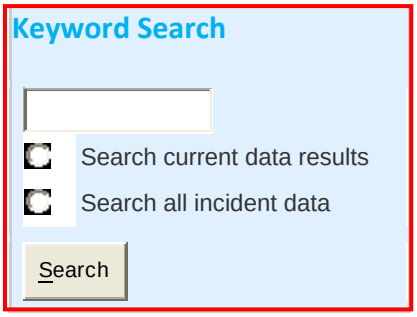
search techniques to refine search are explained below.

Keyword search



Keyword search provides users with a search tool that can pinpoint straight to the data. By searching through keywords, users that aren't familiar with the *"3 Click"* process are still able to access to the causal factors and risk mitigation practices.

Advanced keyword search



In the same way that the filtering data functionality works, users are also able to refine search results, which appear following the *"3 Click"* approach, or Browse data options, by using the Advanced keyword functionality and selecting *"Search current data results"* and continuing to search by keywords of interest. Refining results in this way is a quick and easy process and is thought of as a final step in filtering data.

"Search all incident data" still functions as the conventional *"Keyword search"* and allows the user to search all the data provided by TYREgate.

Refine search

Refine search by using synonyms and related terms is another unique and innovative solution to search TYREgate. It is necessary because not all users may be fully acquainted with the lingo or terminology of accident description and also helps break language barriers where users from different countries may have a specific word for particular accidents which isn't widely used. For instance, in Australia 'tyre' is spelt with a 'y', whereas in the United States, tyre is spelt 'tire'. TYREgate overcomes this problem by offering a range of spelling options and synonyms that can be used in a search.

Within this capability once a search has commenced, users are able to peruse terms that they may have forgotten or not known about. Users can select from a list of ***"synonyms and related terms"*** given in an extended text box on top of the search results as shown in Figure 13.

This process can lead either into a wider, broader search where the user has not covered all terms or into a more accurate narrow search where a user has forgotten the specific terminology. The synonyms and related terms list is created by the project team which means that terms have been given much thought before being implemented on TYREgate. This feature acts as a complimentary search guide when using keywords and underpins TYREgate's searching capability.

The example below shows a keyword search for "Tyre" which can have many different related terms. Related terms "rim", "wheel", and "assembly" have been selected and the results are shown in Figure 13.

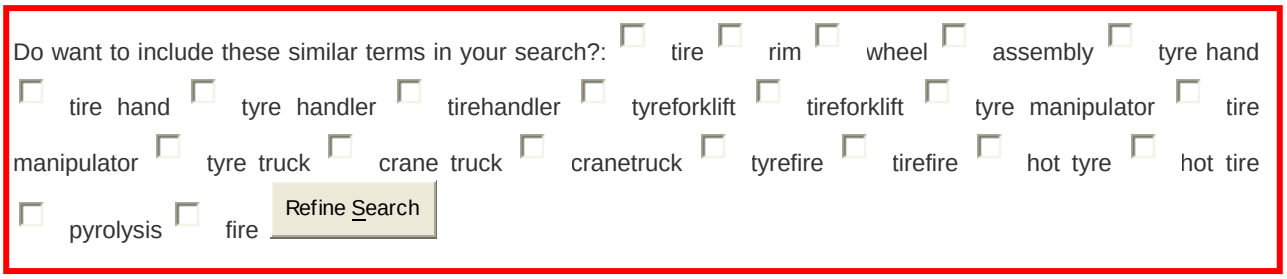


Figure 13. Refine Search option.

For more information about any of the search tools please refer to Appendix Section 4.

6.5 TYREgate Data Entry Tool & Administration

The project not only delivered access to the tyres and rims related accident and incident Causal Factors Database and Australian and global risk mitigation practices, but also developed a ***"TYREgate Data Entry Tool"*** to allow further population of the database in a consistent manner as new data becomes available.

The design of the Data Entry Tool allows the project team to access the TYREgate administration tool in a secure environment to add and analyse new or edit existing incident data to the TYREgate Causal Factors Database as shown in Figure 14. The data entry and administration of the back end of TYREgate can be conducted anywhere around the world as opposed to a local database system. The relevant data entry categories can be selected from the left hand side of the screen to ensure data entry is carried out in a consistent manner. Once a record has been added or updated, the graphs linked to these records are created dynamically so a user can always have the most up-to-date information and statistics. This is one of the many key innovations of the TYREgate site.

Figure 14. TYREgate Data Entry Tool

Admin Home
Add New Incident
Edit Incident
Add/Edit Root Causes
Add/Edit Consequences
Add/Edit Organisational Factors
Add/Edit Task or Environmental Conditions
Add/Edit Individual or Team Actions
Add/Edit Absent Failed Defences
Add/Edit Risk
Add/Edit Synonyms

7.0 TYREGATE BENEFITS

A particular strength of this unique system is allowing searching through a graphing scheme – dynamically created graphs that clearly demonstrate the root and contributing causes of accidents and events in **"3 clicks"**, provision of a range of incident and accident information, and risk mitigation recommendations, that if implemented will have a marked impact in reduction of this type of incident and accident scenario.

The Project team firmly believes that TYREgate's ability to provide information and ongoing communication of its findings will assist in making the mining industry a safer place of work. This will be achieved through adoption of industry risk mitigation recommendations by tyre service/management personnel, Original Equipment Manufacturers (OEMs), industry groups and mining companies' management framework, based on the deliverables provided by TYREgate.

While in the past improvements in tyre and rim related safety were (often by default) allocated to the actual tyre maintenance service provider, TYREgate will assist in clarifying how modifications and improvements to the design of equipment being used, such as tyres and rims, earthmoving equipment, tyre handling equipment and tools that can assist in improving tyre and rim related safety.

The benefits include (but are not limited to):

- An innovative graphical searching scheme that includes fault trees (event causation) and event trees (event escalation),
    - to better illustrate dependencies, weaknesses and/or defences of accident scenario,
    - to allow a quick access to root and contributing causes of accidents and incidents within "3 clicks",
- User friendly presentation via industry endorsed MIRMgate portal,
- Easy access to
    - accident and incident data that have occurred in the Australian and international (where available) coal and metalliferous sectors, and their detailed analysis (root causes and contributing factors, particularly design, maintenance and operating issues), report and recommendations (based on underlying risk) on what needs to be done to improve tyre and rim maintenance to an acceptable level of risk,
    - breakdown of when/how the mishap occurred in the work process/flow,
    - industry developments in Australia and the rest of the world,
- Detailed examination of training and competency issues,
- Reporting of tyre and rim related design improvements and technological initiatives covering a range of equipment and practices including enhancements of tyre and rim related design issues e.g.
    - design of rims,
    - design of tyre and rim specific safety innovations,
    - maintenance tooling, and
    - tyre handler and tyre manipulator improvements,
- Highlights safety critical tasks that must be observed to ensure a safe outcome,

- Identifies of shortcomings in management systems such as less than adequate supervision, tyre and rim management, tyre and rim history tracking and proactive follow-up, in line with benchmark tyre and rim management approaches,
- Provides a commentary regarding chosen controls and their effectiveness as compared to the 'hierarchy of control',
- Raises awareness around tyre and rim safety across a number of levels within an organisation, from tyre service men, supervisors, middle management to senior management by sharing the learnings, and
- Up-to-date global industry causal factors and leading practice database.

Feedback to date has shown that TYREgate is an elegant solution in capturing, analysing and reporting on a range of diverse data related to tyre rand rim related accidents and incidents.

Similar approaches have already been adopted by other high risk industries such as the nuclear, aviation and the petrochemical sector, with considerable success.

8.0 TECHNOLOGY TRANSFER

TYREgate was launched on Aug 19th, 2008 at the annually held *"Queensland Mining Industry Health and Safety Conference (QMISHC)"* and has since been made available on the web: http://www.mirmgate.com/tyregate/index.php.

While less than 9 months since completion, this project has shown to benefit several key industry stakeholder groups, e.g.

- Tyre maintenance and tyre manager personnel through exposure and access to a wide body of accident and incidents and prevention measures,
- OEMs through easy access to high quality, reliable tyre and rim related design improvements and initiatives covering a range of equipment and practices, and
- Mining industry in general through access to causal factor information and recommendations which will assist in creating safer and more reliable management strategies and organisations.

TYREgate is a practical tool which can be utilised for site safety training for new and existing personnel at mine sites. TYREgate would allow comparison of site practices with global hazard mitigation practices.

9.0 TYREGATE KEY FINDINGS & OUTCOMES

TYREgate's functionality to 'store' publicly available safety information of different formats and origins, and provide the user with reliable 'near real time' reports of safety risk is the core function and deliverable of TYREgate, and has been demonstrated.

It was borne out of the real need to make a range of accident and incident data available to decision makers in 'near real time'.

TYREgate was launched at the 2008 Queensland Mining Industry Health and Safety Conference and has since been made available on the web: http://www.mirmgate.com/tyregate/index.php.

While the number of people directly involved in earthmover tyre and rim maintenance is comparatively small compared with other maintenance functions, TYREgate has been visited 3,518 times via 34 pages in the first 10 months of its existence (TYREgate Google Analytics 2009).

Consistent feedback from industry is that TYREgate provides both sound information and an intuitive way to present information based on risk. Its ability to also provide checklists and industry adopted hazard mitigation practices is seen as a particularly powerful feature.

Its link to EMESRT and its Design Philosophies was seen as an elegant solution for connecting two databases.

The TYREgate web-based system is fully functional and freely accessible, and has provided reliable support to the industry to date.

Its updating facility was found to be easy to use which will encourage future update of the data itself.

A key point of this project is that it has demonstrated its ability to be "THE" pilot for like projects towards creation of reliable databanks that could be of assistance across a range of design or safety projects.

Building a set of consistent databanks of accident/incident data has not been supported by the mining industry yet, but has been accepted by other high risk industries with success for many years.

2009 will see the rollout of a simple questionnaire prompting the user to give his or her feedback to allow continuous improvement of TYREgate. Feedback from the survey will also be used in designing the new gate-initiative, **ISOgate**, for which ACARP funding has been provided in late December 2008.

While TYREgate is considered highly intuitive, an online help facility is also available within the system. A ***"TYREgate User Guide"*** has been designed and this will be available for download from the TYREgate site.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The trigger to TYREgate was a tyre related fatality at a North Queensland mine site in February 2004. This event and 5 other tyre related deaths that year flagged the real need to collect tyre and rim related accident data and incident data and provide a detailed report to industry.

This was achieved through a 2006/07 ACARP project C15046, initiated by Klinge & Co. known as ***"Review and Analysis of Tyre Related Accidents and Incidents – a Study with Recommendations to Improve Tyre & Rim Maintenance and Operational Safety of Rubber Tyred Equipment".*** One of the report's recommendations was to make the data also available through MIRMgate, in particular data and findings were to be presented to decision makers in 'near real time' and in an easily understood (graphical) format.

Further ACARP funding for a joint project between the Minerals Industry Safety and Health Centre (MISHC), Queensland Department of Mines (DME) and Klinge & Co. was made available culminating in the development and launch of TYREgate in August 2008.

TYREgate database has been further developed and expanded to include ***"EMESRT Risk"*** to achieve full integration with the EMESRT *"Tires and Rims"* Design Philosophy (DP), and to provide its users with the ability to refine their searches by ***"Year"*** and / or ***"Country"***.

TYREgate now not only contains the ACARP project C15046's findings that was based on a total of 82 publicly available incident reports occurring between 1989 and 2006 (largely from the Australasian, American, & Canadian regions), 30 of which resulted in single or multiple fatalities, but also publicly available accident and incident data occurred since the completion of the previous project. The TYREgate content is updated on an ongoing basis as new accident and incident data becomes available to share the learnings from these unwanted events and assist with prevention of future accidents and incidents. The innovative system design allows the project team to access the TYREgate administration tool to add and analyse data consistent with the previous entries.

Without the root cause review, safety improvements around tyre and rim maintenance and their use will continue to remain reactive rather than proactive and are likely to continue their focus on less effective means such as procedural 'fixes' rather than solutions addressing the root cause of the mishap (such as the design of the equipment).

Feedback to date has shown that TYREgate is a comprehensive solution to capturing, analysis and reporting on a range of diverse data related to tyre and rim related accidents and incidents. Furthermore, general feedback on TYREgate and specific comments on its intuitive graphical interface and the ability to provide the user with specific hazard based checklists have demonstrated the opportunity to expand TYREgate's methodology to other areas of safety research and communication. To that end, ACARP has provided funds for the 2009 development of ISOgate, a further causal factor database aiming at presentation, analysis and reporting of 'isolation' related accident and incidents.

TYREgate currently links to one EMESRT *"Tires and Rims"* DP and ISOgate will link to EMESRT *"Isolation of energy, including parking"* DP. Given the EMESRT charter to identify equipment risks (problems) to enable equipment design improvement in "13" other areas ranging from *"Equipment Access and Egress"*, to *"Working in Confined Spaces",* it is recommended to build the corresponding ***"Gates"*** that offer a detailed insight and analysis to the respective accidents and incidents, the hazards that have led to the mishaps, the consequences to those, including industry adopted mitigation as a base line for equipment design improvements, ideally aimed at the factory level. Figure 15 shows all EMESRT DPs and highlights the completed and on-going ACARP projects.

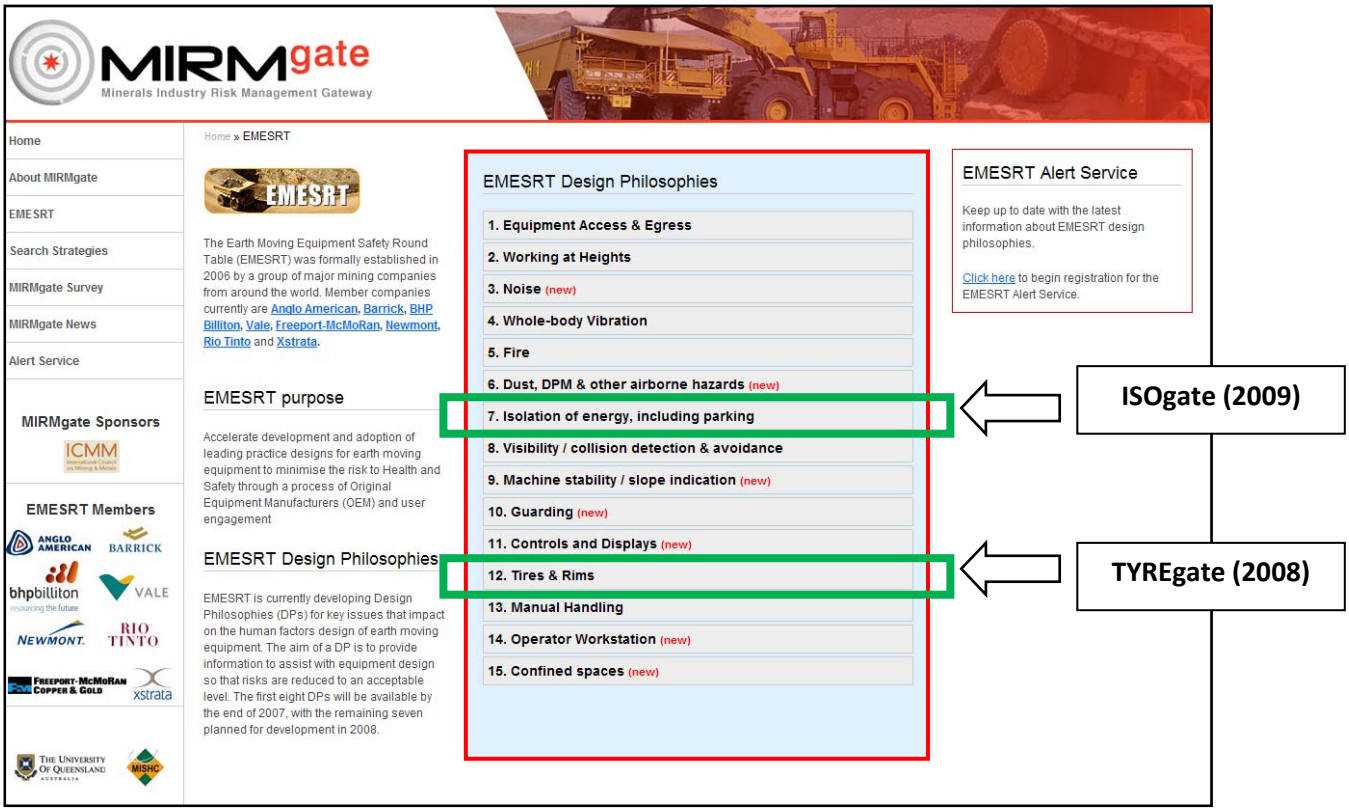


Figure 15. MIRMgate EMESRT home page and 15 EMESRT Design Philosophies (DPs) are demonstrated. *"Isolation of energy, including parking"* DP and *"Tires and Rims"* DP are highlighted *(MIRMgate 2009)*.

The authors firmly believe that it is vital for this work to be supported and continued into the future. In near future, they will aim to establish ***"COLLISIONgate"*** as their next *"Gate-initiative"*.

One of the most common risks that occur in the Loading and Hauling (L&H) activity of an open pit mine operation is the one related to injury and in some cases fatality and / or equipment damage from vehicle collisions.

An on-going ACARP project C17032, *Developing a Risk – Cost – Benefit (RCB) Decision Support Tool for the Mining Industry by Using the Bow Tie Analysis Technique (Kizil G, Bye A & Joy J 2008 -2009)*, examined heavy earth moving equipment collisions occurring at surface mines and reviewed in detail nearly 400 cases occurred during a 3 year period, 2004 - 2007. Furthermore, this project gathered significant and high quality industry adopted Collision Avoidance and Fatigue Technology related information and latest developments in these areas. In a separate project, Mr Rasche

investigated and identified suppliers of the Collision Avoidance Technology and distributed a questionnaire to the suppliers. The questionnaire results were analysed by Mr Rasche.

The suggested COLLISIONgate would provide objective, sound causal factors analysis of accidents / incidents (event & consequence analysis) and provide industry adopted risk mitigation practices including technological advancements in Collision Avoidance and Fatigue Technology. The COLLISIONgate would directly link to the EMESRT *"Visibility / collision detection & avoidance"* DP. See Figure 16.

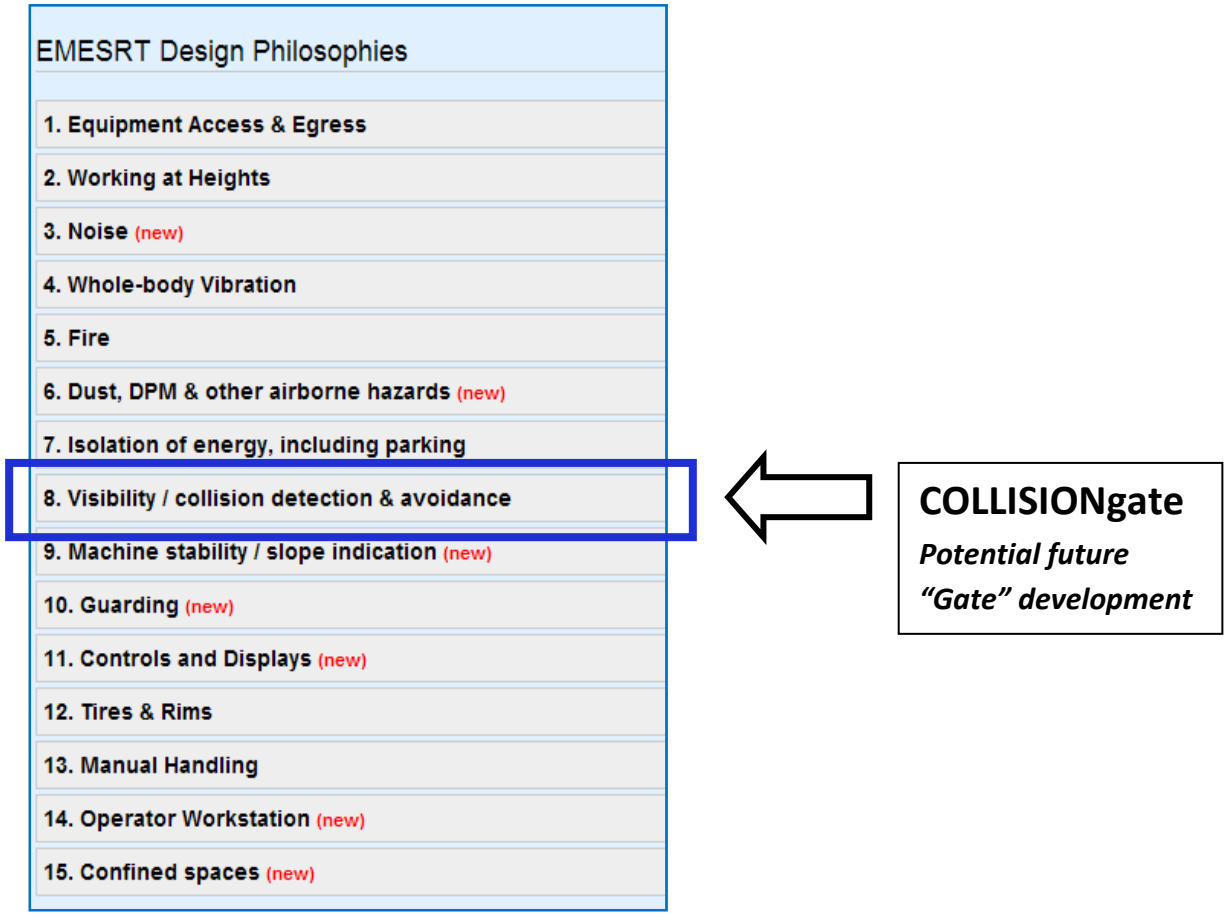


Figure 16. A list of EMESRT Design Philosophy (DP) topic areas including EMESRT *"Visibility / collision detection & avoidance" (MIRMgate 2009)*.

In the longer term, the authors aim to establish further ***"Gates"*** in the remaining EMESRT Design Philosophy topic areas. There is also potential to adopt the approach to build *"Gates"* in catastrophic risk areas such as mine fires, explosions. TYREgate already provides the required framework to build the further *"Gates"* and adoption of the approach into other areas will make better use of funds already invested in TYREgate establishment. The development of TYREgate has also proven the benefits of collaboration between a research body *(Minerals Industry Safety and Health Centre (MISHC), The University of Queensland)*, a regulatory body *(Queensland Department of Employment, Economic Development and Innovation, Division of Mines and Energy)* and Klinge & Co *(a mining industry service provider, contractor and consultant specialising in earthmover tyre and rim*

management systems). It is recommended that such collaborative efforts are encouraged for future projects.

Because of its innovative approach and detailed recommendations, the authors believe that this project, and others building on the project's demonstrated methodology, will assist EMESRT and Original Equipment Manufacturers (OEMs), and industry at large to achieve their goals of a safer, injury free workplace.

REFERENCES

1. EMESRT 2008, *MIRMgate EMESRT Tires and Rims Design Philosophy*, viewed on Aug 2008, <http://www.mirmgate.com/emesrt.asp>.
2. EMESRT 2008, *MIRMgate EMESRT Tires and Rims Design Philosophy*, viewed on Mar 2009, <http://www.mirmgate.com/emesrt.asp>.
3. Joy J, Kizil G & Leveritt S 2007, *Human Factors Engineering and Large Surface Mining Equipment Design*, ACARP Project C14046.
4. Kizil G, Bye A & Joy J 2008 – 2009, *Developing a Risk – Cost – Benefit (RCB) Decision Support Tool for the Mining Industry by Using the Bow Tie Analysis Technique, ACARP Project C17032.*
5. Minerals Industry Safety and Health Centre (MISHC) 2009, *Minerals Industry Risk Management Gateway (MIRMgate), viewed on Oct 2009,* < http://www.mirmgate.com/emesrt.asp>.
6. Offshore Reliability Data (OREDA), *Offshore Reliability Data*, viewed 3 September 2007, http://www.sintef.no/static/tl/projects/oreda/.
7. Queensland Coal Mining Safety and Health Act 1999.
8. Queensland Mining and Quarrying Safety and Health Act 1999.
9. Rasche T & Klinge T 2006, *Review and Analysis of Tyre Related Accidents and Incidents – a Study with Recommendations to Improve Tyre & Rim Maintenance and Operational Safety of Rubber Tyred Equipment*, ACARP project C15046U.S. Department of Labor, *Tire and Rim Safety Awareness Program, in Instruction Guide Series, MSHA IG 60. 1996, U.S. Department of Labor, Mine Safety and Health Administration*
10. *NSW DPI Mine Safety Upd*ate, *TYREgate opens the door to improved safety in mining, January 2009, viewed Jan 2009,* http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/262389/Mine-Safety-Update-January-2009.pdf

APPENDIX. TYREGATE USER GUIDE

TYREgate USER GUIDE

May 2009

Dr Guldidar V. Kizil
Senior Research Officer
Minerals Industry Safety and Health Centre (MISHC), The University of Queensland

Mr Tilman Rasche
Senior Inspector of Mines
Queensland Department of Employment, Economic Development and Innovation,
Division of Mines and Energy

Preface

TYREgate provides a searchable database of incidents and accidents on Tyres and Rims safety and risk management. The following *"User Guide"* contains the TYREgate Key Features and a How to Use guide of TYREgate. The "User Guide" is intended to be used as a reference manual for those who are new to the system.

Table of Contents

List of Figures

1. Introduction

TYREgate offers a comprehensive search database covering Tyres and Rims related accidents that have been categorized using the ICAM approach. The following user guide will cover examples of how to effectively gain the most out of using TYREgate. Section 2 covers search basics and the "3 Click" approach, an easy option that allows users to be able to search using graphs rather than keywords. The end of Section 2 covers links to MIRMgate EMESRT where users can gain more information on the topic they are interested in and TYREgate checklists which are a tool that can help mitigate risks. Section 3 aims to show users how they are able to browse through the database by *"consequences"*, *"root and contributing causes"* and *"EMESRT Risks"*. Section 4 showcases more advanced searching options including how to get the most out of keyword searches and how to filter data.

2. Getting Started with TYREgate

To get started, you can find the TYREgate website by pointing your browser to: http://www.mirmgate.com/tyregate/index.php.

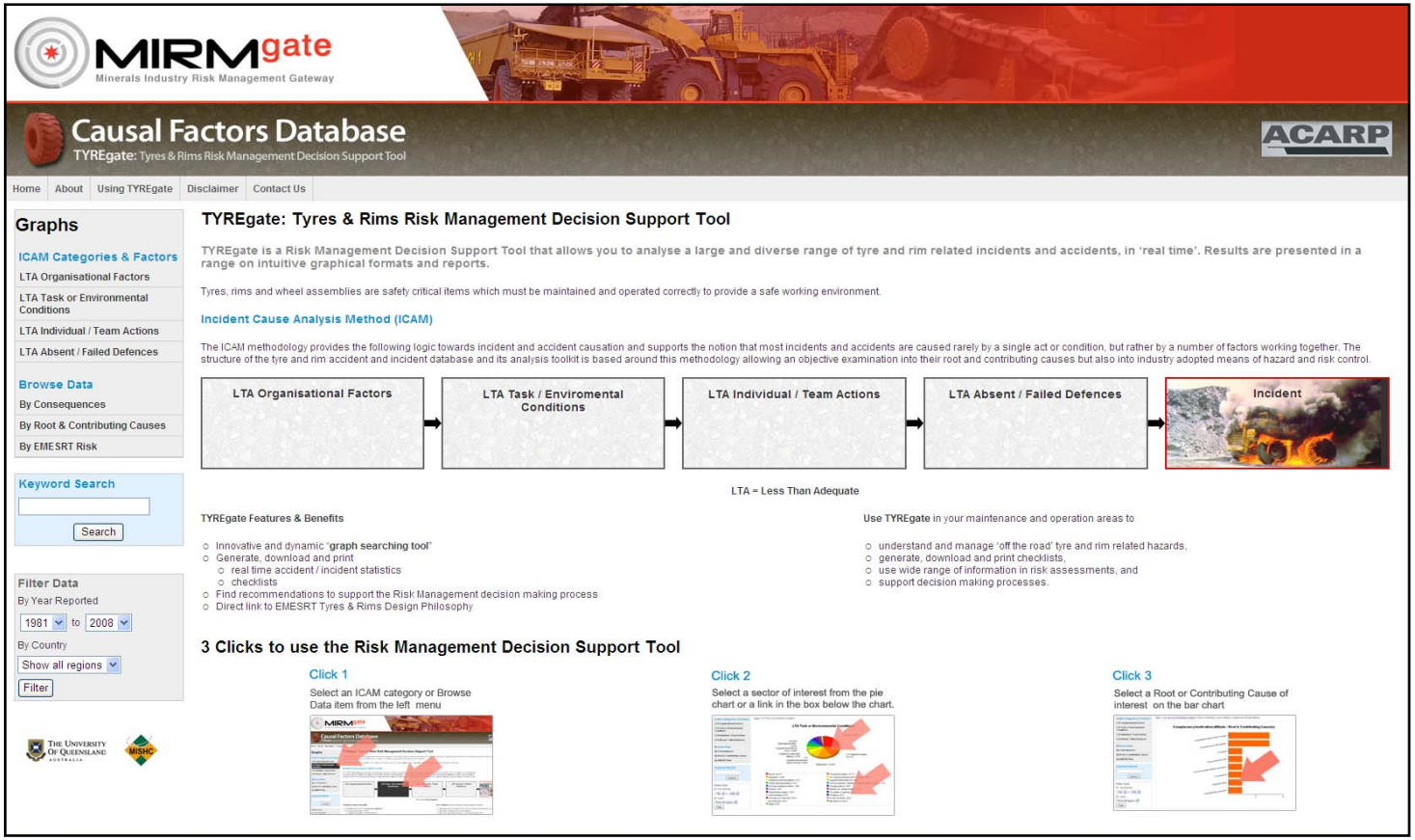


Figure 1-TYREgate Homepage

2.1 "3 Click" Approach (Visual Searching)

TYREgate aims to make searching for data easier by doing the hard work for its users. One of primary ways of doing this is through the graphical representation of data using Pie Charts and Bar Charts. These provide a general overview of the more significant potential failures and causal factors as categorised by the ICAM approach.

The "3 Click" approach is one of the more innovative features of TYREgate. Within 3 clicks, users are taken through a series of graphs displaying the key causal and contributing factors of tyres and rims related accidents and incidents in real time leading to a search result by answering the following questions:

What are my major risk factors? *(Click 1)*

Where can I find the cause of these factors? *(Click 2)*

Why did these specific accidents occur? *(Click 3)*

How can I mitigate the risks at my own operation? *(TYREgate Checklists)*

ICAM Categories are selected from the left hand side or from the flow chart as shown overleaf. "Click 1" searches a selected ICAM category and all incidents/accidents containing the ICAM category. Clicking on the image of the burning dump truck (Incident) gives a search result that contains a list of all the incidents in TYREgate Database. An example "3 Click" search is shown in *Figures 2-5*.

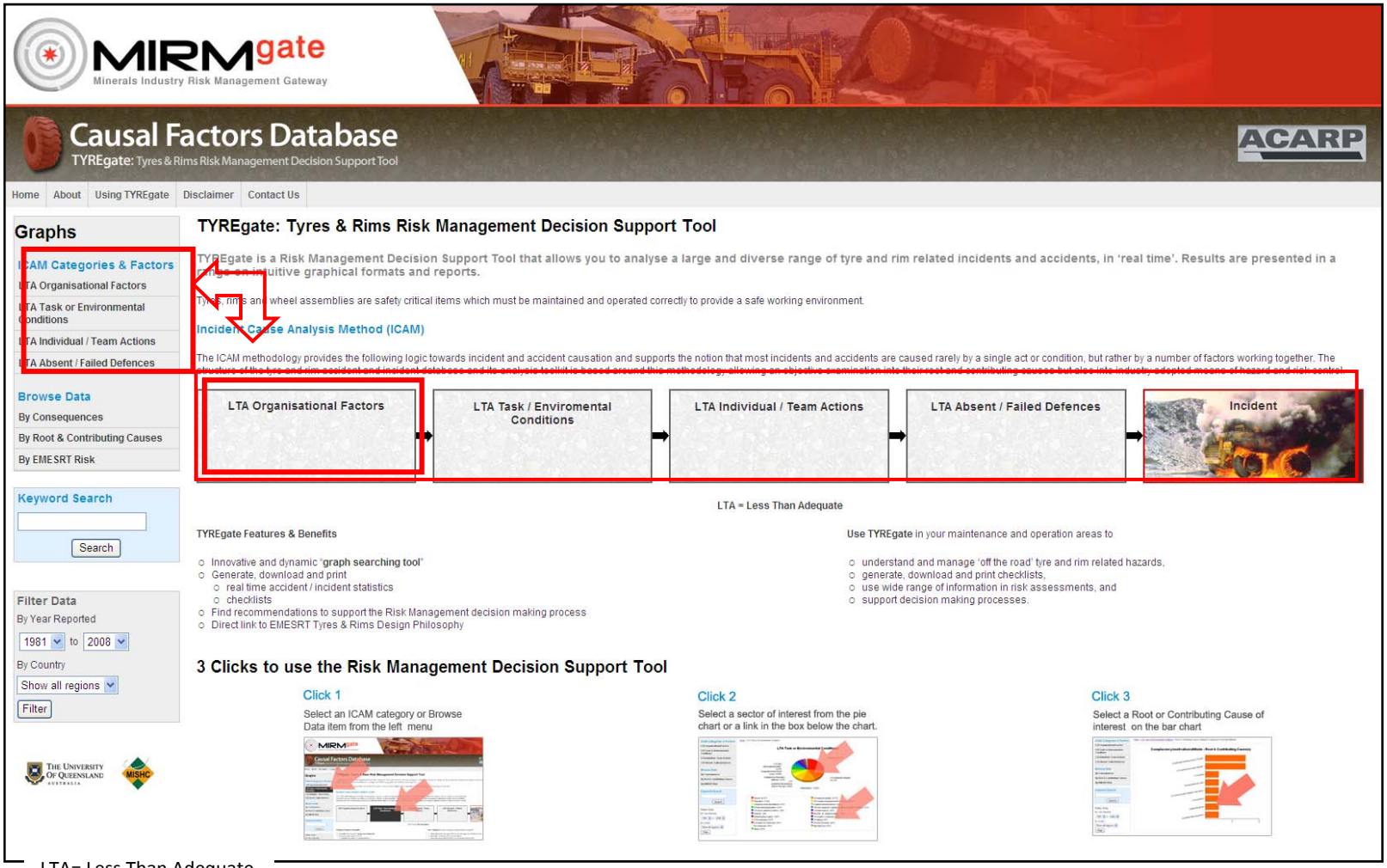
Click 1: In the example search, ***"LTA Organisational Factors"*** is selected as shown in *Figure 2*. This particular search leads into a dynamically created pie chart showing all relevant areas related to that ICAM category as shown in *Figure 3*.

Click 2: Clicking on the individual slices of the chart as shown in *Figure 3*, users then advance to root and contributing causes, displayed as a pareto graph.

Click 3: In the final step, the user is taken to the specific record of information about the accidents and incidents. Clicking on individual bars of the pareto graph, users are then (and only then) provided with detailed written information about the underlying causes of incidents and accidents.

What is covered: Searching through the graphical interface, Search results and Links to TYREgate Checklists & EMESRT content**.**

Click 1 - To begin your search you can start by selecting the ICAM Categories & Factors you are interested in:
LTA Organisational Factors, LTA Task/Environmental Conditions, LTA Individual / Team Actions and LTA Absent/Failed Defences.



LTA= Less Than Adequate

Figure 2-Click 1 ICAM Categories & Factors

Click 2 – Select a sector of interest from the pie chart or click on a link in the box below the chart.

The example search: The second click searches all **LTA Maintenance** incidents/accidents by clicking on a sector from the pie chart or clicking on a link in the box below the chart as shown in *Figure 3*.

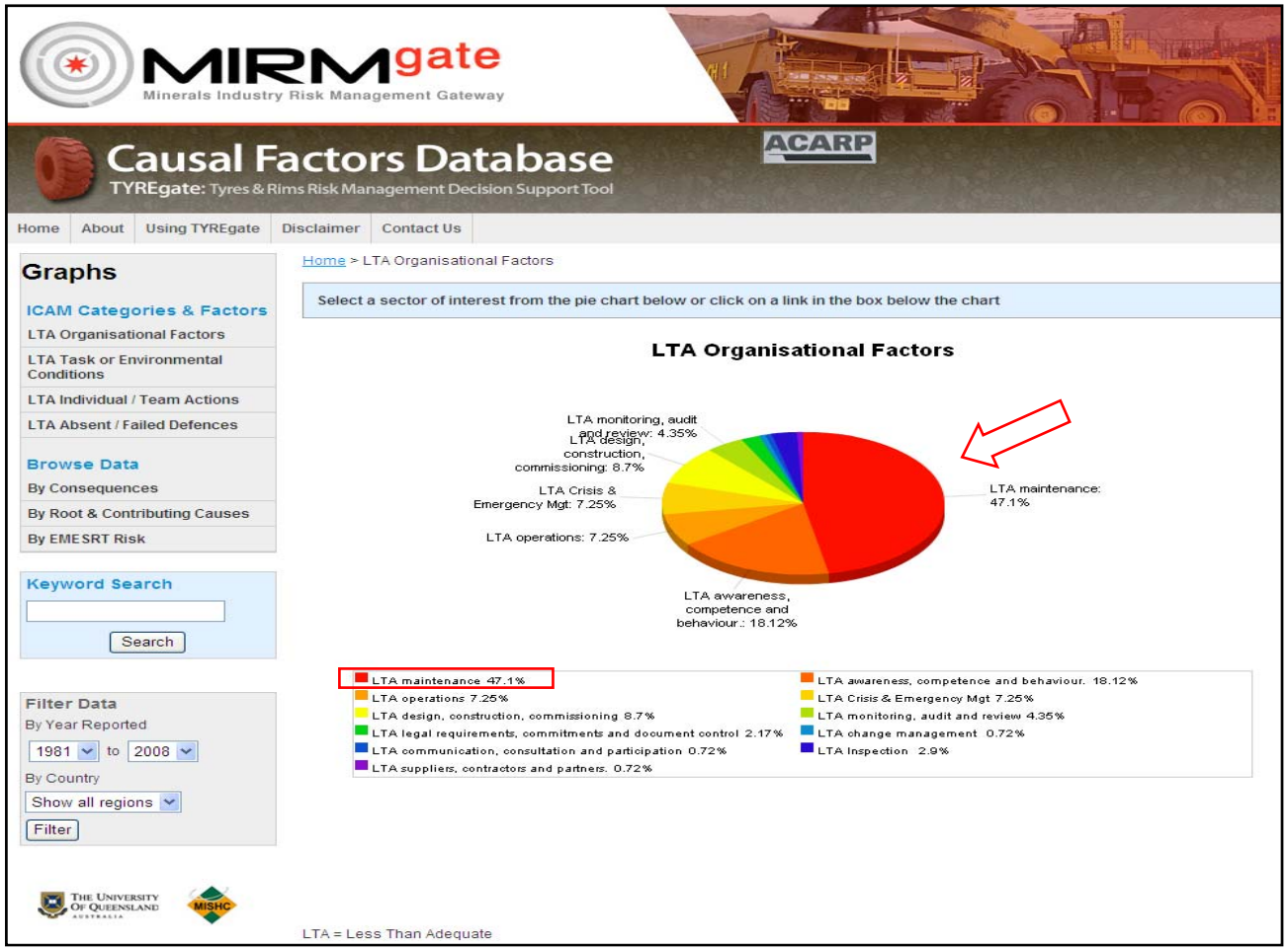


Figure 3-Click 2 Pie Chart

Click 3 – To view incident data, select a Root or Contributing Cause of interest on the bar chart

The example search: The third click searches all **LTA material testing/fatigue NDT** incidents/accidents by clicking on the Root or Contributing Cause of interest on the bar chart. See *Section 2.2* to review the search results page content.

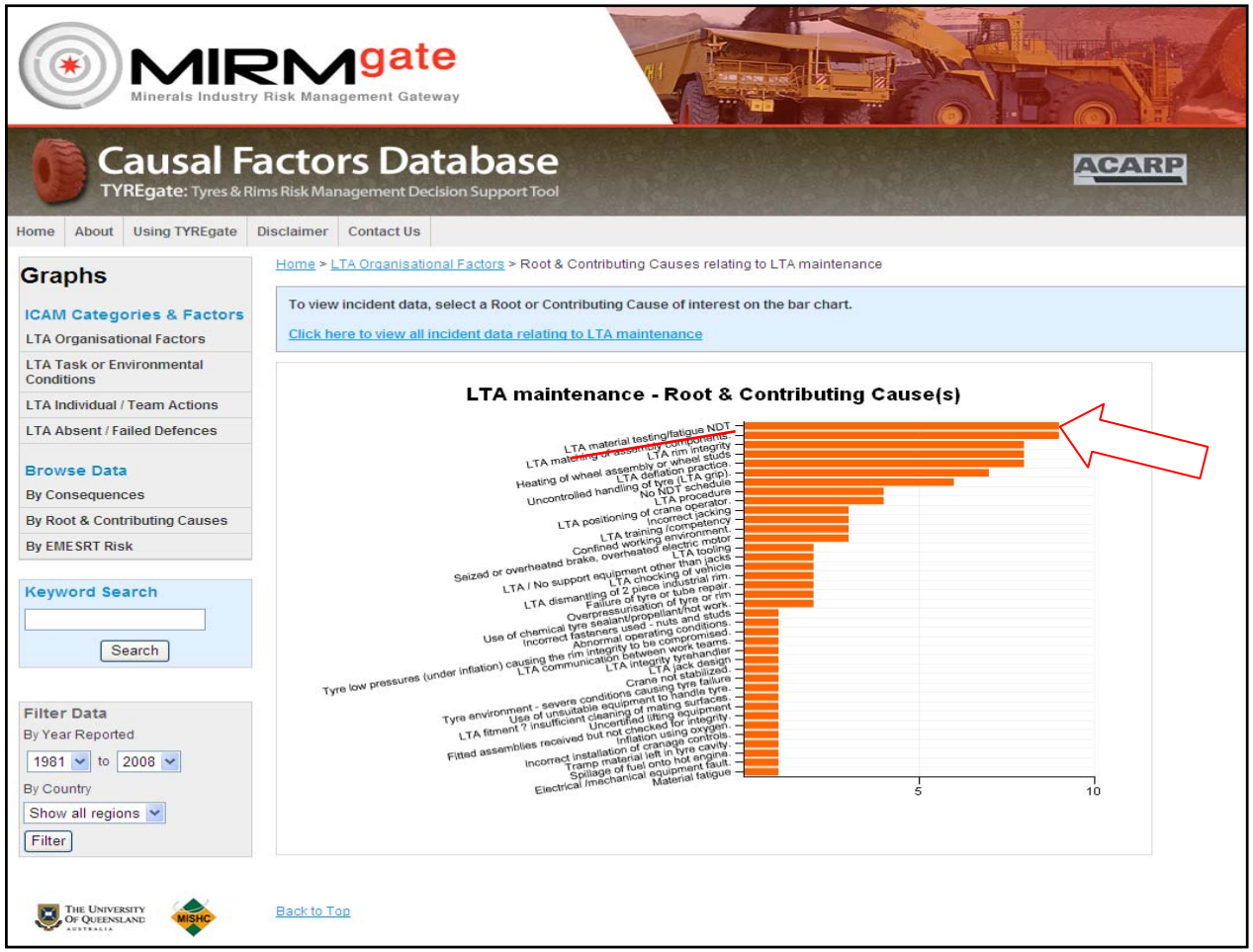


Figure 4- Click 3 Bar Chart

2.2 Search Results

An example search results page is shown in *Figure 5*. The results allow the users to access detailed information on accident / incident data including root and contributing causes of accidents and incidents. On the following page, an example search criteria used along with information about the number of records and date ranges (discussed under refining results) are highlighted. The search criterion that was used returned 9 incidents.

Search results also provide access to MIRMgate EMESRT *"Tires & Rims"* Design Philosophy and relevant TYREgate Checklist(s). Links to the DP and Checklists are briefly described in Section 2.2.1 and they are highlighted in *Figure 6*.

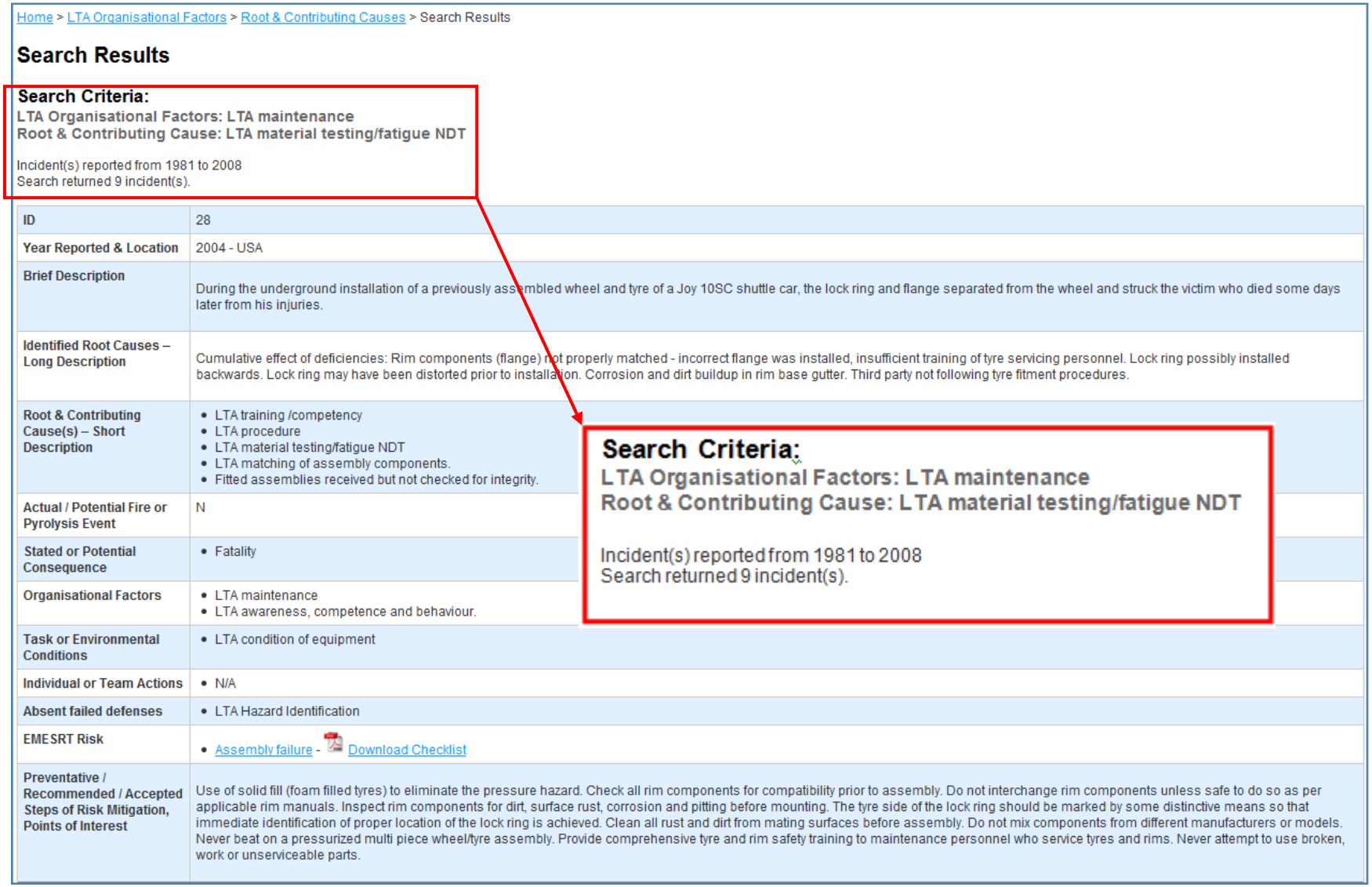


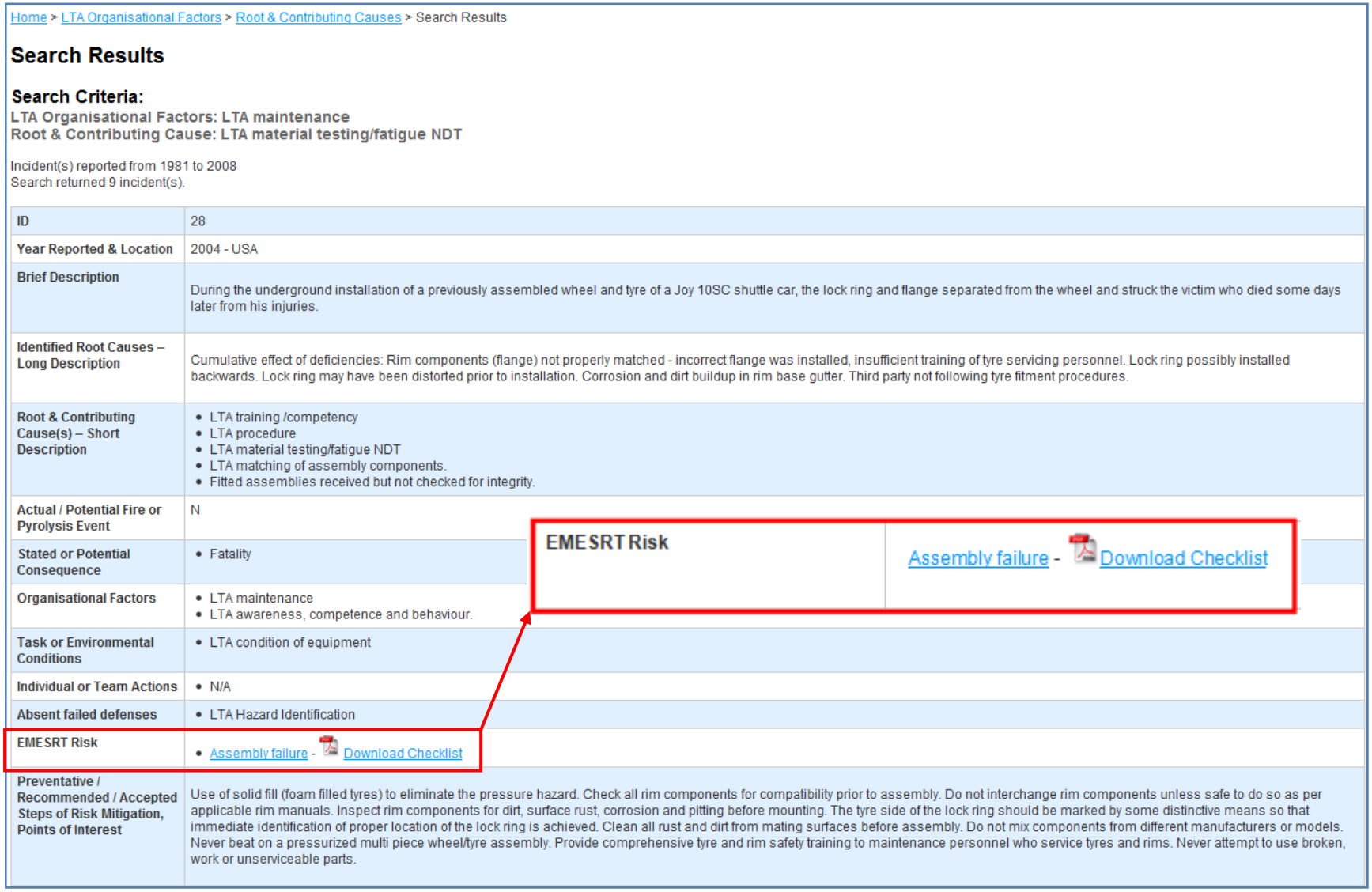
Figure 5-Search Results

2.2.1 “EMESRT Risk” and “TYREgate Checklist” Links

Also contained on the search results page are links to MIRMgate *“EMESRT Risk”* and *“TYREgate Checklist”*. The MIRMgate *“EMESRT Risk”* link allows users to gain more information on the subject and promotes integration between the two websites. “*TYREgate Checklists”* are useful tools in order to manage potential accidents. These can be accessed within the record shown on the following page.

The link on the left, *“Assembly failure”* leads into the MIRMgate EMESRT *“Tires & Rims”* Design Philosophy” while the link on the right “Download Checklist” allows a user to gain access to a Checklist.

Section 2.3 explains the link to DP 12, and Section 2.4 explains the *“TYREgate Checklists”*.



Home > LTA Organisational Factors > Root & Contributing Causes > Search Results

Search Results

Search Criteria:

LTA Organisational Factors: LTA maintenance
Root & Contributing Cause: LTA material testing/fatigue NDT

Incident(s) reported from 1981 to 2008
Search returned 9 incident(s).

ID	28
Year Reported & Location	2004 - USA
Brief Description	During the underground installation of a previously assembled wheel and tyre of a Joy 10SC shuttle car, the lock ring and flange separated from the wheel and struck the victim who died some days later from his injuries.
Identified Root Causes – Long Description	Cumulative effect of deficiencies: Rim components (flange) not properly matched - incorrect flange was installed, insufficient training of tyre servicing personnel. Lock ring possibly installed backwards. Lock ring may have been distorted prior to installation. Corrosion and dirt buildup in rim base gutter. Third party not following tyre fitment procedures.
Root & Contributing Cause(s) – Short Description	• LTA training /competency • LTA procedure • LTA material testing/fatigue NDT • LTA matching of assembly components. • Fitted assemblies received but not checked for integrity.
Actual / Potential Fire or Pyrolysis Event	N
Stated or Potential Consequence	• Fatality
Organisational Factors	• LTA maintenance • LTA awareness, competence and behaviour.
Task or Environmental Conditions	• LTA condition of equipment
Individual or Team Actions	• N/A
Absent failed defenses	• LTA Hazard Identification
EMESRT Risk	• Assembly failure - Download Checklist
Preventative / Recommended / Accepted Steps of Risk Mitigation, Points of Interest	Use of solid fill (foam filled tyres) to eliminate the pressure hazard. Check all rim components for compatibility prior to assembly. Do not interchange rim components unless safe to do so as per applicable rim manuals. Inspect rim components for dirt, surface rust, corrosion and pitting before mounting. The tyre side of the lock ring should be marked by some distinctive means so that immediate identification of proper location of the lock ring is achieved. Clean all rust and dirt from mating surfaces before assembly. Do not mix components from different manufacturers or models. Never beat on a pressurized multi piece wheel/tyre assembly. Provide comprehensive tyre and rim safety training to maintenance personnel who service tyres and rims. Never attempt to use broken, work or unserviceable parts.

Figure 6- Links to *"EMESRT Risk"* and *"TYREgate Checklist"*

2.3 Link to MIRMgate EMESRT *"Tires and Rims"* Design Philosophy

The *"EMESRT Risk"* hyperlink connects with the MIRMgate EMESRT *"Tires and Rims"* Design Philosophy (DP) (http://www.mirmgate.com/emesrt.asp). The search example shows the MIRMgate EMESRT *"Tires and Rims"* DP and *"EMESRT Risk"*, *Assembly failure*, linkage.

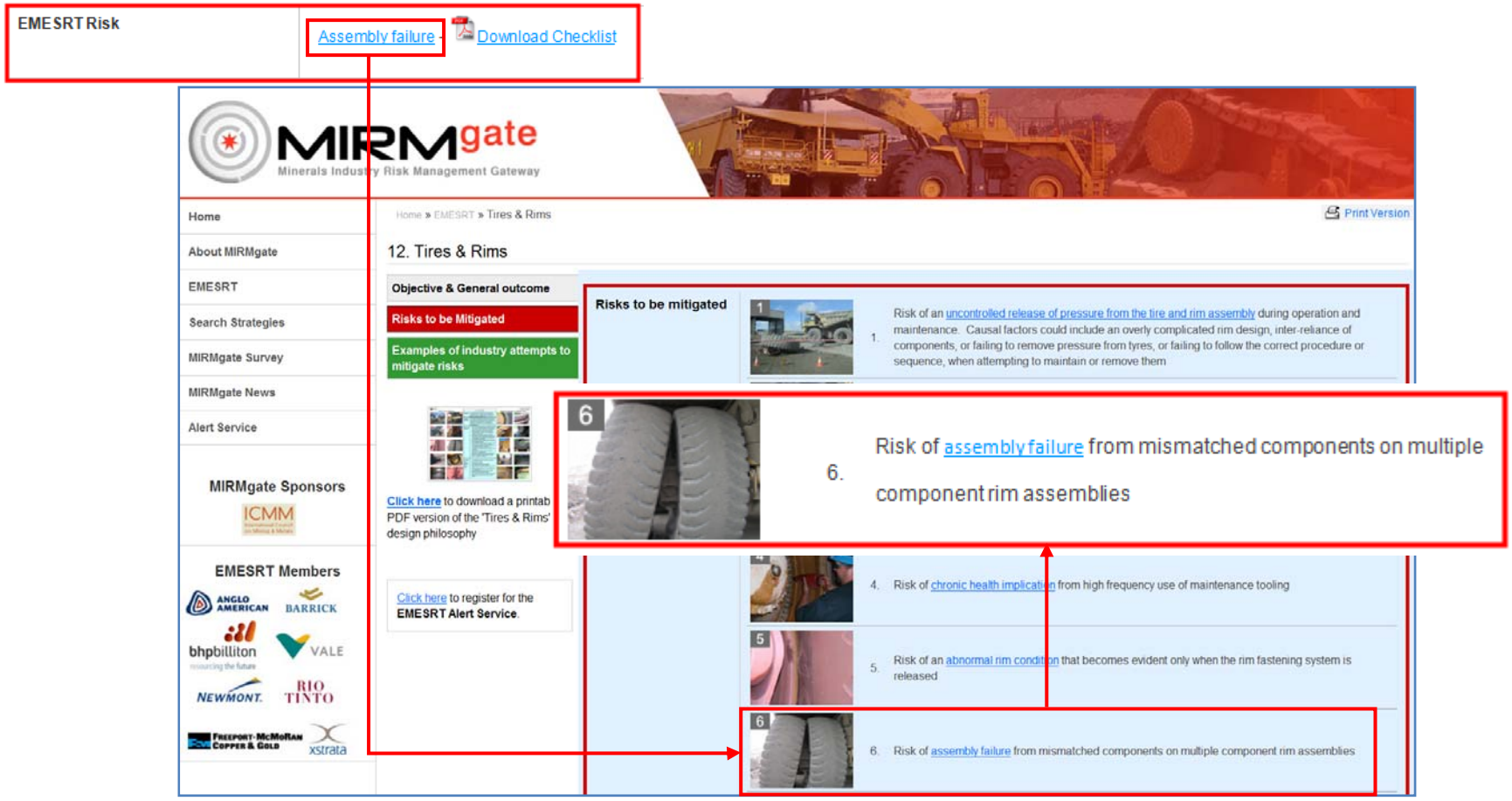


Figure 7-MIRMgate EMESRT Tires and Rims Design Philosophy

2.4 TYREgate Checklist

The *"TYREgate Checklist"* contains *"Root and Contributing Causes and Preventative, Recommended and Accepted Steps of Risk Mitigation, Points of Interest"* and information relevant to specific incidents. The Checklists will assist the users to identify if issues and industry adopted solutions exist within their workplace. The *"Download Checklist*" hyperlink links to a *"TYREgate Checklist"* containing all TYREgate incidents with the same EMESRT Risk (eg. Assembly Failure).

Figure 8-Download Checklist link

An example Checklist is shown overleaf in *Figures 9-11*.

TYREgate Checklist example

EMERST Risk: Assembly failure *TYREgate: Tyres & Rims Risk Management Decision Support Tool - www.mirmgate.com/tyregate*

ID	Root & Contributing Causes	Preventative / Recommended / Accepted Steps of Risk Mitigation, Points of Interest	Site Answers & Comments
3	- LTA matching of assembly components.	All components were new and free from defect. The lock ring had no markings of identification, size or fitting instruction. The tyre fitter had recently received instruction in tyre assembly from an international tyre company. Most lock rings fail safely as they cannot be retained in the lock ring groove 'the wrong way around' or they 'peel out' at very low pressures. A new type of lock ring bearing the warning 'Do not inflate wrong way around' has been located. Safety Alert Number 78 was issued in May 1995 and recounted a very similar story. If we do not learn from mistakes we are doomed to repeat them.	
28	- LTA training /competency - LTA procedure - LTA material testing/fatigue NDT - LTA matching of assembly components. - Fitted assemblies received but not checked for integrity.	Use of solid fill (foam filled tyres) to eliminate the pressure hazard. Check all rim components for compatibility prior to assembly. Do not interchange rim components unless safe to do so as per applicable rim manuals. Inspect rim components for dirt, surface rust, corrosion and pitting before mounting. The tyre side of the lock ring should be marked by some distinctive means so that immediate identification of proper location of the lock ring is achieved. Clean all rust and dirt from mating surfaces before assembly. Do not mix components from different manufacturers or models. Never beat on a pressurized multi piece wheel/tyre assembly. Provide comprehensive tyre and rim safety training to maintenance personnel who service tyres and rims. Never attempt to use broken, work or unserviceable parts.	
41	- LTA matching of assembly components.	Employees undertaking tyre fitting work must be given adequate instruction and training as per relevant mining acts and regulations. Persons engaged in tyre fitting work must ensure the tyre being fitted is the correct size and compatible with the rim. All light vehicle or industrial tyres that have just been mounted onto a rim must be inflated inside a tyre cage. Personnel should stand to one side of the wheel during inflation. During inflation process, the tyre pressure should be regularly monitored using a suitable pressure gauge. Tyres must never be inflated beyond manufacturers` recommendations. Damaged tyres that are no longer serviceable should be discarded and not reused.	
42	- LTA rim integrity - LTA material testing/fatigue NDT	It is unsure what exact root causes caused the failure of the bead seat band, however as a precaution the following steps are recommended: 1. Closely inspect all rim components prior to assembly for suitability, cracks, damage, deformation and corrosion. If in doubt consult with a supervisor or the original equipment manufacturer to check safety and serviceability of the componentry. 2. Always ensure that all rim components are fitted correctly and rim assembly integrity is assured. 3. Never stand in the trajectory zone (i.e. in front of a tyre and rim assembly) while it is being inflated. Either use a certified inflation cage, or use a 3 m long inflation line as per SWP and stand well away from the tyre. 4. While the assembly is being inflated check seating of all componentry for proper seating, and stop/dump all the air if a problem is identified. 5. Ensure all your rim bases and components are tracked and nondestructively tested as per industry Standards.	
51	- LTA matching of assembly components.	COMMENTS AND PREVENTATIVE ACTION Care must be exercised when assembling rims and tyres provided with a split lock ring. Particular attention must be given to: i) The removal of rust and other foreign matter from the rim and the split lock ring before assembly. ii) The application of recommended lubricant on the rim or tyre bead to reduce friction between tyre and rim. iii) Partial inflation of tyre and inspection of the degree of fit between tyre and locking ring. iv) Full inflation of tyre to manufacturer`s specification, in a tyre cage, and further inspection of degree of fit between tyre and split locking ring before removal from cage.	

Figure 9-Example Checklist 1st page

TYREgate Checklist example continued…

EMERST Risk: Assembly failure *TYREgate: Tyres & Rims Risk Management Decision Support Tool - www.mirmgate.com/tyregate*

ID	Root & Contributing Causes	Preventative / Recommended / Accepted Steps of Risk Mitigation, Points of Interest	Site Answers & Comments
55	- LTA training /competency - LTA procedure - LTA matching of assembly components.	Recommendations Two areas of concern identified were the fitting of the tyre and installation of the wheel onto the axle. Attention must be given to: 1. The provision of suitable equipment and a safe system of work to remove and fit the tyre to the rim. Suitable equipment should include a tyre cage, tyre pressure gauge in the airline, soft headed hammer (not steel), suitable rim cleaning equipment and a chart that provides details of tyre-rim compatibility. 2. Whenever a tyre is replaced, rims must be inspected for defects such as rust, distortions, cracks and imperfections before a new tyre is fitted. 3. Wheels must be placed into a restraining device (safety cage) before inflation. 4. The person inflating the tyre must stand to the side of the wheel in a safe position, and not in the trajectory line of the split ring. Note the diagrams below. 5. The airline should incorporate a hand piece with gauge and be a sufficient distance from the valve stem attachment so the fitter is in a safe position while inflating the tyre, should the split ring part with the wheel. 6. Inflation should be undertaken in stages, not more than 70kpa (10psi) at a time. (While AS 4457-1997 does not apply to these rims it is recommended initial inflation should be nominally 35kpa.) The ring should then be checked for correct seating. 7. When fitting the wheel to the axle hub, the fitter should not sit or crouch in the unprotected trajectory line of the split ring. 8. Always consider the trajectory line of the split ring components and rim during any stage of dismantling, re-assembling and fitting of wheels to a vehicle. DON`T be unprotected and in the path at any stage. NEVER allow an untrained unsupervised person to undertake the fitting of tyres to a split ring rim.	
59	- LTA rim integrity	As a precaution the following steps are recommended: - Closely inspect all rim components prior to assembly for suitability, cracks, damage, deformation and corrosion. If in doubt consult with a supervisor or the original equipment manufacturer to check safety and serviceability of the componentry. - Always ensure that all rim components are fitted correctly and rim assembly integrity is assured. - Never stand in the trajectory zone (i.e. in front of a tyre and rim assembly) while it is being inflated. Either use a certified inflation cage, or use a 3 m long inflation line as per SWP and stand well away from the tyre. - While the assembly is being inflated check seating of all componentry for proper seating, and stop/dump all the air if a problem is identified. - Ensure all your rim bases and components are tracked and nondestructively tested as per industry Standards.	
62	- LTA matching of assembly components.	- Do NOT install a light truck tire on an industrial wheel - if in doubt, stop and consult with the tyre manufacturer. - Always check vehicle OEM specifications on correct tyre size and type recommended for mounting to a vehicle rim/wheel. - Ensure bead angle of the tyre will be compatible with the bead angle of the rim/wheel.	
82	- LTA rim integrity - LTA matching of assembly components.	If the tyre assembly is to be used for Underground Service, then replace the Lock Ring at each Tyre Change to ensure safety. For Surface Service, replace Lock Rings in accordance with Site Specific Safe Operating Procedures (SOP) or when wear, rust, pitting and or damage is evident. All Rim Bases must be NDT tested (non destructive testing) in accordance with site specific SOP. Clean rim parts of all foreign matter taking special care around bead seating areas and inspect for wear, rust, cracks or damage Apply rust inhibiting primer to the rim, in accordance with site SOP`s as necessary. Check that all rim parts to be assembled are of the same manufacturer, are of the same size and specification and are properly matched. If unsure do not proceed! If doubt exists as to the suitability for continued service, identify (by marking clearly) the areas of concern, tag the item `out of service` and notify your supervisor. The mismatching of rim components and the use of unserviceable components can lead to extremely hazardous incidents, causing severe damage, injury or death. Unserviceable rim components must be destroyed i.e. cut with HOT TORCH.	

Figure 10-Example Checklist 2nd page

TYREgate Checklist example continued…

EMERST Risk: Assembly failure *TYREgate: Tyres & Rims Risk Management Decision Support Tool - www.mirmgate.com/tyregate*

ID	Root & Contributing Causes	Preventative / Recommended / Accepted Steps of Risk Mitigation, Points of Interest	Site Answers & Comments
93	- LTA procedure - LTA dismantling of 2 piece industrial rim. - Incorrect fasteners used - nuts and studs	Short term Controls: - Attach information tags to rims adjacent to wheel struts "Tyres must be deflated and valve stems removed before removing wheels" on forklifts fitted with split rims. - Only use contractors who hold the competency – MNCG1031A "Remove, fit and adjust Wheels" to repair and refit tyre/wheel assemblies for all equipment used on site. - Reinstate all forklift wheels to OEM specifications. Long Term Controls - Identify alternate rims/tyre types for forklifts to eliminate the exposure associated with slit rims (solid tyres are available for all forklift sizes) - Audit all mobile plant and equipment on site to identify other equipment that may be fitted with split rims.	

Date Printed: Tuesday 10th of February 2009 04:47:46 AM

Figure 11-Example Checklist 3rd page

3. Browse Data in *"3 Clicks"*

The "Browse Data" menu allows the user to search by *Consequences*, *Root and Contributing Causes* and *EMESRT Risk*. Searches are also conducted using the *"3 Click"* approach discussed above.

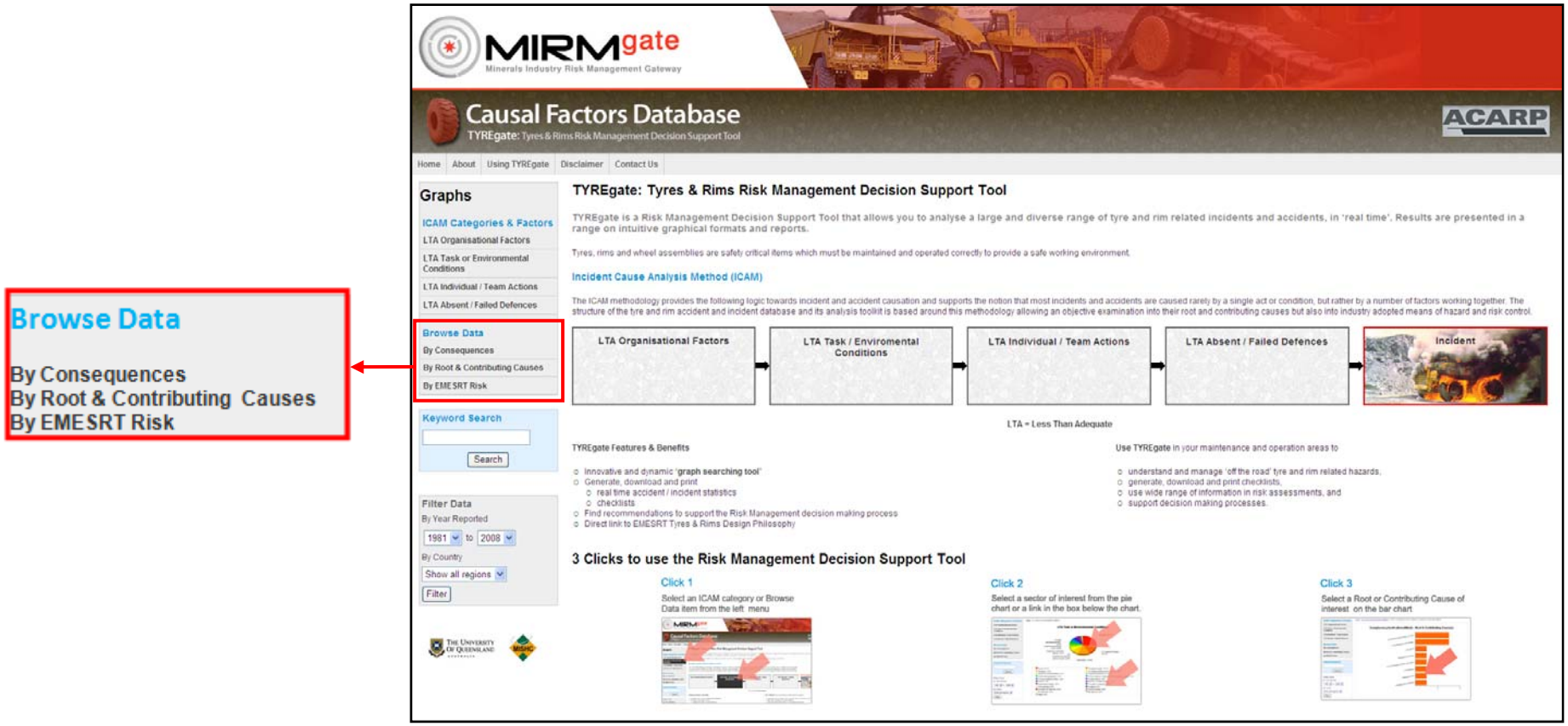


Figure 12-Browse Data Option

3.1 Browse by Consequences

Browsing data *'By consequences'* allows users to understand the risk factors involved in the occurrence of an accident where the final outcomes can be quite serious. This can allow tyre maintenance and management personnel, Original Equipment Manufacturers (OEMs) and the general mining community worldwide to implement strategies to reduce the risks of the more common root or contributing causes that may lead to the potential accidents.

An example search is shown below. To browse data by consequence click on *'By consequences'* below the Browse data heading, see *Figure 13*.

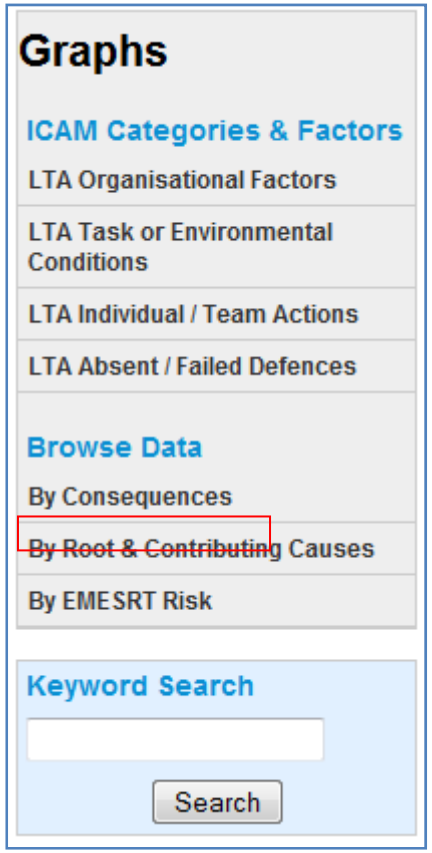


Figure 14--Browse by Consequences

Search by selecting the relevant consequence from the pie chart or the text in *Figure 14*.

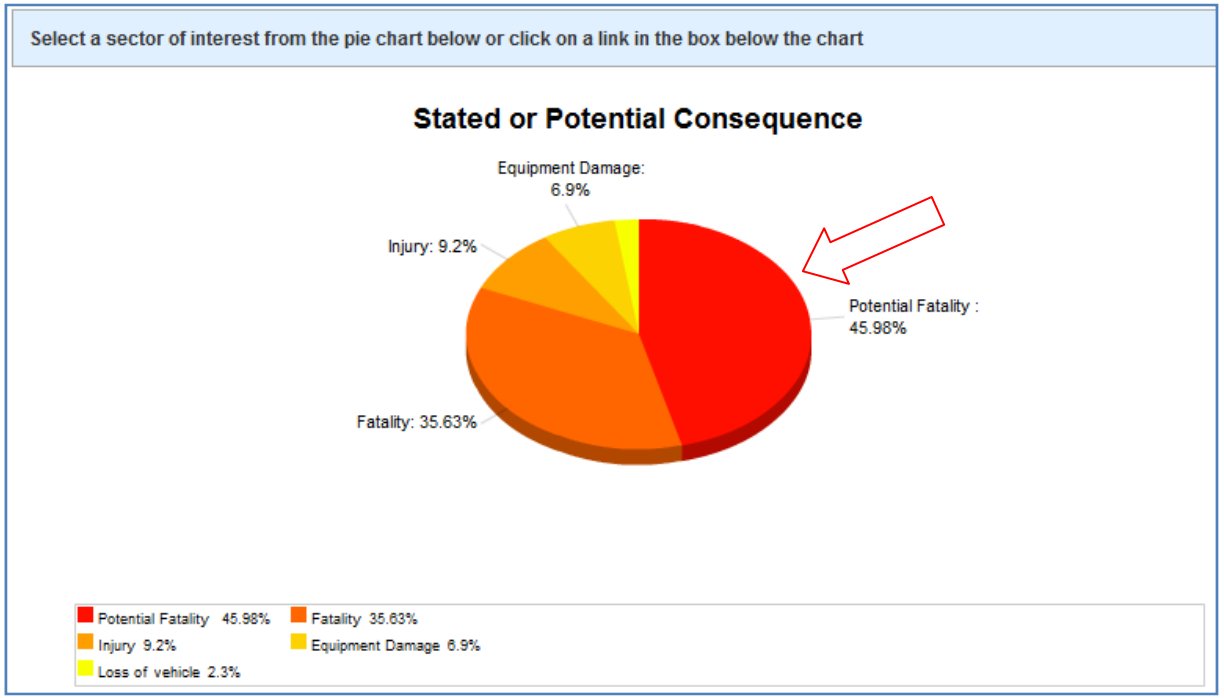


Figure 13-Stated or Potential Consequences

Search by selecting relevant root and contributing causes from the bar chart, see Figure 15.

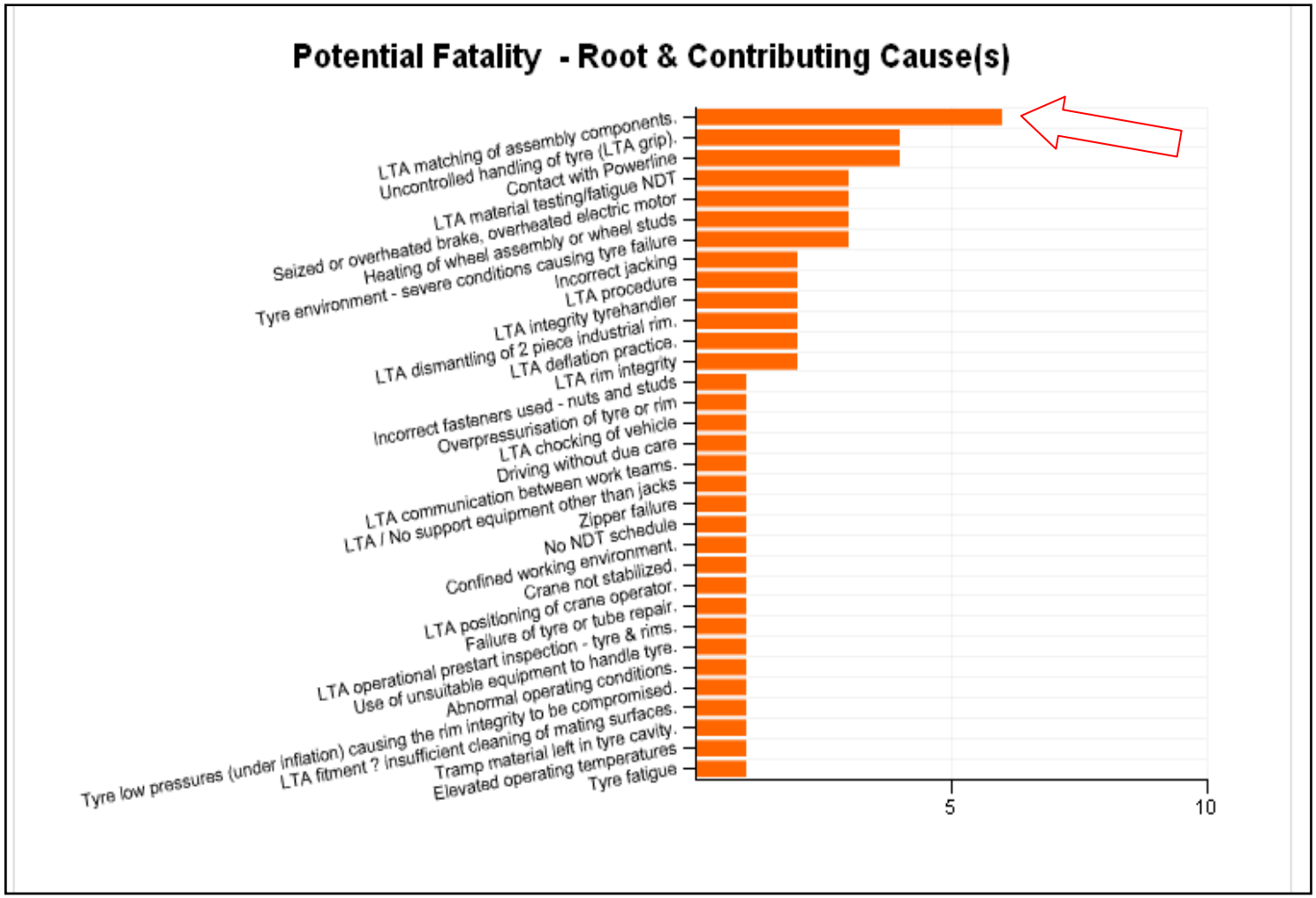


Figure 15- Root & Contributing Causes

3.2 Browse by Root or Contributing Causes

Browsing data *'By Root or Contributing Causes'* allows users to filter results by the accidents cause. This allows easy identification of highly occurring causes that can be mitigated using the checklists. An example search is shown below. To browse data by causes click on *'By Root & Contributing Causes'* below the Browse Data heading, see *Figure 16*.

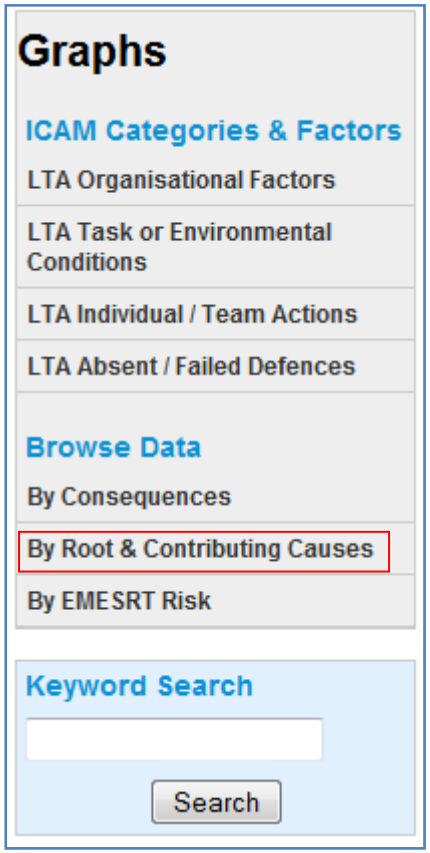


Figure 16-Browse by Root & Contributing Causes

Search by selecting relevant 'root and contributing causes' from the pie chart or the text in the box below, see *Figure 17*.

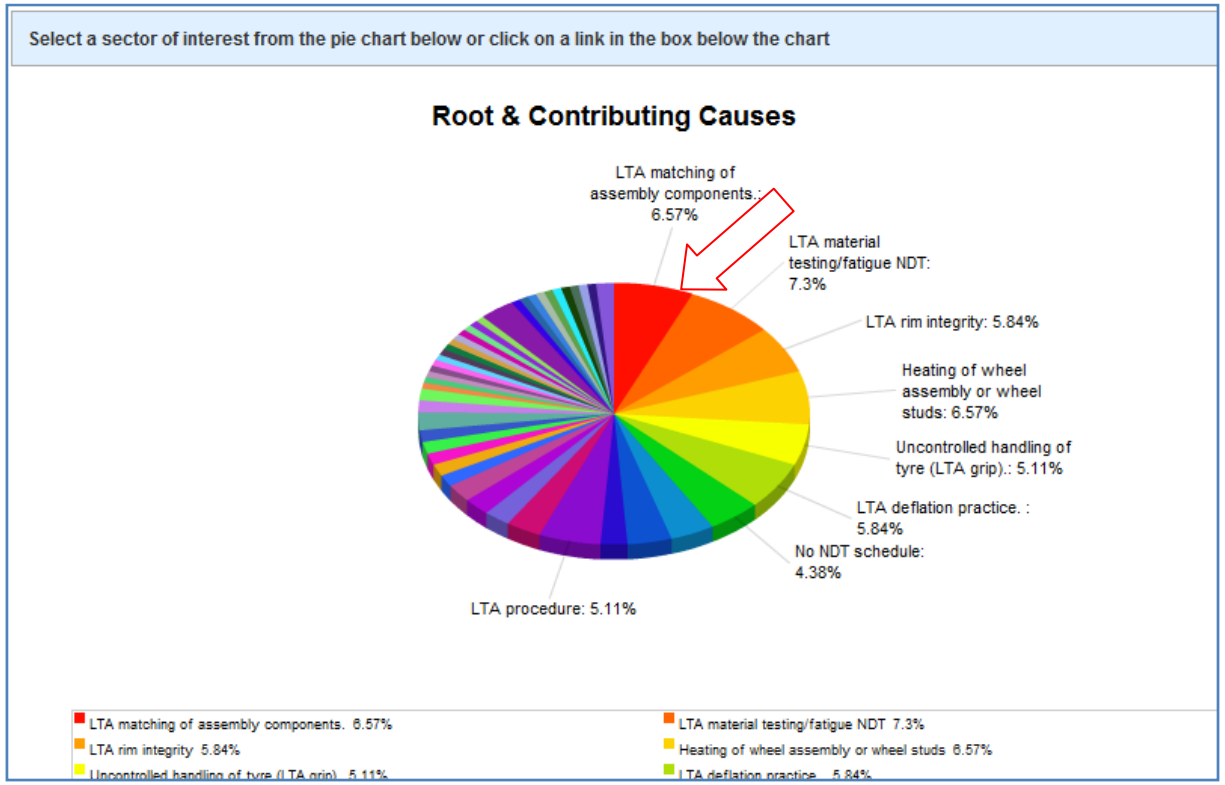


Figure 17-Root & Contributing Causes

3.3 Browse by EMESRT Risk

The Earth Moving Equipment Safety Round Table (EMESRT) was formally established in 2006 by a group of major mining companies from around the world. The goal of EMERST is to accelerate development and adoption of leading practice designs for earth moving equipment to minimise the risk to Health and Safety through a process of Original Equipment Manufacturers (OEM) and user engagement. EMERST forms an integral part of MIRMgate and the TYREgate database has developed to provide seamless integration with the EMERST *"Tyres & Rims"* Design Philosophy. To browse data by EMESRT Risk, click on *'By EMESRT Risk'* below the Browse data heading, see *Figure 18.*

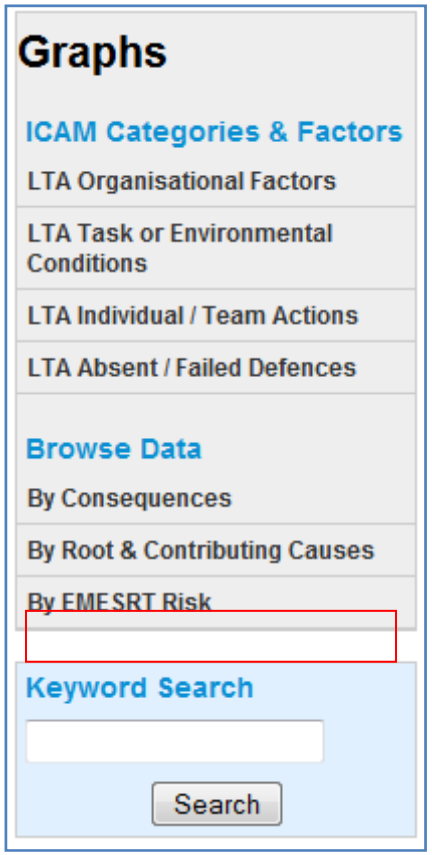


Figure 19-Browse by EMESRT Risk

Search by selecting relevant 'EMESRT Risks' from the pie chart or the text in the box in *Figure 19*.

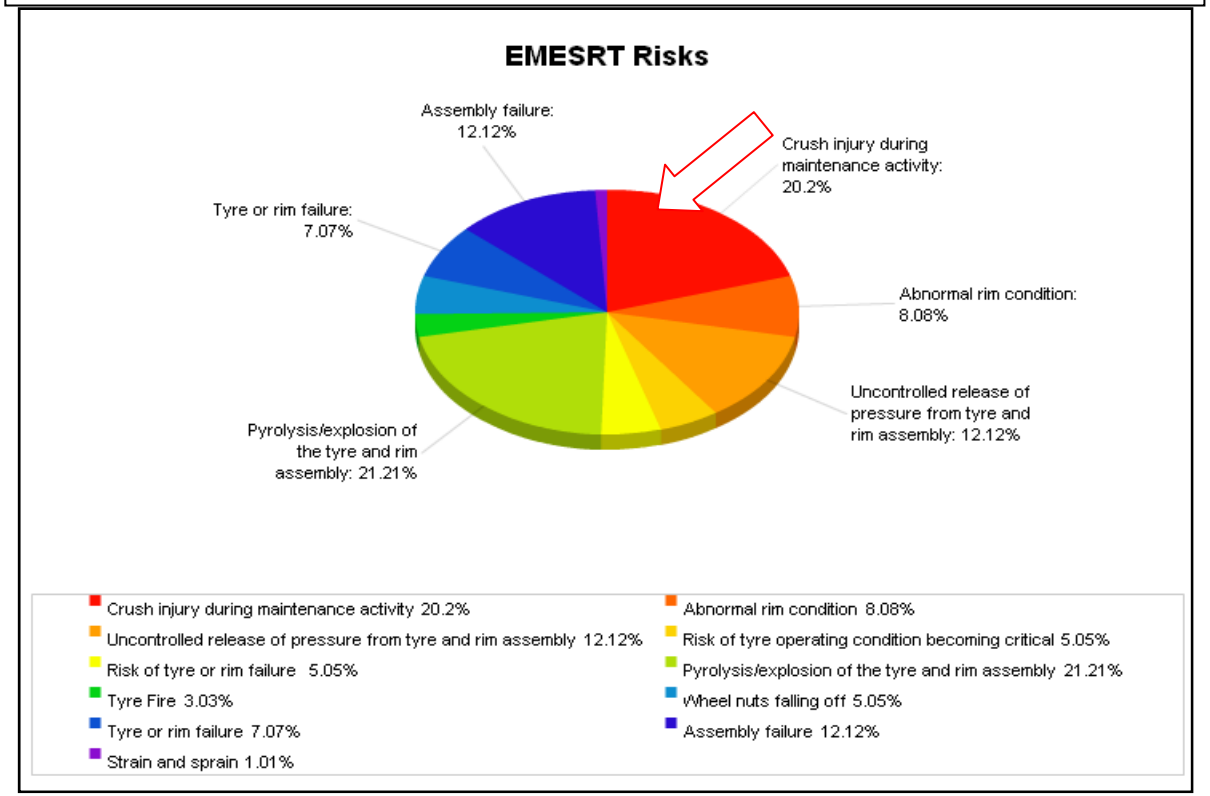


Figure 18-EMESRT Risk

Browsing by EMESRT Risk allows you to download and print charts and Checklists, see *Figure 20*.

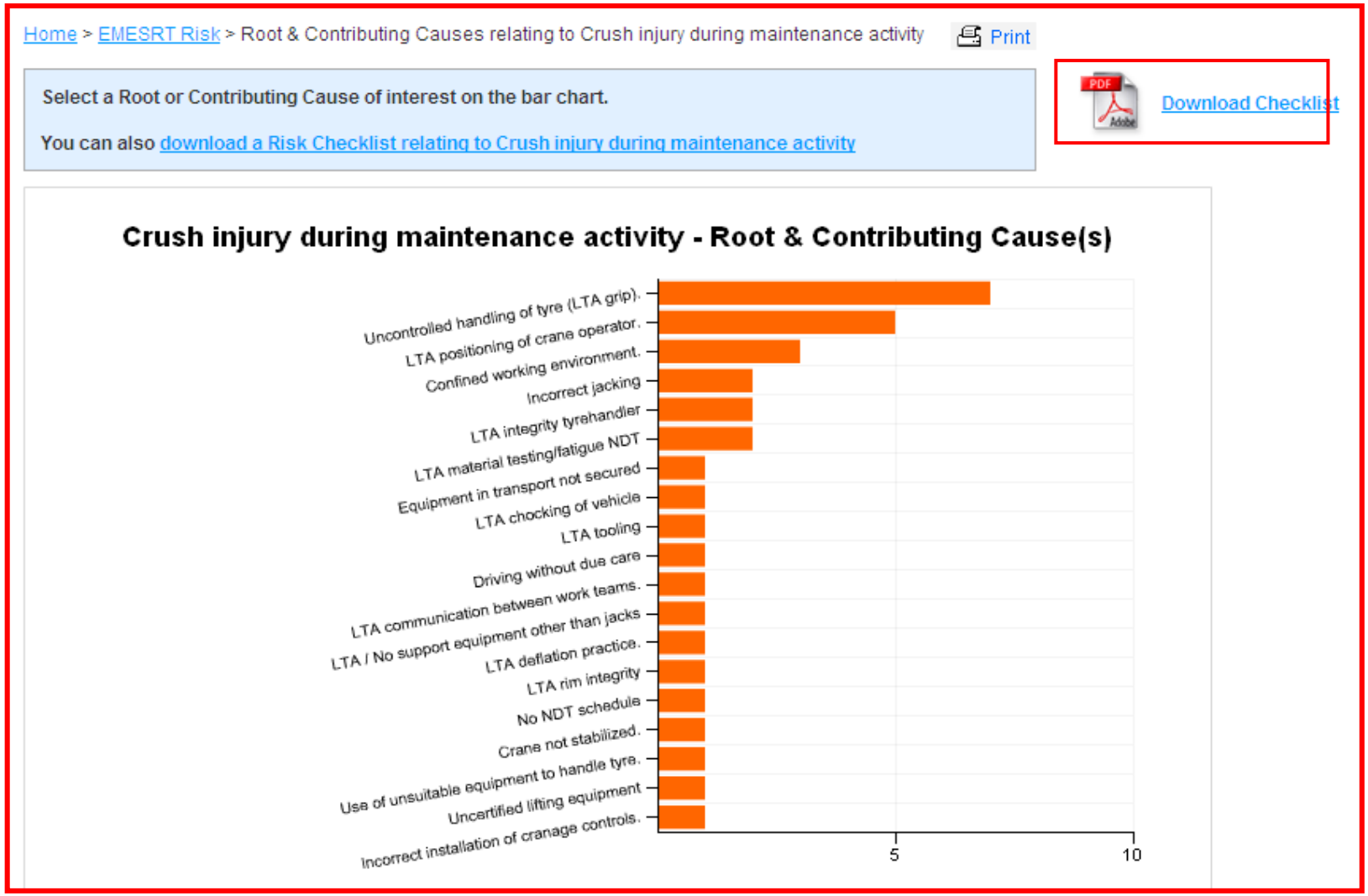


Figure 20-Download Checklist

4. Keyword Search and Advanced Search Techniques

TYREgate can be searched by conventional Keyword Search techniques.

The search results that appear following the *"3 Click"* approach, Browse data options or Keyword search can also be further searched or refined and expanded in a number of ways. These are explained below.

What is covered: Keyword Search, Advanced Keyword Search, Refine Search and Filter data by Year and / or Country.

4.1 Keyword Search

Along with the graphical search engine, data can be searched through keywords. The keyword search textbox is located in the left hand menu bar as demonstrated below.

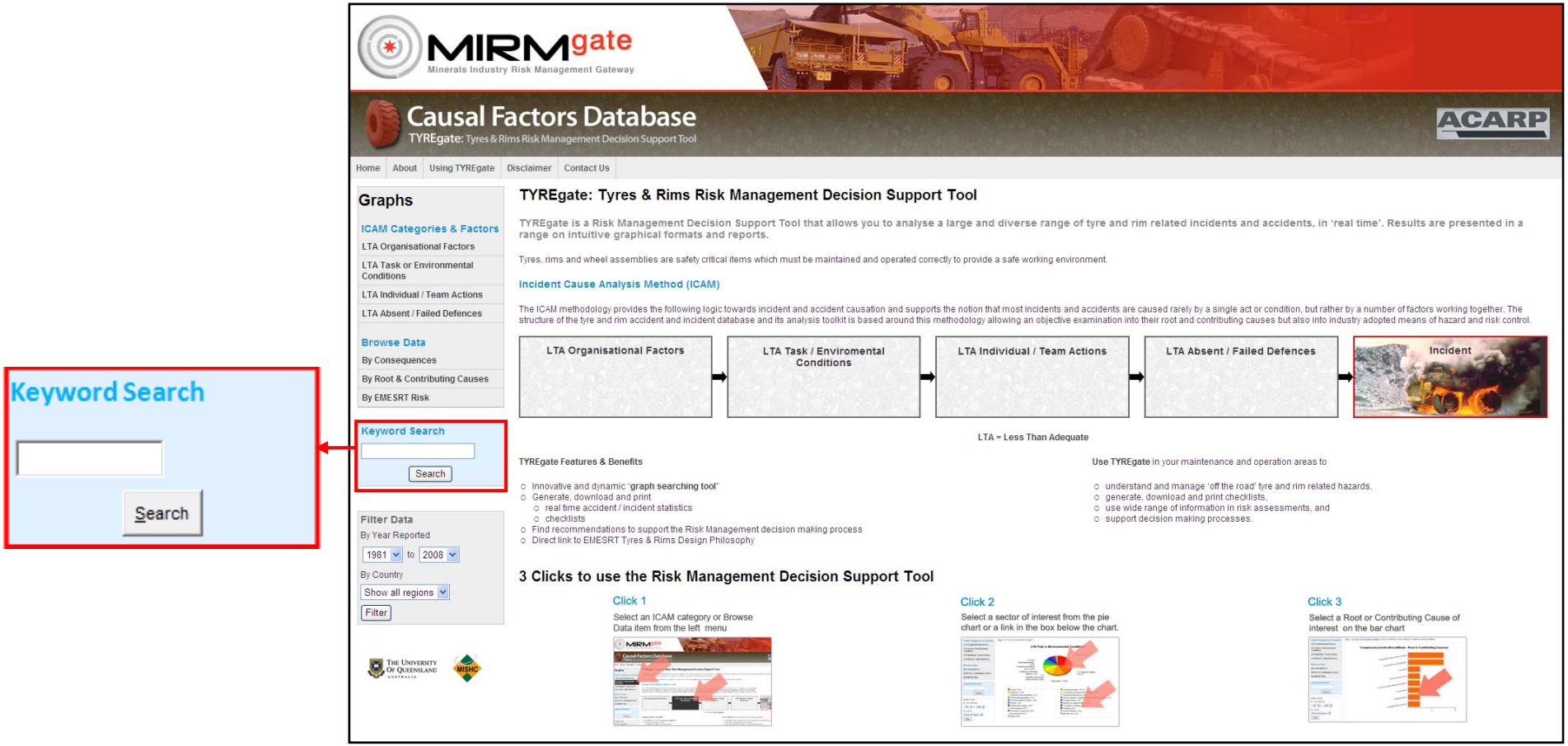


Figure 21- Keyword Search

4.2 Unique "Advanced Keyword Search" option

When the user is presented with search results, the user is provided with an option to refine the search results by using the "Advanced keyword search" functionality. This is another unique TYREgate feature that allows the users to refine their current search results by selecting ***"Search current data results"*** and using keywords of interest (*see Figure 23*). *"Search all incident data"* still functions as the conventional "Keyword search" and allows the user to search all the data provided by TYREgate (*see Figure 22*).

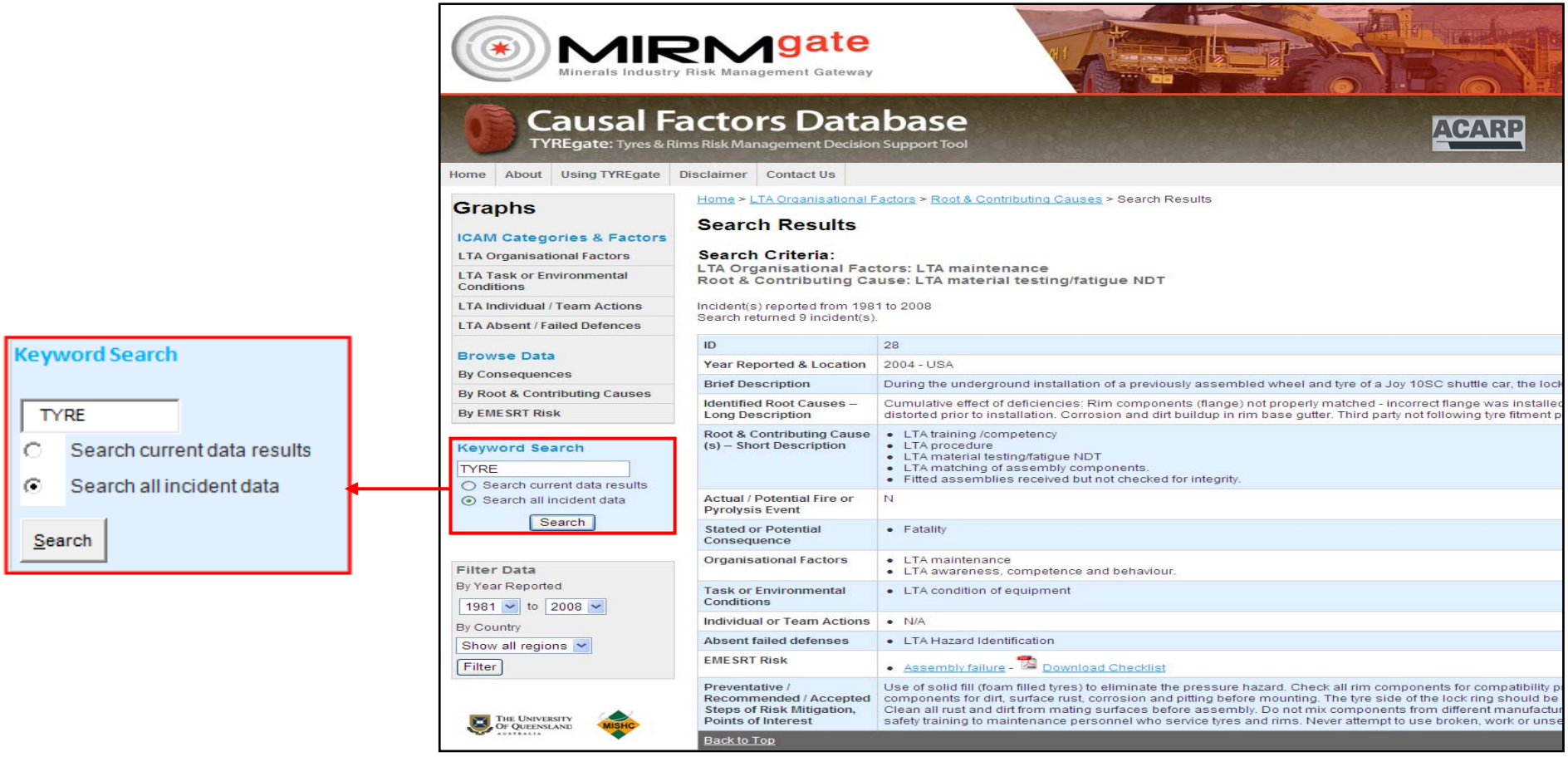


Figure 22- TYREgate Search Results page: "Advanced Keyword Search" all incident data

The following example (*Figure 23*) shows a refinement of results from a previous search.

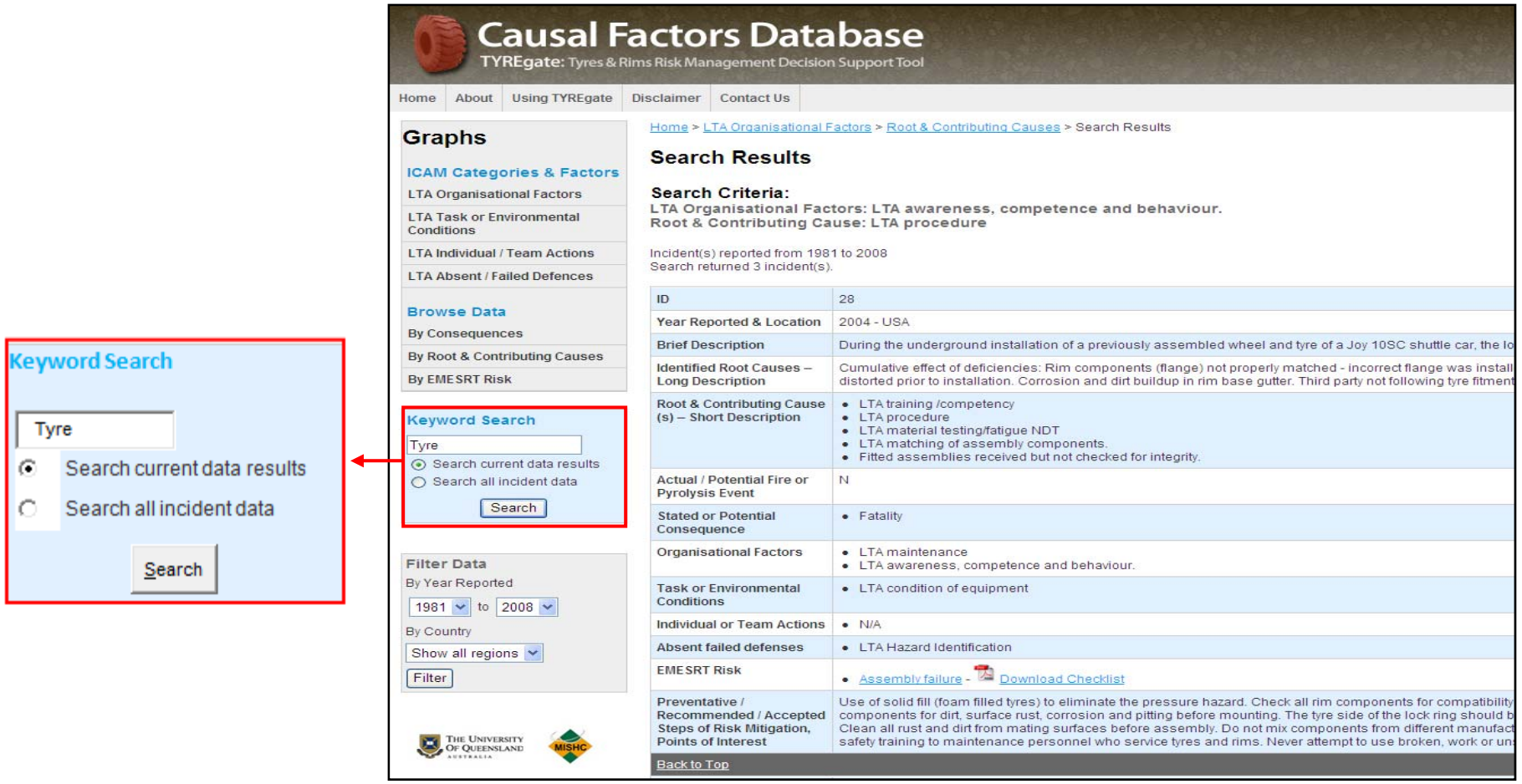


Figure 23- TYREgate Search Results page: "Advanced Keyword Search" current results

4.3 Refine Search

TYREgate offers a range of synonyms and related terms**.** The terms list provides a way to further refine the data or to expand TYREgate search process.

Users can select from the list of ***"synonyms and / or related terms"*** given in an extended text box on top of the search results thereby allowing refinement or expansion of previous searches as shown in *Figure 24*. Once related term(s) have been checked, a search will encompass selected related terms allowing refined results to appear. The example below shows a keyword search for *"Tyre"* which can have many different related terms. Related terms *"rim"*, *"wheel"*, and *"assembly"* have been selected and the results are shown in Figure 25.

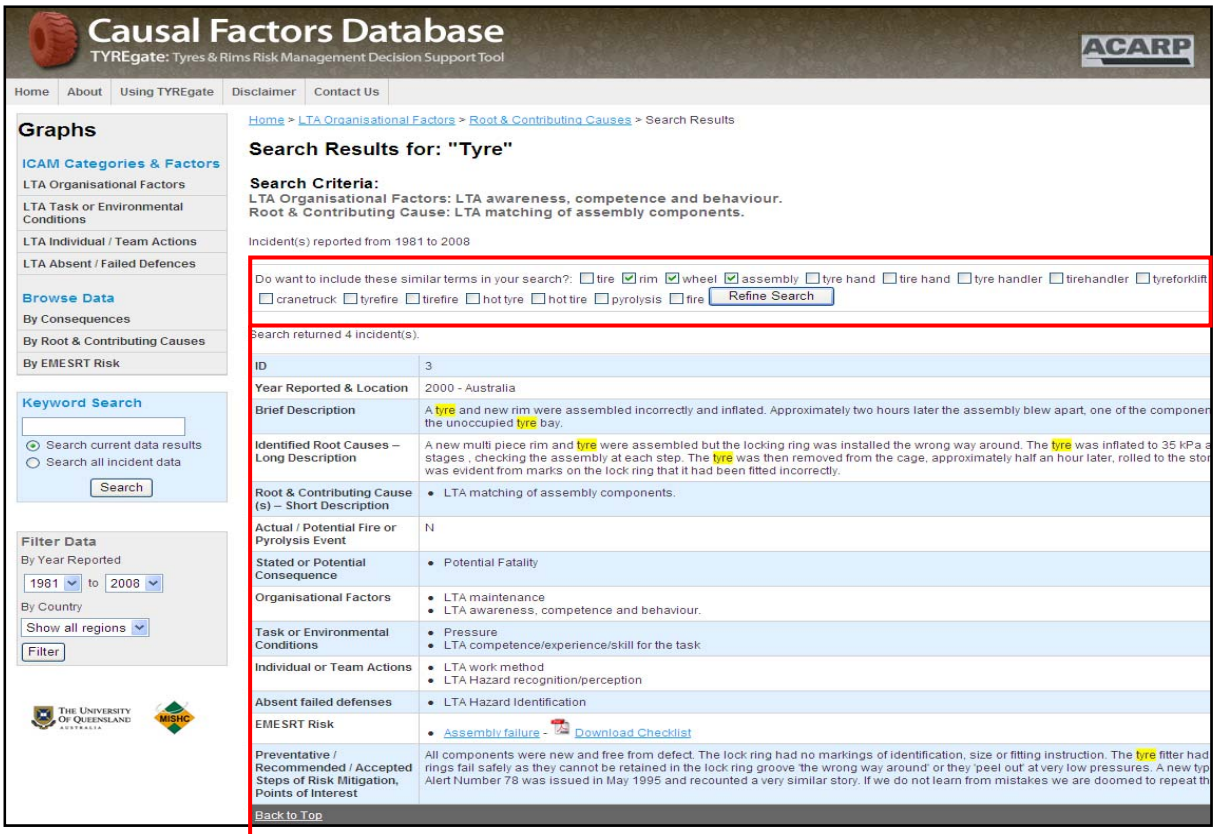
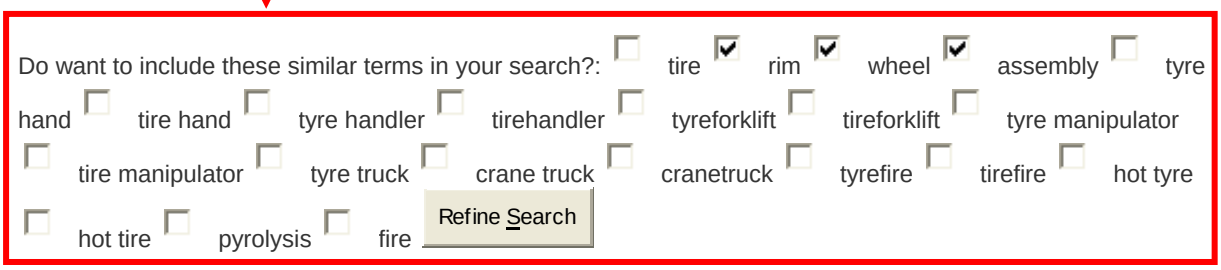


Figure 24- Refine Search Option (Refining by similar terms)



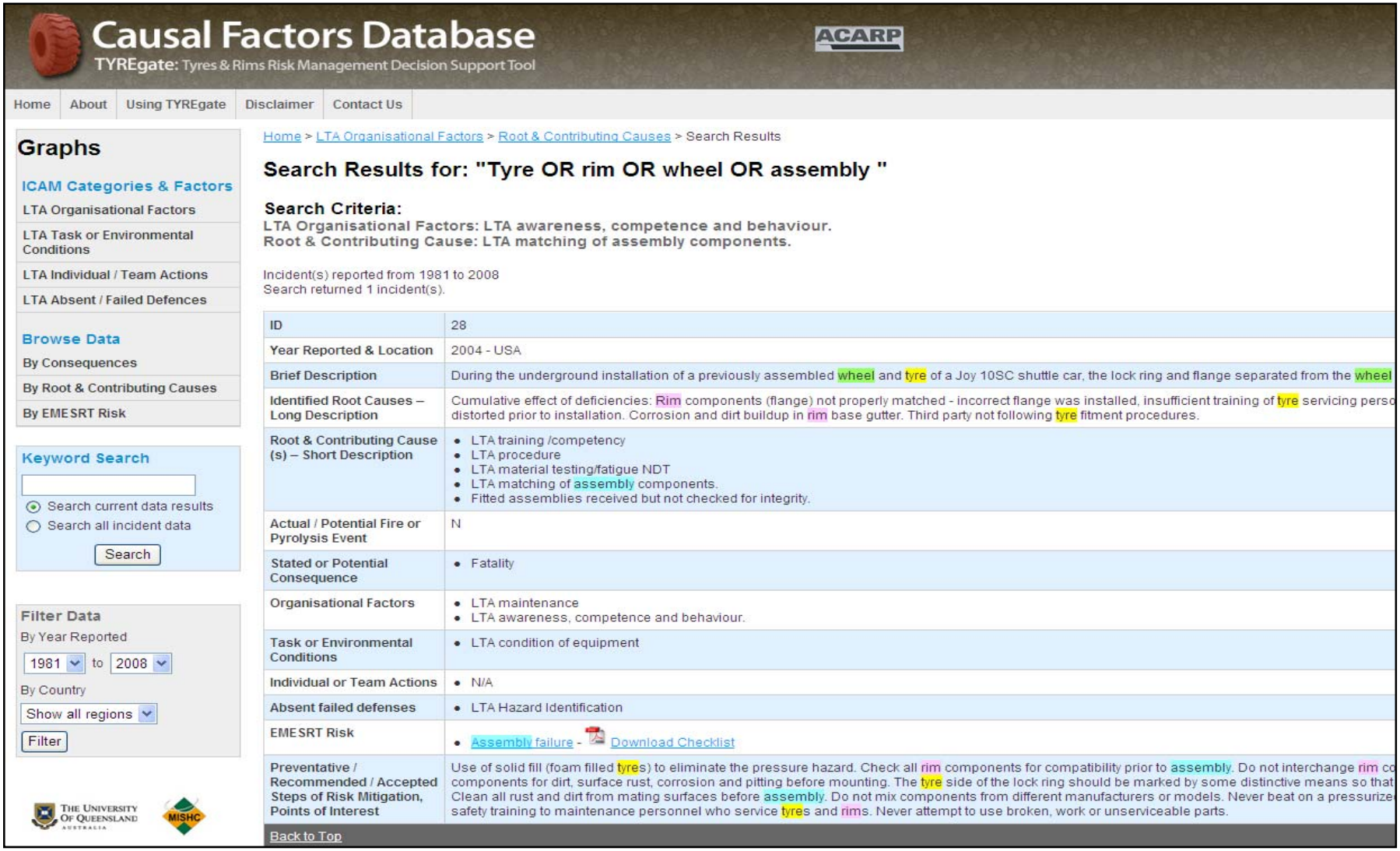


Figure 25- Search results of "Refine Search" option

4.4 Filter data by Year and /or Country

A commenced search can be filtered by the ***"Year"*** and / or the "***Country"***; once a search has begun, users can filter the results taking away any skew or bias related to Year and Country that might present itself in the overall data.

4.4.1 Filter data by "Year"

An example shown below has filtered data by the ***"Year"***, 1994-2002. The original search returned 9 incidents (see *Figure 5*). By refining the search by the years 1994-2002, the new search results returned 6 incidents.

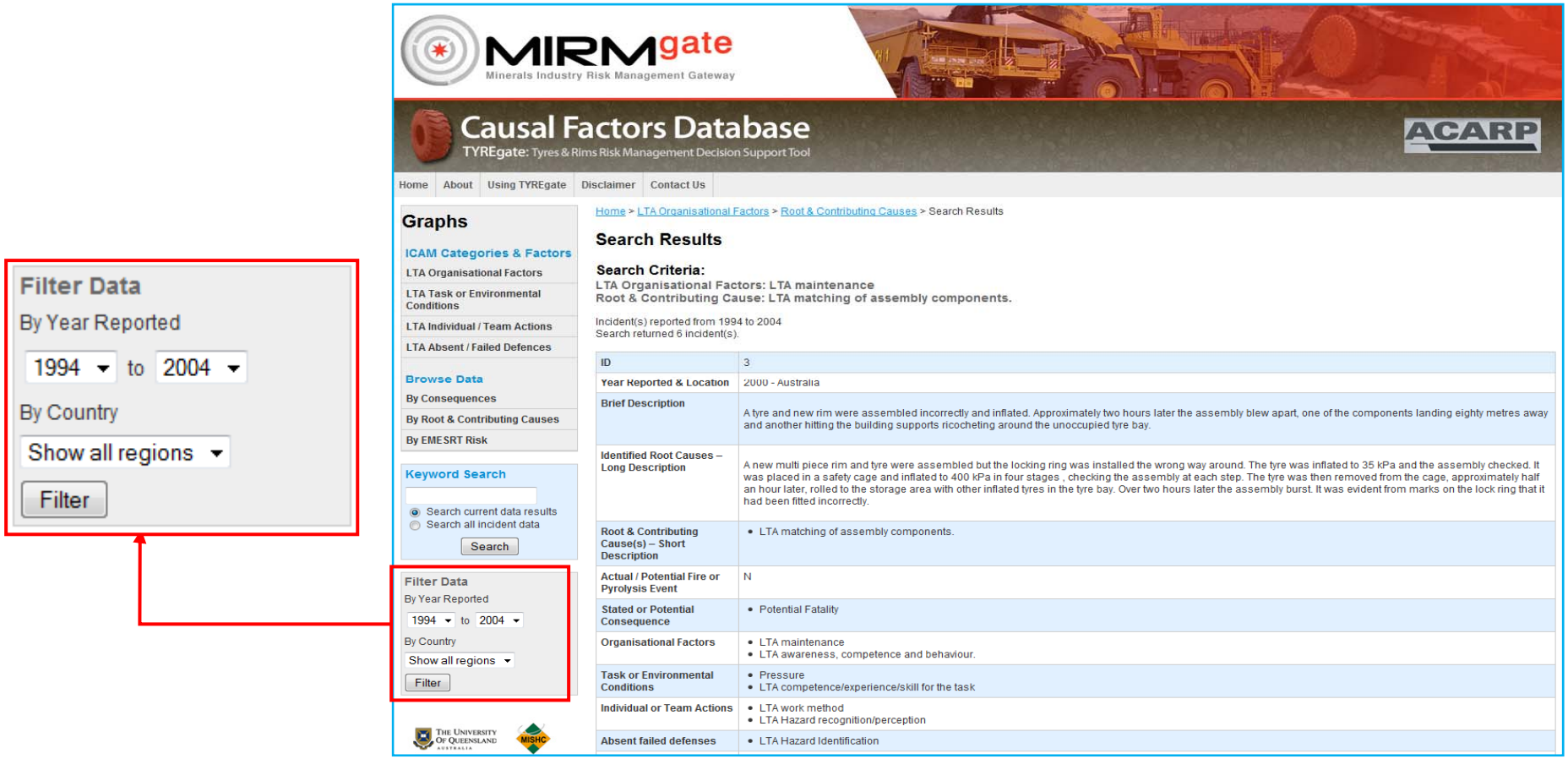


Figure 26- Filtered data by Year (1994 - 2002)

4.4.2 Filter data by "Country"

An example shown below has data filtered by the ***"Country"*** the results originated from. The original search returned 9 incidents (see *Figure 5*). By refining the search by *"Country"* (Australia), the new search results returned 8 incidents.

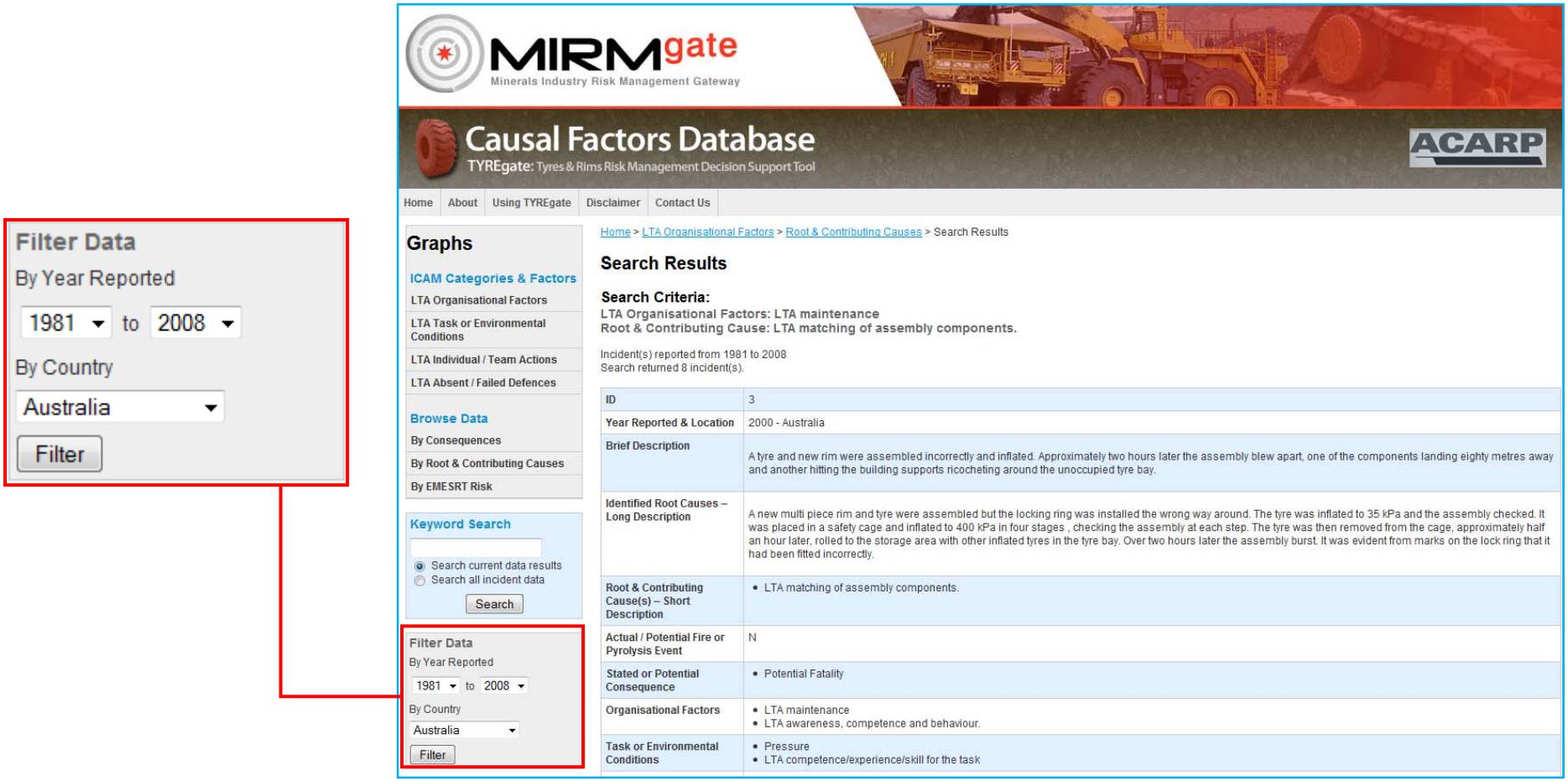


Figure 27- Filtered data by Country