The Need for Improved Accident Investigation Education & Research

Associate Professor Geoff Dell, PhD
Associate Professor Yvonne Toft, DProf

Central Queensland University
Rockhampton, Australia

INTRODUCTION

Accident investigation has long been recognised as a core element of effective safety programs. Few would argue with the premise that the fundamental purpose of an investigation is to determine the facts, conditions and circumstances relating to an incident so that the causes may be established and appropriate steps taken to prevent a recurrence. In 1931 H. W. Heinrich in his book "Industrial Accident Prevention" proposed a chain of multiple events model for understanding accident causation (*Heinrich (1931)*). He suggested that accidents were the result of a series of factors, each acting on the next over a period of time leading to the accident. In 1946, in the First Edition of its Accident Prevention Manual for Industrial Operations, the National Safety Council (*NSC 1946)*) suggested that *"accident investigation and analysis is one of the means used to prevent accidents. As such, the investigation or analysis must produce information that leads to countermeasures which prevent or reduce the number of accidents."* This base purpose has since remained unchanged, as the Australian Transport Safety Board (ATSB) suggested: "*The objective of investigating accidents and incidents is to prevent the occurrence of future accidents*" (*ATSB (2010)*).

Also, there have been many investigation models postulated (See for example *Viner (1982), Reason (1997) and Hudson (2000)*) which suggest accidents are multi-faceted and the development of an understanding of all facets is necessary to establish effective and comprehensive preventive measures and identify the learnings. Despite this long term consensus, accidents continue to occur unabated and there is emerging concern that the lessons from those accidents are not being learned. As *Kletz (1993)* suggested…. "*the apparent inability of organizations to learn, and retain in the long-term, the lessons drawn from accidents……is a reason incidents of a similar type continue to occur within companies repeatedly*". This phenomenon also transcends industry boundaries (see for examples *BBC (2007), Rigot B (2007)* and *Hudson (2010)*).

No doubt the poor standard of investigations is one reason some accidents seem to recur (*Kletz (1993)*, *Oakley (2003) and Dell (2006)*).

POOR INVESTIGATIONS WITH SHALLOW REMEDIAL ACTIONS

Many companies have a very superficial approach to incident investigation. In a 2002 study by Monash University Accident Research Centre, eighteen large Victorian companies were examined in detail to identify their approaches to safety management (see *Dell et al (2002)*). As part of the assessment, the companies' methods and arrangements for accident and incident investigation were analysed. Only three of the companies had formal investigation procedures in place. In the remainder, investigation was a task left to line managers and supervisors, little guidance was given to them on

how to conduct an investigation and the information gathered was not used for any real prevention effort. These investigations were usually very poorly conducted, missed significant causal factors entirely and often blamed the victims of the events. Indeed, the authors also found that two thirds of companies had not embraced a “No-blame” investigation precept and focused solely on the errors and omissions of the worker/s involved in the incidents.

Consequently, these shallow investigations seldom identified remedial action beyond procedural intervention or retraining. As *Dell (2003)* suggested “*these investigations focus only on the last couple of factors in the sequence, ignore many of the contributing factors and miss valuable opportunities to prevent future events”*. Often no investigation training was provided at all and very basic investigation forms or checklists were provided to facilitate the investigation process (*Dell (2006)*).

Accident investigation is a global need which transcends all industries (see for example Ogbuokiri (2010) and Thomas & Bridges (1998)). Governments and industries across the globe conduct investigations into the myriad of accidents, incidents and other events which occur. All have a need for suitably qualified investigators, yet the education programs to deliver those investigators are few and far between.

Within Australia, all companies have a need for accident investigation skill sets within their businesses. Many have safety professionals working within their organizations who are tasked with conducting those in-house investigations. Many are not trained at all, or have received training in theory only short courses. For example, in 2005, the Safety Institute of Australia estimated that there were upwards of 25,000 people working in OHS management positions in Australia (Skegg (2005)). Toft et al (2010) found a strong consensus (95%) across OHS educators, professionals and graduates, as well as registered training organizations, that OHS professionals should be able to perform sound accident investigations. In addition, there are significant numbers of people from other professions routinely tasked with the conduct of accident investigations and yet have received no education in the discipline. Most, if not all, of these personnel would benefit from access to improved accident investigation education.

THE LACK OF APPLIED INVESTIGATION EDUCATION

Most university safety education programs in Australia today teach only the theory of accident causation. Students gain instruction on the popular accident models, such as: Tripod-Beta (*Doran & Van der Graaf (1996)*), ICAM; Incident Cause Analysis Method (*BHP 2000*), MORT; Management Oversight and Risk Tree (*Johnson (1973) & NRIF (2009)*), TapRooT (Paradies & Unger 2000); the Time Sequence & Energy Damage Models (*Viner (1991)*) and perhaps the best known ‘Swiss Cheese’ Model, formally Reason’s Model of Accident Causation (*Reason (1997)*), to name a few. These all deliver variations on a systematic framework to aid understanding of how accidents occur in theory. To varying degrees they are useful as the basis for investigation and establishment of the particular causes of accidents post event. Although, all of the models have strengths, weaknesses and limitations and potentially deliver different investigation outcomes (see *Benner (1985)* and *Lundberg, Rollenhagen & Hollnagel (2009)*) unless the users understand those strengths, weaknesses and limitations.

In addition, what's almost universally lacking in the training presently available in industry is how to go about the task of investigation, what models and methods to use in what

circumstances, and how to ensure investigation fidelity. Furthermore, most of these models focus almost solely on investigation data capture and analysis, leaving out a plethora of equally important issues around the more practical aspects of investigation such as planning, preparation, site safety, witness interviewing techniques, pathology, forensic engineering and accident photography. In addition, effective approaches to outcomes communication, such as development of robust supportive arguments, conclusion formation, design of effective recommendations and, perhaps most importantly, effective report writing are also almost universally omitted.

There are only a handful of the existing professional development (PD) investigation courses available globally that teach all of the theory, use a competency based approach and which are available to industry. There are none in Australia.

Globally, there are a small number of PD programs which focus solely on aviation accidents, teach some of the theory and have an applied “hands on” approach. Both the University of Southern California (*USC (2010)*) and the Southern California Safety Institute (*SCSI (2010)*) have programs which teach methodologies from the International Civil Aviation Organisation Annex 13 Aircraft Accident and Incident Investigation (*ICAO (2001*)) and have practical approaches to learning that involve use of “crash laboratories” where wreckage from actual accidents are available for use in the student learning experience (see Figures 1 & 2).

In the UK, the Cranfield University Safety and Accident Investigation Centre (*CSAIC (2007)*) provides a multi-transport mode investigation PD program which includes a ‘field’ phase of study, where students interact with accident wreckage (see Figure 3) in a similar fashion to USC and SCSI. Although the investigation theory taught applies generally, the school is focused on the three transport modes of air, rail and maritime safety, although traditionally most of its students have had an aviation investigation interest.

Figure 1
Satelite Photo of Helicopter Wreckage in the USC/USAF[1] Crash Lab

[1] USAF: United States Air Force

Figure 2
Accident Wreckage in the SCSI Crash Lab[2]

There are no courses in the southern hemisphere which combine teaching the full spectrum of accident causation theory, all aspects of accident investigation theory and the applied investigation methods. Also, none involve the application of a crash laboratory containing real accident wreckage to aid learning, and none which apply the principles of learning across all the transport modes and other industry domains, such as general OHS, mining or process safety.

Figure 3
Accident Wreckage used in Training at Cranfield[3]

HIGHER DEGREES AND RESEARCH

Globally, it seems only Cranfield University offers a postgraduate degree in the investigation discipline, a Master of Science in Safety and Accident Investigation Degree (*Cranfield (2007)*). The program is "offered to Aircraft Accident Investigators", is by course work and is based on the Cranfield investigation short course curriculum but involves an additional "individual research thesis".

[2] Source: SCSI website http://www.scsi-inc.com/SCSI-crash-lab.php
[3] Source: Cranfield website http://www.cranfield.ac.uk/soe/facilities/accident-investigation-lab.html

In USC's case, the investigation school is a part of the Engineering faculty, and the investigation programs are delivered only in PD short course fashion and not delivered as a postgraduate program. There seems to be a relatively low penetration of the accident causation and investigation science into the higher degree research arena, based on their published information.

In Australia, some existing tertiary programs in OHS teach accident investigation as a single course (see for example *Toft et al (2010), VIOSH (2009)* and *UNSW (2009)*). Generally, these programs vary significantly in scope and the investigation methods taught, as well as in the methods of course delivery. By and large they provide a learning framework for OHS course graduates to a level considered appropriate for them to conduct a reasonable standard in-house investigation for their subsequent industry employers.

There are no undergraduate or postgraduate specialist accident investigation programs in Australia, indeed there are none in the southern hemisphere dedicated to the accident causation and investigation science domain. As such, there are really no tertiary programs delivering graduates who might be considered professional or specialist accident investigators. There is also very little research activity in relation to accident investigation.

THE NEW CENTRAL QUEENSLAND UNIVERSITY (CQU) SUITE OF TERTIARY ACCIDENT INVESTIGATION PROGRAMS

To redress the shortcomings and gaps in the safety investigation education and research domain described above, CQU is developing a suite of tertiary programs, including a Bachelor of Accident Forensics, Graduate Diploma in Accident Investigation and a Master of Accident Investigation (Specialisation) degree for offer in 2012. The course work is supported by a robust research program that includes opportunities to conduct research as part of a research Masters or Doctor of Philosophy.

The Bachelor of Accident Forensics will deliver a combination of core investigation courses and draws others from an existing successful OHS degree as well as from other science and engineering programs (see Figure 4). Graduates will be well qualified for investigation roles, for example in the insurance assessor area and will also be well placed for employment in OHS roles in industry where their investigation education would allow them to be the specialist investigator within their company.

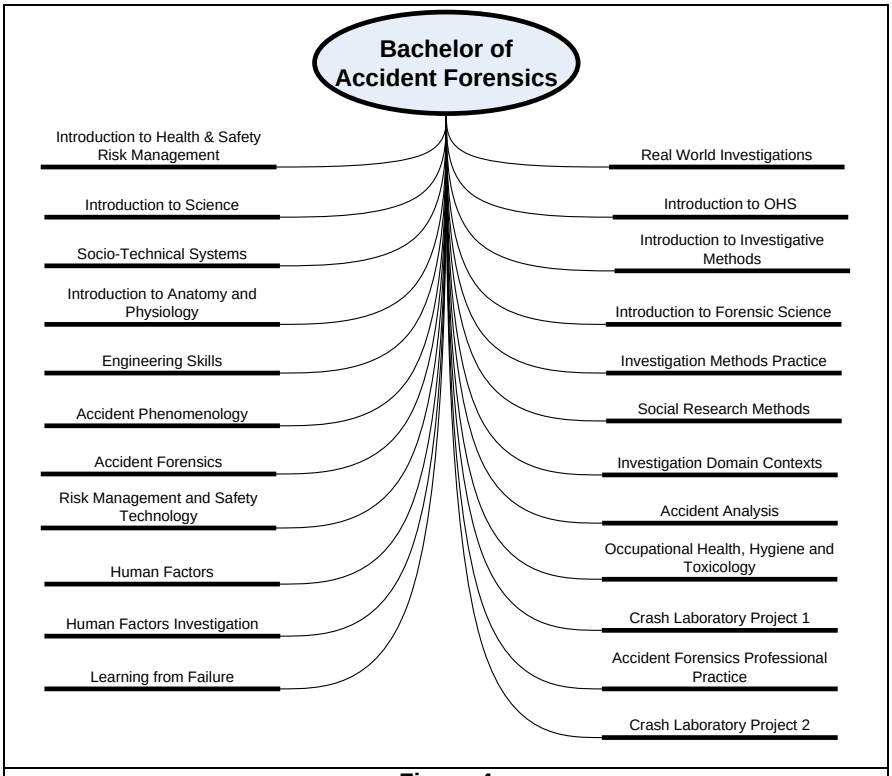

Figure 4
Bachelor of Accident Forensics: Courses of Study

The Graduate Diploma in Accident Investigation will deliver a broad suite of courses which deliver subject matter common to all investigation domains and industries (see schematic at Figure 5). The program is designed to be attractive to people working in safety, engineering or management roles that have a responsibility to conduct accident investigations and those people aspiring to such roles.

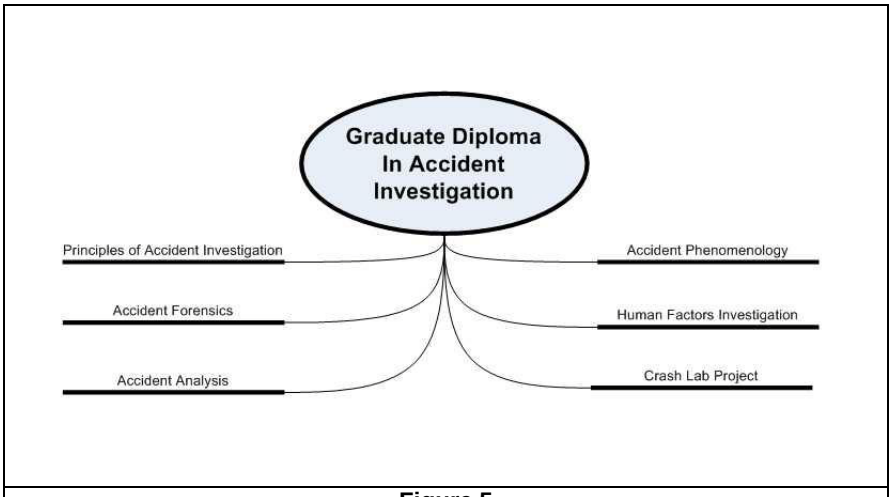

Figure 5
Graduate Diploma In accident Investigation: Courses of Study

For those wishing to specialize in a particular industry domain, the Masters program extends the study beyond the general investigation concepts and methods, to focus on those aspects of the investigation science specific to one of four industry domains; aviation, rail, road and general industry. To undertake the Masters, students must complete the program of study required for the Graduate Diploma, then select one specialisation domain and complete three courses in that specialisation. To complete the Masters, students must then complete a capstone three-course research project (see Figure 6).

For those students wishing to gain qualifications in more than one domain, it is planned to offer each of the four specialisation streams as a standalone graduate certificate. In this way, students can gain one specialisation as a part of their Masters and return to study in any or all of the other three specialisations and be awarded accordingly with the relevant qualification ie Graduate Certificate in Air Safety Investigation, Rail Safety Investigation, Road Safety Investigation or Industrial Safety Investigation. Streams in other domains are under consideration for future development.

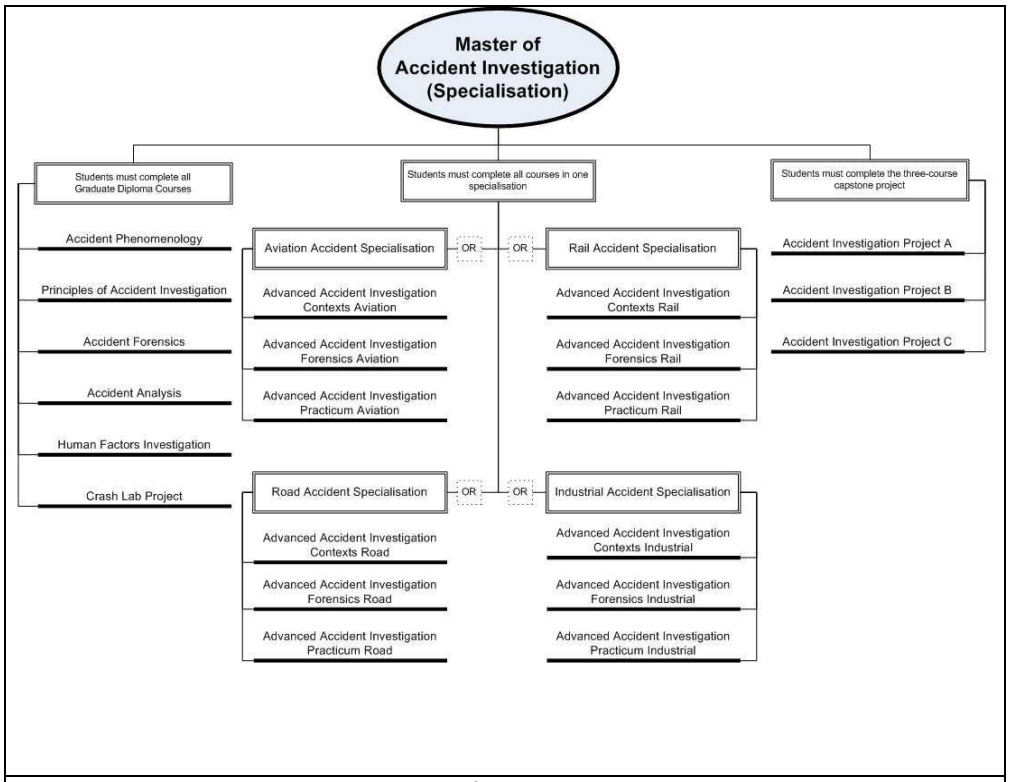

Figure 6
Master of Accident Investigation (Specialisation)

Additional features of the proposed approach to investigation learning, that make this CQU model unique, are:

- ✈ Distance education delivery of much of the theory component of the program
- ✈ On campus, residential, blocks of timetabled course work covering critical concepts, practical exercises and applied assessment tasks

- Integration of applied learning experiences, such as practical witness interviewing, photography and giving expert witness testimony, designed so that every student has an opportunity to hone their techniques in practical aspects of investigation
- Strong emphasis on evidence-based practice
- Informed by a program of disciplinary research and scholarly activity

CQU Crash Laboratory

In addition to the other benefits and features of this suite of accident investigation programs, the establishment of the CQU Crash Laboratory will ensure the CQU investigation learning experience is unique in the world. The Crash Lab, under development at CQU's Bundaberg campus will include examples of transport accident wreckage and industrial accident scenarios, with each accident supported by appropriate documentation, data and other supporting evidence to make the investigation experience realistic.

The CQU Crash Lab would be the only such laboratory in the southern hemisphere and the only one globally designed from the outset to cater for investigations outside of the aviation domain. The crash lab will also be significant in the attraction of students to the CQU accident investigation programs.

SAFETY SCIENCE & INVESTIGATION RESEARCH

Australian Governments are all slowly elevating the issue of safety across the community, especially in the OHS domain but also in all forms of transport. By and large, the accident rates across society remain unacceptably very high. For example, the Australian Safety and Compensation Council (*ASCC (2009)*) suggested that workplace injuries alone were estimated to be costing $57billion per annum including the social costs to the victims and their families. In the transport domains, road accident frequencies are also universally considered to be unacceptably high. In 2006, a University of Queensland study found that road accident trauma was costing $17 billion per annum in Australia (*Connelly (2006)*). This represents a combined impost on the Australian annual economy amounting to around 8% of GDP. Clearly, there is a need for better understanding of the causation of those accidents if effective and lasting interventions are to be found.

In aviation, there is also now concern that there has been such growth in the passenger and flight numbers, that the present accident rates will soon mean that the public will be confronted with news of a major accident so often, that it will adversely affect confidence in the ability of the industry to deliver a safe transport option (*Braithwaite (2000)*). Similar concerns also are beginning to emerge regarding level crossing and other accident types in the rail industry. Some of this problem is no doubt due to increasing exposure as a result of population and economic growth. This has led to more workplaces and more work, more use of transport infrastructure and a general increase in uptake of services as the average net wealth of the population has grown. It is equally apparent that more effective and innovative interventions will be required to trigger and sustain reductions. Accordingly, there is no doubt that gaining better understanding of the accident phenomenon is very fertile ground for research and development activities, not

only in the area of prevention, but also into gaining better understanding of the accidents which do occur.

Accidents have been shown to be multifaceted problems, as previously described, and often require complex interventions. There appears to be an emerging understanding by governments that the shallow generalized regulatory prevention approaches of the past will not deliver sustained improvements. The search appears to be starting to find the answers. Collaborative research arrangements, for example in Australia, the Collaborative Research Centre for Rail Innovation which includes universities, all rail industry stakeholders and Government agencies, acknowledge the issues and are funding applied prevention projects in the accident and injury domain. Even the Government funded research agencies such as the Australian National Health and Medical Research Council and the Australian Research Council are starting to consider the importance of the issues. As such, a growing proportion of research funds are likely to be offered to support accident prevention projects.

REFERENCES

ASCC (2009), "*The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2005-06*", Australian Safety and Compensation Council, Canberra

ATSB (2010), "*Aviation Safety*", Australian Transport Safety Bureau, http://www.atsb.gov.au/aviation/safety.aspx

BBC (2007), "*Potters Bar Lessons 'Not Learned'*", BBC News, http://news.bbc.co.uk/2/hi/uk_news/6399347.stm

Benner (1985), "*Rating Accident Models and Investigation Methodologies*", Journal of Safety Research, Vol 16 p105-126, Elsevier, Amsterdam

BHP (2000), "*ICAM Incident Investigation Guide*", BHP, Melbourne

Braithwaite G. (2000), "*Air safety experts believe more crashes likely*", Interview by ABC Reporter Richard Aedy, http://www.abc.net.au/pm/stories/s207016.htm

Cranfield (2007), "*Safety and Accident Investigation MSc/PGDip/PGCert*",

CSAIC (2007), "Fundamentals of Accident Investigation", Cranfield University Safety and Accident Investigation Centre, http://www.cranfield.ac.uk/SOE/ShortCourses/atm/page3797.html

Connelly L. (2006), "$17billion annual bill for road trauma", Centre for Economic Research on Health, University of Queensland, Brisbane

Dell G, Larsson TJ, Dell S, McWilliams G, Teasdale A, Rechnitzer G & Clayton A (2002), *"Safety Management: A Hazard Control Function"*, Monash University Accident Research Centre, Clayton.

Dell G (2003), *"Safety Investigation In Industry: The Lessons From Aviation"*, Safety in Australia, Vol 25 No. 2, Safety institute of Australia, Melbourne.

Dell G (2006), *"The Need for Improved Investigation Skills In Industry"*, Presentation to the 2006 Safety in Action Conference, Safety institute of Australia, Melbourne.

Doran J and Van der Graaf, "*Tripod-BETA: Incident investigation and analysis"*, Society of Petroleum Engineers, http://www.onepetro.org/mslib/servlet/onepetropreview?id= 00035971&soc=SPE

ICAO (2001), "*Aircraft Accident and Incident Investigation*", Annex 13 to the Convention on International Civil Aviation, International Civil Aviation Organisation, Montreal.

ICAO (1970), *"Manual of Aircraft Accident Investigation"*, Fourth Edition, International Civil Aviation Organisation, Montreal.

ICAO (1948), "*Manual of Aircraft Accident Investigation*", First Edition, International Civil Aviation Organisation, Montreal.

Heinrich (1931), *"Industrial Accident Prevention",* McGraw-Hill, New York

Hudson P. (2000), *"Safety Management and Safety Culture: The Long Hard Winding Road"* Proceedings of the First National Conference on Occupational Health and Safety Management Systems, University of Western Sydney.

Hudson P. (2010), "*Rethinking Safety: It's not Rocket Science, It's Much Harder*", 2010 Dr Eric Wigglesworth AM Memorial Lecture, Safety Institute of Australia, Melbourne.

Johhnson W. (1973), "*The Management Oversight and Risk Tree – MORT*", U.S Atomic Energy Commission, Washington DC.

Kletz T. (1993), "*Lessons from Disaster: How Organizations Have No Memory and Accidents Recur",* First Edition, Gulf Publishing, Houston

Lundberg J., Rollenhagen C. & Hollnagel E. (2009), *"What-You-Look-For-Is-What-You Find – The consequences of underlying accident models in eight accident investigation manuals"*, Journal of Safety Science, Vol10 December 2009 pp1297-1311, Elsevier, Amsterdam

NSC (1946), "*Accident Prevention Manual for Industrial Operations*" First Edition, National Safety Council, Chicago.

NRIF (2009), "*NRI Mort User's Manual* ", Noordwijk Risk Initiative Foundation, Delft.

Oakley J. (2003), "*Accident Investigation Techniques*", American Society of Safety Engineers, Des Plaines.

Ogbuokiri P. (2010), "Aviation Expert Stresses Need for Accident Investigation", http://allafrica.com/stories/201001150306

Paradies, M. & Unger, L. (2000), *"TapRoot®. The system for root cause analysis, problem investigation, and proactive improvement,* System Improvement, Inc, Knoxville.

Reason J. (1997), *"Managing the Risks of Organisational Accidents"*, Ashgate, Aldershot

Rigot B. (2007), "*Lessons Learned from Texas City Refinery Explosion*", Energy Facility Contractors Group, Escondido.

SCSI (2010), "*Certificate Program in Aircraft Accident Investigation*", Southern California Safety Institute, http://www.scsi-inc.com/AAI-certificate.php

Skegg D. (2005), "*The OHS Professional*", Presentation to the 2005 Visions Conference, Safety Institute of Australia, Melbourne

Thomas J. & Bridges W. (1998), "*Exxon's Worldwide Approach to Incident Investigation Training*", International Conference and Workshop on Reliability and Risk Management, Centre for Chemical and Process Safety, New York

Toft, Y, Capra, M, Moodie-Bain, D, Kift, R, Pryor, P, Eddington, I & Joubert, D (2010), *"Safeguarding Australians: mapping the strengths, challenges and gaps toward sustainable improvements in learning outcomes from diverse models of OHS education"*, Australian Learning and Teaching Council, NSW, http://www.sia.org.au/sigs/education/education-projects/education-projects-safeguarding.

UNSW (2009), "*Aircraft Accident Investigation Techniques – AVIA5022*", Department of Aviation, University of New South Wales, http://www.handbook.unsw.edu.au/ postgraduate/courses/2010/AVIA5022.html

USC (2010), "*Aviation Safety and Security Program*", Viterbi School of Engineering, University of Southern California, Los Angeles

Viner D. (1991), "*Accident Analysis and Risk Control*", VRJ Delphi, Carlton

Viner D. (1982), *"Risk Engineering"*, Proceedings of the Victorian Industrial Safety Convention, Vol. 1, pp 49 -63.

VIOSH (2009), "*Graduate Certificate and Graduate Diploma in Occupational Hazard Management*", Victorian Institute of Occupational Safety and Health, University of Ballarat, http://www.ballarat.edu.au/ard/sci-eng/viosh/framework.shtml