Can Simulation Replace On The Job Training?

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Simulation is rapidly becoming recognised as an integral part of the future of training in the resources industry. From heavy equipment, to rescue, to maintenance, we will see this technology being increasingly used to safely prepare our workforce for a variety of roles. Certainly there are examples of incidents where simulation training can be attributed to the avoidance of disastrous results. But how do we ensure confidence in the safety outcomes of simulation training in our industry?

In other industries it is generally agreed that governance and standards greatly influence the effectiveness and cost of simulation training. (The most notable use of simulation training is in the aerospace industry, where it is heavily regulated through validation, verification and accreditation standards, allowing certain training to occur with 'zero fly time'.) Such standards fit with the regulatory framework within mature simulation industries and provide a basis for measuring and assessing the appropriate design, use and maintenance of training simulators. However this level of confidence comes at a high price, both in terms of the increased cost of more sophisticated simulators required to achieve the desired level of realism, and the added burden of developing and enforcing appropriate training quality to support simulation training.

In all simulation industries, the driving force behind the growth of simulator use is the overwhelming demand for skilled workers, and the need to get them up to speed as safe and productive workers, as quickly and efficiently as possible. The cross-over of simulation tools and technology from other industries is valid yet we need to identify ways in which it can be done viably in the resources industry.

This paper presents an overview of simulation use in those industries with mature simulation programs and discusses key considerations for the development and application of simulation training standards for the resources industry. The purpose of this paper is to generate discussion within the resources industry about the need for, and potential role of, standards for simulation training, specifically:

- Will standards give us confidence that 'zero fly time' simulation training is safe and in which applications? How are **other industries** measuring and assessing appropriate use of simulation?

- Will simulation that can support 'zero fly time' meet our other business requirements (cost, efficiency, skills development)? What **learnings** can we take from other industries about regulatory frameworks and standards that support safe use of simulation?

- What are key features required in a standards system for simulation training in the resources industry? How do **we** measure and assess the appropriate use of simulation in the resources industry?

The Simulation Industry Association of Australia's Jawahar Bhalla describes *'the opportunities that simulation provides to deliver results in alignment with organisational objectives – such as an integrated analysis and communication tool suite for all business units, reducing the cost of ownership through simulation, or improving the quality of training and learning. It encompasses the cost-effective use of simulation for experimentation and analysis, concept and capability development, system design refinement and validation, process and systems modelling, and in the training of users. This applies to customers and suppliers alike, in all sectors — including defence, aerospace, mining, construction, manufacturing, transport, homeland security, education and business sectors'.*

In 2006, the Mining Industry Skills Centre purchased a range of heavy equipment simulators through a grant of $3.5M from the Queensland Government. Two of the greatest shared challenges in effectively supporting the industry in using these simulators have been to overcome the myths about simulation capability and to understand the requirements for effective simulation training.

Firstly, we need to understand the context in which we are using simulation. The Board of Examiners in Queensland identifies a range of roles under the *Coal Mining Safety and Health Act 1999,* the *Coal Mining and Safety and Health Regulation 2001,* the *Mining and Quarrying Safety and Health Act 1999*, and the *Mining and Quarrying Safety and Health regulation 2001*. These regulatory roles have specified AQF training package competencies that are recognised by the *Coal Mining Safety and Health Advisory Council* and the *Mining Safety and Health Advisory Council*. Within the AQF training packages, the assessment criteria allow for assessment to be conducted in a simulated environment.

How can we have confidence that the use of simulation in training will meet best practice? What are the quality guidelines that need to be met?

Throughout 2007 and early 2008, the Mining Industry Skills Centre conducted a worldwide review of mature simulation operations. This review focussed on in-depth interviews with key stakeholders representing simulation manufacturers, simulation users and simulation governing authorities across a range of industries. Following is a brief synopsis of our findings.

<u>Resources Industry</u>
The use of simulation in the resources industry is a drop in the ocean compared to other industries such as defence, health and aviation. In the resources sector, available simulation technology is centred around training operators of heavy machinery, with new products becoming available for training underground mine workers (predominantly in coal mining).

Simulators have also enabled us to identify problems associated with current operators. Simulators can assist in the identification of undesirable operator habits that cause wear and tear on vehicles (using brakes instead of retarders, using inappropriate manoeuvres on hazardous roads). Combined with a lack of focus on team work this behaviour brings a reduction in overall financial benefits. In effect simulators are part of the systems and processes used to strive towards zero harm environments.

Training programs that include the use of simulators are becoming more widespread, and are by all indications, set to grow exponentially. So what are our challenges?

- How do we develop an understanding of the factors that influence or limit the effectiveness of simulators in achieving safe training outcomes?
- How will simulation suppliers from other industries need to adapt

when introducing simulation tools into the resources industry?
- How do we identify our needs to simulator suppliers?
- How can governance and standards support the acquisition and use of training simulations in our industry?

Aviation

The civil aviation industry has a concept called 'zero fly time' which allows experienced pilots to undertake 100% of their training on new types of aircraft using simulation. The graduates of this program fly a real aircraft for the first time when it is in service and full of passengers. The regulatory environment that surrounds this training program ensures safety and effectiveness at all times.

The need to use simulators in aviation, as in any industry is driven by the need to maintain operating machinery in service and to find viable and safe alternatives for skilling operators. The Civil Aviation Safety Authority (CASA) has identified that to enable 'zero fly time', a thorough knowledge of how simulators are used in training is required. It is for this reason that there are four statutory roles in civil aviation: CEO, the Head of Engineering, the Safety Manager and the Flight Standards Manager.
The Flight Standards Manager statutory role is required to have experience in using simulators for training. The reality of 'zero fly time' is not as reckless as it first sounds. The blended training program is structured to enable effectiveness at each stage of skill development.

First Officers and Pilots undertaking 'zero fly time' training for an A320 Airbus or 737 commences training with a 'paper bomber' (cardboard mock-up) used in conjunction with self paced, computer based training modules. The next stage is an electronic version of the cockpit (still not a full cockpit) based on touch screen technology. The focus of this stage is muscle memory. This is important as when the pilots perform key tasks, (for example, pre-start checks have a number of gauges, dials, switches etc) they need to be checked or activated rapidly, subconsciously and accurately. In this stage the electronic simulator facilitates practice and testing of the speed with which they can extend their arm to the right place at the right angle to the correct distance to activate a particular control.

The third phase involves a fixed base simulator where trainees complete the majority of their actual flying practice. Trainees progress to full motion flight simulators during the final stage of training. Assessments are conducted in the full motion flight simulator.

The industry also has a heavy emphasis on 'human factors' built in to the simulator sessions - clarity of communication; appropriate assertiveness; correct problem-solving and resolution, task allocation etc.

The flight simulators (sophisticated and basic) have capabilities to such an extent that, in the hands of an inefficient instructor, the simulator experience can actually be damaging to the trainee. Negative training such as this can cause the company or organisation to suffer as a result.

The full endorsement process does not stop with simulation training. It is followed by the trainee being accompanied by an experienced pilot (either captain or first officer) and a certified assessor for the first 8-12 flights. Once real landings are assessed then the trainee undertakes 100 hours with a trainer captain. Finally the trainee is assessed again by certified assessor. This assessor cannot be the same person who has assessed the pilot previously.

As reflected in various industries, certification within aviation is mandated for: providing training on simulators, training assessors, assessing trainers and assessors, and assessing emergency behaviours.

CASA also requires the establishment of a Training and Checking organisation to be established within the purview of the Flight Safety Standards officer, as shown in Figure 1. The training and checking is in effect training and *assessing* and requires the development of manuals that specify the following:

- roles, qualifications, levels of assessment authority and requirements, pre-qualification experience
- schools and syllabus (the endorsement program is separated so that it can be updated and maintain currency)
- techniques and procedures for training and assessing
- requirements for recurrent training every six months
- simulation specifics
- training checklists, including forms used to record training evidence.

employed in the resources industry to ensure safe and effective use of simulators for training.

<u>Rail</u>
Within the Rail industry a similar blended approach to the use of simulators for training is employed. However the regulatory environment is less specific than aviation in regard to the use of simulators for training.

A *Model Rail Safety Bill* was developed by the National Transport Commission and national and state regulators have been going through the process of adopting the bill. They are currently in various stages of legislative processes. The *Model Rail Safety Bill* seeks to ensure these state by state arrangements are aligned nationally.

Essentially rail operators are individually responsible for the competency of staff under existing state Rail Safety legislation, and how they determine the competency of staff. Rail operators are defined as: owners of track and infrastructure, and; owners of rolling stock.

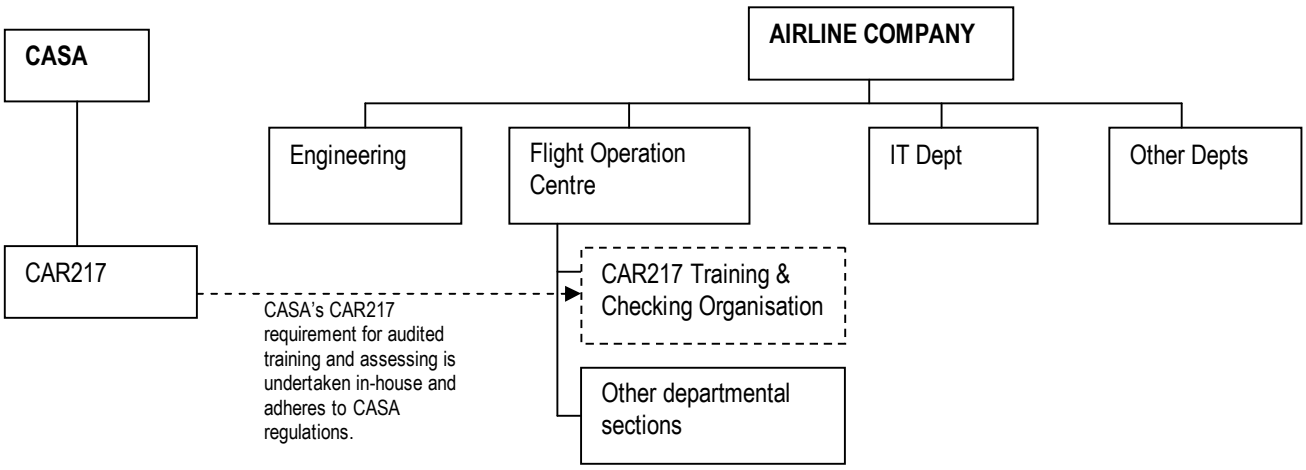

Figure 1: CAR217 Training and Checking Organisation is a department within a company that is akin to a CASA representative.

These standards and governance processes are what the CASA has established as necessary for safely training operators within the aviation industry.

We need to consider what aspects of the aviation industry can be

Those holding statutory roles are able to delegate responsibility through a process of accreditation. The National Bill explicitly calls for training and assessment to be competency based using nationally recognised training where possible, for the first time. In

particular the Australian Qualification Framework (AQF) is identified. Within this national framework defining qualifications, is the *Transport and Distribution Training Package* which has been superseded, by the *Transport and Logistics Training Package* (Cert I – IV Rail Infrastructure).

In some instances, however, regulators will accept a robust risk-based training needs analysis, without reference to legislative requirements for nationally defined competencies. For example, RailCorp in NSW have developed a risk based training needs analysis approach in direct response to a recommendation from the Special Commission of Inquiry into the Waterfall Train Incident and this approach has been accepted by the Independent Transport Safety and Reliability Regulator (ITSRR) in NSW.

Notably, within each element of the units of competency within the *Transport and Logistics Training Package,* the assessment criteria allow for assessment to be conducted in a simulated environment. This provision is also present in the resources industry training packages. Is this sufficient to give us confidence that simulation based training is appropriately managed?

Within Queensland Rail, a four stage blended learning environment is provided to coal and freight locomotive drivers. The simulators are interlinked to provide the environment in which the driver would be experiencing on a real train locomotive.

Stage 1 is based in foundational theory. Stage 2 takes the trainee into a Depot environment applying theory of stage 1 with a tutor. Stage 3 covers the theory associated with the operation of vehicles in depth. This is combined with engagement with simulators to apply practical operation of loco and train management skills. Stage 4 takes the trainee into a train with a tutor until ready for final assessment.

The same motivator for the use of simulators for training is maintained, and that is to maximise use of operational machines while ensuring training for safety and efficiency. Another significant motivator for the use of simulation in training is the opportunity to not only train for rare and dangerous events, but to practice those skills.

The way in which Rail interlinks simulators is supported by a range of interoperability standards. These technology standards are as significant to the success of using simulators for training, as the quality of the training programs.

Simulators that don't communicate with other computers or with each other very well, presents an unnecessary business cost overhead into the training budget. The cost lies in time and money spent aligning systems, which has an overall effect of slowing down the throughput of safe and efficient trainees. The resources industry has the opportunity to identify these requirements to suppliers.

<u>Defence</u>

Defence use simulation in a wide variety of contexts including mission rehearsal and tactical planning. The focus is on decision making, information analysis and process re-engineering within an operational planning context. There is also a focus on motor skill acquisition, but to a lesser degree.

For many years, Defence have conducted training activities with defence departments from around the world (joint forces training). In a simulation context, they have progressed to developing agreements on data sharing. These agreements include the development and adoption of interoperability standards to enable the sharing of data, for the purposes of simulation training and mission rehearsal. This leverages HLA (High Level Architecture) or DIS (Distributed Interactive Simulation) technology which describes how data is transmitted across

a network (including the internet) in a multi player environment. This will become highly relevant for mining as more sophisticated simulation tools are made available.

Defence policies refer to CASA and the International Civil Aviation Organisation (ICAO) for the use of simulators for flight training and to certify, de-certify or deny certification of full flight simulators. Ongoing validation of function and fidelity is conducted annually or when reconfigured.

All trainers are required to hold the AQF Cert IV for training and assessing. Notably, assessors must have experience as an effective trainer. It is also mandatory for a Training Needs Analysis to be conducted prior to any training , including the use of simulators for training.

Health

In Health a significant focus is part task training and the use of de-briefing or after action review. Like previously described scenarios, blended training programs take participants from low fidelity tools through to high tech high fidelity simulators. For example the field of endoscopy involves a range of tools from very basic, almost non technical tools, which begin to familiarise the trainee with idiosyncrasies of microscopic surgery (especially the reverse or counter intuitive nature of scopes, and working with magnification). The facilities extend through to fully computer generated simulations for laparoscopic and endoscopic surgery where the actual surgical tools are used in conjunction with a computer generated simulated image of the patient. These tools include full haptic capability that allow students to feel the true tension and force feedback experienced when performing those particular operations.

Another focus is simulated wards for nursing training (bedside manner, logistics associated with transporting patients and emergencies such as heart attacks in the toilet).

In regard to surgical training, part task training is used in areas such as specific surgical procedures, including incisions, emergency resuscitation and midwifery. The use of full simulated theatres, however, allows trainers to input simulated information into the real-life monitoring systems commonly used in theatres and emergency rooms. The simulated theatre room is adjoined by a control room operated by the trainer. This facility focuses on delivering technical skills (diagnosis and treatment) in a team learning environment.

Another central theme in health simulator training methodology is de-briefing and after action review. Queensland Health has installed communication suites with video and audio recording devices which are used after completing a simulation. Trainees move to a lecture room where the audio and video recordings are played back and a very thorough de-brief about patient history taking, grief counselling, general practitioner consultations etc is conducted. The AV set-up allows for the screen to be split into three or four different sections including the instructor screen and one or more video replays of the simulation. This enables the trainees to dissect what actually happened (compared to their individual perception of what happened).

The most interesting observation is that the majority of health simulation technology is real equipment interacting with simulated data. Either body parts are computer generations on screens interacting with genuine scopes or high fidelity mannequins provide model patients that send simulated data to heart monitors, or IV setups.

The Health industry accreditation process for training providers does not specify standards or regulations about simulators in particular. However, linkages between the Australian Society for Simulation in Healthcare and the (international) Society for Simulation in

Healthcare have commenced discussion in this area.

From a technical perspective, a variety of standards support the interaction between simulated models. In Health, as in many of the industries that use simulators, systems are developed with proprietary products. The development of simulators using standardised software protocols is emerging in defence where international inter-operability is required. The maturity of simulator use within defence allows the agenda of integrated use to have a high profile.

The level of interoperability existing in defence simulation sets precedence for the development of simulators for other industries. Simulator suppliers who restrict their development to proprietary product will significantly limit their market.

Notably, medical companies that have used proprietary software to capture image data (cat scans etc), are unable to provide that data to clients, because it is not in an interoperable format. When those companies close that data is lost.

The work of the Simulation Interoperability Standards Organization (SISO) and open source initiatives promote the ability to connect and exchange data between systems.

How simulation supports resources industry training priorities

Recent understandings validated through the Mining Industry Skills Centre's (Skills Centre) Heartbeat project focus on skills shortages in the areas of maintenance trades (specifically electrical and diesel fitting), as well as professions such as surveying, engineering and geology. There is no existing simulation product that is immediately available to support the resources industry in dealing with these skills shortages.

Further, the Skills Centre's recently published skills strategy *Securing the Critical Capability – towards an Holistic Skills Strategy for the Mining Industry* (Skills Strategy), includes an analysis of the way training is currently delivered in the industry and how well this approach is meeting the needs of the industry in terms of skilling.

Combined, Heartbeat and the Skills Strategy tell a story of the priorities for skilling strategies, solutions, and training approaches to meet specific skills shortage needs within the industry. The Skills Strategy also identifies the need for more skills for trainers, supervisors and managers to support the statutory requirements of these roles. The aim for trainers and assessors in particular is encompassed in Workforce Development Goal4:

> *To create industry specific professional development for Trainers and Assessors that encompasses leading practice in:*
> - *learning facilitation and assessment;*
> - *learning management;*
> - *learning technology;*
> - *training program design and implementation; and*
> - *interpretation of the VET framework.*

The Skills Centre's Simulation Research, Development and Training Centre (which is currently under development in Mackay) will overlay simulation capability across these training needs.

The work will focus on urgent requirements for training solutions where the current approach is not meeting the need and where simulation provides an appropriate mechanism for meeting that need. Further research is required in order to identify and prioritise what simulation is available, and what development work is required to develop simulators to meet those needs.

We also need to understand success factors of simulation programs in other industries, as well as planned future direction of simulation manufacturers. Currently there is no central repository for that type of information and as such this will be an area of focus for the Centre.

The maturity of simulation in the defence and health industries has fostered a buyers market. The relatively recent and limited amount of simulation use in mining means that we are in a supplier driven market. An important focus of the standards discussion is to identify resource industry needs and requirements so that they can be communicated to suppliers.

What is meant by 'Standards'
In aviation CASA has drawn a direct link between regulations and training standards, including the use of simulators in training.

In Rail, Health and the Resources industries, legislation mandates a range of safety and health requirements supported by competencies under the AQF.

This discussion about the need for simulation training standards includes technology standards which specify the fitness for purpose of simulators in various contexts.

Standards Australia's IT-031 Committee is currently developing a *Guide to Australian Modelling and Simulation Standards (the Guide)*. The Guide (to be published in 2009) will provide an introduction to the importance of standards in acquisition, development, management and application of simulators. It is designed for use by those involved in using, operating, developing, procuring, maintaining and managing simulation projects and facilities.

Particular to this discussion, the draft Guide describes *Fitness for Purpose* in relation to: fidelity standards; verification, validation and accreditation standards; and regulatory certification.

> *Confidence building standards are being developed to help increase the adoption of simulation by increasing the level of confidence of users of simulations that the simulations are fit for purpose. This requires, amongst other things the simulation builder to define the intended purpose against which the fitness for purpose is to be measured.*
>
> *Confidence Building Standards incorporate all those standards associated with ensuring fitness for purpose, establishing both the overall credibility of simulation outcomes and the necessary levels of user confidence in them.*
>
> *Simulation fidelity requirements are determined by the need to meet the fitness-for-purpose criteria for the intended application. As fidelity requirements are application specific and require detailed knowledge and expert judgment in relation to how good is good enough, current fidelity standards have been developed by specific industry groups for specific applications.*
>
> *Due to the long history and comprehensive safety regulations of the aviation industry, flight-training simulators are the only simulation application with widely adopted fidelity standards. Interoperable simulators should be built to a consistent fidelity standard to provide a level playing field (for all participating simulations). There can be little confidence in the overall result being any better than the lowest fidelity simulator.*
> ***DRAFT***

Fitness for purpose also refers to the situation where a simulator may be used to provide a trainee with introductory information. This same simulator is not necessarily fit for the purpose of comprehensive emergency response analysis.

How is the *fitness for purpose* to be defined for simulators used in the resources industry? What will give us confidence that someone is suitably or appropriately trained using a simulator?

The legislative Acts that govern mining specify the need to ensure that suppliers understand and recognise the specific requirements of the industry. The legislation also requires that this extends to the use of simulators for training.

Standards for the Resources industry

The process to develop the standards and governance for simulation use in the resources industry needs to be a collaborative exercise across the sector and it has already begun.

The Mining Industry Skills Centre is committed to a program of work to investigate the role that standards play in ensuring appropriate use of simulators to promote safe and efficient practice.

The Skills Centre is an active member of the peak organisation for simulation in Australia – the Simulation Industry Association of Australia (SIAA). In this role, we have led the establishment of a mining and construction oriented Special Interest Group to focus on issues particular to our community. Currently this committee is chaired by the Skills Centre CEO, Derek Hunter.

In addition the Skills Centre has representation on the Standards Australia IT-031 committee for *Simulation and Modelling Standards*. Through involvement with this committee we are ensuring that resource industry priorities are being addressed at a national level. In 2009, Standards Australia will be publishing a hand book that will support not only the technical developers of simulators, but also aims to provide those procuring and implementing simulators with an understanding of relevant issues and indications of quality benchmarks.

There are a growing number of companies from defence and aerospace perched on the verge of the mining sector, ready to extend their products and services into our field. Our involvement in these forums ensures our needs are defined and we are able to interpret what these suppliers are offering, and how these offerings meet our actual needs.

Additionally, the Skills Centre is partnering with the University of Queensland (UQ) and the Construction Training Centre (CTC), in an Australian Research Council funded five year study to determine the effectiveness of simulation training. This work will provide a research-based platform to inform the development and measurement of appropriate standards and governance models for our industry.

We have also actively pursued the development of networks with other industries to identify best practice and opportunities to bring those lessons learnt into our growing field of simulator use.

The Skills Centre is committed to ensuring the industry view on this issue is appropriately represented, within the broader context of assuring high levels of training quality. As such, we are seeking to engage with a variety of stakeholders through relevant existing networks.

The next major piece of work is to better understand the governance frameworks relating to simulation standards in other industries and the relationship of these to governance frameworks relating to safety and training in the resources industry. Proposed models for consultation and governance structures will then be developed and implemented as appropriate. It is expected that proposed models and a draft framework for standards development will be published around December 2008, with a view to achieving the first set of

resources industry endorsed benchmarks by mid-late 2009.

Conclusion

Engaging in the discussion about standards will give us confidence in how the use of simulators for training can bring about both safety and business benefits for the resources industry.

The concept of fitness for purpose for training simulators seeks to give confidence to Senior Site Executives, Safety Managers and Training Managers that both skills and behaviours are targeted. Simulators can support the development of both physical motor skills and subconscious responses to hazards. Training programs also need to promote and embed attitudes about safety and efficient practices.

Can simulation replace on the job training? The major motivators for the use of simulation in training include:

1. the opportunity to maintain operational equipment in service
2. the opportunity to engage in training and practice of rare and dangerous events, and
3. to measure and evaluate behaviours that effect efficiency and safety

In summary, the key indicators for effective use of simulators for training include both blended learning environments and governance structures.

Adult learning theories are supported by a blended approach to learning programs. Employing a staged approach from low to high fidelity simulators, in combination with self paced learning materials and de-briefing, supports a variety of learning styles and outcomes.

Instructor programs that aim to support the cultivation of technical expertise, confidence and safe behaviour are essential. Assessors rely on training skills in the validation of learning outcomes. It is essential to the development of safe and effective practices, that problem solving and recognition of hazards is inherent in training programs.

Governance structures describe accountability for the overall safety and efficiency of simulators. Rules that identify standards requirements align daily use of simulators to long term business goals.

These motivators, the governance trends set by mature uses of simulators, and the blended learning environments that situate simulators as appropriate training tools all describe an environment where simulators will significantly alter the face of on the job training, rather than replace it entirely.

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Site Visits
5DT
Anglo Coal
Australian Defence Standards Organisation
BHP Billiton
BMA
Boeing Australia
Boral SEQ Quarries
CAE
Construction Training Centre (Qld)
Coal Services
Immersive Technologies
QANTAS
QinetiQ
Queensland Mines Rescue Services
Queensland Rail
Queensland Health
Sydac
Thales
Thoroughtec
University of NSW
Xstrata Copper

Case Studies
Sydac
Peabody Energy
Queensland Rail
Standards & Management Group, Chris Smith

Organisations
Army Simulation Wing
CSIRO
Department of Mines and Energy (Queensland)
Defence Science and Technology Organisation (DSTO)
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