AN INFORMATION SOURCE FOR IMPROVING SAFE DESIGN DECISIONS

Prue Howard and Yvonne Toft
Centre for Integrated Engineering Asset Management
Central Queensland University

***Abstract**:* While it is important to recognize that business risk, safety, performance and optimisation depend on the events that occur on the shopfloor, there must be a method for managers to use these issues within their decision making processes. The call for papers for this conference states that "success of our future business endeavours relies not only on information, but establishing which information is relevant, instructive and useful to make increasingly complex decisions." Information that allows organizations to learn from accidents without repeating them will be of vital importance in any sustainable organization.

This paper outlines how a transdisciplinary approach to engineering design, incorporating the disciplines of Engineering, Occupational Health and Safety and the Coroner can help management make decisions that result in safer work environments as well as better products. The paper reports on the process of developing a web based data base that is industrially focused and draws on coronial data to identify design issues that will have safety implications.

The outcome from this project for organisations in general will be an improvement in the products and processes that are made available, and the confidence to know that accidents should not be repeated.

Keywords: design, safety, coroner , OHS,

INTRODUCTION

"*The classic of all design deficiencies which have come to our attention was a combination safety shower and eyewash constructed at a northern missile site. In order to operate the eyewash, it was necessary for a man, who might already be blinded by acid, to put his head in the eyewash bowl and then to turn on the water valve with his right foot. The only problem was that the foot-operated valve was about four feet to his rear and higher than his waist. As an additional feature, if a man did happen to hit the valve, he got a full shower from overhead as well as getting his eye washed out. However, the whole problem became academic in winter because the whole system froze up." (Anonymous, 1959)*

It is generally accepted that practicing professional engineers of the future will require abilities previously not considered 'core' to their professional practice. The Engineers Australia accreditation process (1) indicates that future engineers will need to consider not only the specified operational needs of a system, but also, the abilities, capacity, expectations and understanding of users at all stages of the system life cycle from the concept stage through to

decommissioning (2). According to Jordan (3), effective human interface design will increase the usability and productivity of a system.
Further to this, consideration of 'human factors' will reduce the likelihood of human error resulting in a safer, more efficient work environment for all stakeholders (4).

Australian standards for professional engineering practice (1) seek to embrace the content and process of sustainability. Broadly 'sustainability' in this context is an expectation of practising engineers to ensure that their work does not degrade, and strives to improve, the quality of life for this generation and generations of the future, and should include consideration of the agendas of social equity, ecological quality, and economic prosperity in relation to one another (5). The significance of sustainability in the context of this research is the interrelatedness of the human, economic and other resources in systems planning and design to optimise quality of life. The greatest benefit of ergonomic intervention occurs if integrated as early as possible in the system life cycle, therefore, consideration of the human factor in planning and design, will be significant in terms of human-machine interaction (2).

THE ENGINEERING PROFESSION AND SAFETY

Any or all stakeholders can potentially contribute to accidents related to human error. There is a duty of care owed by designers and manufacturers under common law (6), and workplace health and safety statutes. Legislative breaches can lead to high social and economic costs borne by both the designer, and the business for which the system was developed. Poor safety performance is likely to result in the threat, and potential reality, of increasing litigation.

According to Jordan (7) there is compelling evidence for the benefits of human factors intervention, in terms of cost, with regard to usability of products. The highest return for investment of human factors analysis is at the concept phase of a product. Mayhew (8), found that the benefits would include decreased costs for providing training, customer support, development, maintenance, training time, and also a decrease in user error and user turnover. Other benefits found which can be costed quantitatively, are improved quality of service, increased sales and user productivity.

According to Crofton (5), as a profession, engineering has embraced the concept of sustainability, but to fully realize sustainable development engineers must first develop an understanding of individual and societal needs. The inclusion of human factors into the engineering process can address this understanding. Blockley (9) describes the gap between technical and human factors,

> *There are limits to the technical approach that are often unrecognized. At the scientific level the developments in modern physics, in quantum mechanics… have shown that there are distinct limits to what we know… The social science approach is broadly split into the individual (psychological) approach and the group (sociological) approach. It is often termed the 'soft' approach in scientific discussions. It is typified by informal models...Theories such as … those concerning human error … are descriptive, but nevertheless aid understanding.*

Blockley (9) goes on to argue,

> *…that these two 'world-views' urgently need to be integrated to a common purpose, recognizing that risk and safety are issues lying at the interface between the technical and the social…that the technical/engineering concept of reliability should be replaced by the social science/legal/management concept of responsibility.*

If it is recognized that sustainability balances on the three legs of economic, environmental and social agendas, then it is easily seen that social responsibility is now a vital factor in any engineering decision. When we consider social responsibility, we generally think of the broader area of community issues and neglect the narrower area of the individual.

One way in which the individual can be recognised is within the issue of health and safety. The National Occupational Health and Safety Commission (NOHSC) had echoed that sentiment in identifying safe design issues (including engineering design) as one of five national priorities in reducing death and injury over the next decade. In 2000 NOHSC conducted a review of workplace deaths (10). The review suggested that in Australia there are on average 10 deaths per week in the workplace. A large proportion of these can be traced back to poor design of equipment or systems. Poor design in this case does not mean technically poor, but poor from a user's perspective. Engineers and engineering managers must be aware of the relationship between technical factors and human factors when considering the decisions that they make related to safety in the workplace.

THE CORONER AND SAFETY

The Engineering profession is not the only profession to recognize its responsibility toward health and safety. According to Johnstone (11), about 7500 violent, unnatural or accidental deaths are reported to Australian coroners each year. Of these, approximately 200 are homicides. Johnstone goes on to say that

> *... Whilst the coroner's work in the area of specific unsolved or 'hidden' homicides is important…it is in the area of health and safety that there is a need for a far greater level of work*

Coroners have historically been seen as people who apportioned blame after an accident. Through their work however, it has been realized that many deaths throughout Australia and New Zealand repeated the same root causes and industry was not learning from the deaths of individuals. The Coroner is in a position to investigate deaths, and make recommendations following a death, but is not able to enforce any recommendations.

A TRANSDISCIPLINARY APPROACH TO SAFETY

So here we have two professions who are both aware of their social responsibility in the area of health and safety. One group has the ability to reduce hazards in the community, and one has the ability to identify hazards in the community. This suggests that there should be value in the two professions working together. Once we start considering having various professions working together toward the common goal of health and safety, there is a third obvious group that should be included, and that is the Health and Safety (OHS) professionals. This brings together an interdisciplinary group to address the issues. However if a transdisciplinary approach was used, there could be learning within the professions as well as problem solving.

A transdisciplinary approach is an approach that fosters joint solving of complex problems across science, technology and society. Transdisciplinarity requires that stakeholders participate from the beginning and remain active over the entire course of the project and mutual learning is the basic process of exchange, generation and integration of existing or newly-developing knowledge in different parts of science and society (12).

So how can the professions benefit each other? From the point of view of the engineers and the health and safety professions, what are the benefits of Coronial inquiries, in Australia, for the community? The benefits of in-depth coronial inquiries to the community are many and varied. However we see the principal benefit of 'in-depth' coronial inquiries as being the ability for the Coroner to conduct the inquiry in an interdisciplinary environment, without the burden of apportioning blame. This allows the Coroner to identify the root cause (both direct and system wide failures) of an accident, so that issues can be acknowledged and addressed.

BENEFITS TO ALL STAKEHOLDERS

There are many benefits that can be derived from this approach. The obvious beneficiaries are the workers who stand a chance of working in a less hazardous environment and to go home safely to their families once more. The other winners are the employers who will reap the rewards of good corporate citizenship and the opportunity to make informed decisions based on information that is relevant and instructive.

Benefits to the Engineering Profession

The engineering profession can benefit, by furthering its' understanding of how and why accidents occur, and the nature of safe design. The profession prides itself on improving the human condition and having community interests at heart. Design engineers do not purposefully build hazards into their products and systems. However, there have been many cases of similar accidents or disasters occurring in different products or systems, indicating that designers do not necessarily learn from the past.

High profile disasters that have had similar root causes are the cases such as the Piper Alpha oil platform fire and the Esso Longford explosion (13). Both of these cases had frighteningly similar technical and communication root causes. While major disasters are normally known of and discussed within the industry in which they occur, disasters and accidents with similar root causes can occur in different industries. Accidents involving only one person may not even be heard of outside the workplace in which they occur. Designers need to be aware of previous incidents and disasters.

So how are engineers expected to learn from the past? A designer may be conscientious about health and safety, but how can individual designers be aware of a root cause that occurred in another industry? By learning from coronial reports, the profession can ensure that safer designs are the norm, and so create a safer environment. In doing so, community trust in the profession is enhanced and consolidated.

Benefits to the OHS Profession

Effective Occupational Health and Safety management depends on useful and timely anticipation of hazards in the workplace. The OHS profession is able to use the findings and recommendations of Coroner's inquiries to inform the design of management systems, workplace practice and environments. This allows the profession to assist organizations to learn from accidents without repeating them.

The coroner's cases are also used in the classroom to prompt problem-solving activities that replicate the real situations that students may find themselves in. They are able to practice many of the core skill set, for example, writing legal position papers, investigating accidents, developing an understanding of direct and latent error sources, and applying their knowledge of hazard control. Context is extremely important in OHS education and practice. Learning from Coroner's inquiries allows students and practitioners to hone their skills in a safe and non-threatening environment.

HOW CAN THE CORONER CONTRIBUTE

Both the current and the next generations of the professions must be educated. If cultural change is to occur, then there must be drivers. To do this, the resources must be there for them to learn. The resources include availability of case studies and databases. The use of case studies to demonstrate how people can be injured, and how systems can be designed to ensure they are safe, is vital. The undergraduates also need the opportunity to work in interdisciplinary or preferably transdisciplinary teams. If this is done at undergraduate level, it becomes easier to work in this manner as a graduate.

The outcomes from the Coroner's reports – the recommendations – can provide a stimulus for treating problems at the system level, which has great potential in the prevention of accidents. Engineers have a duty of care to end users of the systems they design under current statutes and at common law. That engineers contribute to human error in systems through latent design error and poor management decision-making is well documented (14). Therefore, the role of engineers can be considered integral to positive outcomes in safety.

Ultimately, it reasonable to expect, that when engineers have a better understanding of the human component in their system designs there will be reduced design related human error, therefore, better health and safety of Australia's workforce and community in general. The 'in-depth' Coroner's inquiries can fill this much needed gap in knowledge.

A further benefit of the 'in-depth' inquiries is that the reports become public domain, and therefore can be used as a source for organizational learning, or simply as a source of identifying issues, particularly in design, that must be addressed so that accidents or disasters are not repeated. An example of this is the Linton Wildfire inquiry and report (15). While the inquiry found the cause of death, it also identified some previously unrecognised flaws within the original design decisions. For example, issues such as identifying exactly what volume of water is needed to be kept in reserve for self-protection of the firefighters, rather than just a percentage of a tank. The rule of thumb that the firefighters worked on was to keep ¼ of a tank in reserve to use as an umbrella for self protection should they find themselves in the path of the fire. As various tankers have different size tanks, using a percentage of the tank means that the different tankers have different levels of self-protection. The coroner's recommendations also highlighted unsubstantiated assumptions as to how much water is actually required for self-protection.

The inquiry also identified that there had been no research to identify exactly how much water was needed for self-protection. In this way, the Coroner's findings and recommendations can inform the future and direction of community centred research. However, the effectiveness of this potential learning is dependant on whether allied professionals are able to access and use the information, and on the quality of the reports.

The outcome for the community in general is then an improvement in the products and processes that are made available, and the confidence to know that accidents should not be repeated. This should be possible where there is a detailed documented analysis of how the event occurred and where the Coroner makes recommendations.

For example, the cause of the series of Mistral Fan fires was identified through the detailed analysis of seemingly unrelated cases (11). It was the Coroner's "bird's eye view" of the commonalities within the cases that led to unravelling the mystery. It is through the recommendations that action is identified and made possible.

HOW CAN THE CORONER'S DATA BE USED?

As a research team we are using the coroner's data for a few purposes. It is currently being used in undergraduate education, and was used for the development of case studies to be used in undergraduate education. However there are many more engineers in industry than are currently being educated, and if the data was made available to them in a useable format, it has the potential to be used to improve the existing design decisions, and management decisions.

User Friendly Databases

If the engineers and health and safety professionals are to learn from the coroners, the information must not only be available, but available in a format that can be accessed and used. Coroner's reports have findings and recommendations that are usually filed and go unimplemented by the vast majority of industry. The company that is affected by the death is usually the only company that implements the recommendations from the inquest. Companies not associated with the death can prevent many failure modes by learning from the death of an individual. The National Coroners Information System, while a commendable project and eminently suitable for its intended purpose, however is not a suitable tool for the designers to use.

If a designer is looking for potential hazards in a new product or system, it would be of great value if they could access a database that identified where accidents had already occurred. As the designer is not usually a typical user, their familiarity with the system can (and does) easily lead to overlooking hazards. While they could work with a health and safety professional to identify hazards, access to databases of previous accidents would only add to the safety of the design. The information in the coroner's reports can provide the basis for such databases.

Current work

This research team is now involved in the CRC - Centre for Integrated Engineering Asset Management (CIEAM). There are currently two projects run by this team that have emerged from that association. They are:

- a pilot project to deliver workshops to industry partners on the use of the coroner's data to prevent accidents through design, and
- a project working with Ford Australia to bring a database of root causes of potential hazards based on coronial data to the Central Queensland University web site.

These projects came about because the Plant Manager and the Corporate Manager of OHS for Ford Australia approached the State Coroner to gain input to setting up a project whereby all industry would learn from the mistakes made in industrial deaths. Ford Australia would set up a database and input all historical data, findings and recommendations from Coroners findings all across Australia. The information would be shared amongst all industries. The State Coroner was supportive of the project and lobbied other State Coroners.

At Ford Australia, a team was formed to establish the techniques for collecting the data, and developing the database. The result is a database that can search on keywords, incident type or incident title. The database's central location was Ford Australia, but it was hoped that a Government Agency would host the database on their web site for all industry to access. CQU has become this partner.

The measurable results from the collection and logging of the data to date is as follows:

- Over fifty cases have been identified and logged onto the database
- Over 300 findings logged
- Over 600 recommendations to avoid industrial death thus far
- Historical data has been loaded from the Australian states of Victoria and South Australia and from New Zealand.

This database has already helped Ford Australia identify the size of manholes as a safety issue. It was identified through deaths in a number of confined spaces that manholes, even if designed to the appropriate standards, could be a hazard particularly in a rescue situation.

Ford Australia as a result of some of the findings and recommendations has reviewed and implemented changes in the following programs:

- Size of manhole covers
- Confined spaces
- Auditing processes
- ECPL procedural review.

Funding has now been obtained to develop and host the Ford database on the CQU website, to allow public information to the information.

The Ford Data Base Project

This project at its most simplest involves taking the Ford Australia database and making it available for all industry to have access to, and benefit from. While this project is being conducted within the OHS/risk management discipline, the underlying processes involved are based within the information/knowledge management realm. The project is taking discrete, objective facts about events (data), and providing it in a format that impacts on the receiver's judgement or behaviour (information).

The purpose of the project is to achieve the following objectives:

i) Making the Ford database available online through the CQU website
ii) Promoting the database to ensure the ongoing reputation, currency and usefulness of the database through the development of a network of industry and jurisdictional champions of the product.

The work of the project includes:

(a) Establishment of a research partnership with Ford
(b) Defining the technical specifications of the Ford database; assessing data integrity, and application platforms
(c) Development of the interface
(d) Negotiate with NOHSC, Engineers Australia and other stakeholders to add links and dedicated web pages to their sites
(e) Use Cooperative Research Centre for Integrated Engineering Asset Management (CIEAM) and other industry links to promote the use of the database
(f) Investigate funding options for the upkeep of the database such as:

- approaching industry partners to provide small cash contribution and to champion the project for their industry type.
- approaching the National Occupational Health & Safety Commission for funding under the Safe Design project action plan
- approach State Government jurisdictions to champion the project
- formally involving CQU OHS and engineering students in the maintenance of the database
- disseminate project collaboration and findings through presentations and publications
- apply for Industry Collaborative and CRC CIEAM funding to match the industry funding to enable a continuing robust network and database

The outputs of the project are:
(a) an online database containing relevant industry data, that is obtained from Coroner's findings
(b) a network that regards the database as essential to the design process and transforms the data into knowledge that contributes to the industry learning.

The project milestones are outlined in Table 1 below.

CONCLUSION

The concept of the three professions learning together as an interdisciplinary group could have positive outcomes for industry and the community. However, the real differences will be seen when the transdisciplinary teams of the three professions start working together to develop and implement solutions. The community problem has been identified – safe products and systems are required. The solution is not so easy. What is required is a cultural change within the professions. While the governing bodies, for example Engineers Australia, may require their members to produce sustainable designs, if the knowledge does not exist, then the outcome is difficult.

Socially robust research in this area will require several prerequisite conditions for success. The most important of these are good quality investigation and reporting, that documents are public domain, and ensuring access to the learning occurs across professions and industries.

It is vitally important that the neutral community partner (the Coroner) has a voice that can provide credible advice and inform change. That the loss of life is not in vain, but that the living can learn from the findings and recommendations, is possibly the greatest benefit for the community. While construction / manufacture and maintenance are important areas of engineering process, it must be remembered that safety is an important component of all of these areas. The focus of the learning experience of this team has been on the use of the risk management process to improve design. This enables engineers to work at the top of the hierarchy of control measures as a first option for elimination of hazards.

The Ford Data Base Project, which is currently in the prototype stage is a tool, that once available to the community in general, should provide the information to allow engineering designers to learn from the past, and to learn from outside their own industry.

MILESTONE PLAN		Organisation: Central Queensland University
Month	Milestone	Project: Ford OHS Database
		Milestone Status
2004 July	Project defined	Funding extension approved by DVC Project defined
August	Quotes from developers	Quote from MDC (and meeting) and HPFM gained Verbal and email agreement from Ford
September		Website structure finalised
October	Developer appointed	HPFM appointed to develop database Ford database content transferred to HPFM
November	Database defined	Document Ford database specifications and information flow
December		
2005 January	Research asssistant	Research assistant appointed for data entry and database coordination
February	Database online	Prototype database online Database usabilty and design evaluated
March		
April	Data usability analysis	Research assistant examined key words, categorisation and data entry functionality
May	Prototype completed Launch planning Project repoting	Updated prototype completed Launch and workshop budget developed Updated project report for Coroner and CIEAM Feedback to Law Committee on the Victorian Coroner's Act Victorian Coroner to report on database to other coroners
June	Data validation Business planning	Data scrubbing and validation Costed 3-year business plan
July	Access to new data	Data entry of new cases and continuted testing to commence Meeting with Vic Coroner and MUNCCI
August	Launch preparation	Liaison and logistics with CIEAM for launch Paper written for Victorian coroner for inclusion in InQuest journal
September	Media/PR	Media release/PR kit
October	Launch Ongoing support	Launch website and conduct workshops on database use Approach to stakeholders about ongoing support
November	Promote database Regaional industry launches	Promotional materials for key stakeholders across relevant industrys, including information on how to link to the site Launches for industry specific groups at other CQU campuses
December	Targeted support	Ongoing anlaysis of database users and targeted marketing to their organisations

Table 1 Ford Data Base Project Milestones.

~~CONCLUSION~~

~~The concept of the three professions learning together as an interdisciplinary group could have positive outcomes for industry and the community. However, the real differences will be seen when the transdisciplinary teams of the three professions start working together to develop and implement solutions. The community problem has been identified – safe products and systems are required. The solution is not so easy. What is required is a cultural change within the professions. While the governing bodies, for example Engineers Australia, may require their members to produce sustainable designs, if the knowledge does not exist, then the outcome is difficult.~~

~~Socially robust research in this area will require several prerequisite conditions for success. The most important of these are good quality investigation and reporting, that documents are public domain, and ensuring access to the learning occurs across professions and industries.~~

~~It is vitally important that the neutral community partner (the Coroner) has a voice that can provide credible advice and inform change. That the loss of life is not in vain, but that the living can learn from the findings and recommendations, is possibly the greatest benefit for the community. While construction / manufacture and maintenance are important areas of engineering process, it must be remembered that safety is an important component of all of these areas. The focus of the learning experience of this team has been on the use of the risk management process to improve design. This enables engineers to work at the top of the hierarchy of control measures as a first option for elimination of hazards.~~

REFERENCES

1 Institution of Engineers, Australia *Institution of Engineers Australia Accreditation Manual*, IE Aust: Canberra. (1999)

2 Kirwan, B. and Ainsworth, L. A guide to task analysis. Taylor and Francis, London, (1992)

3 Jordan, P. W. An introduction to usability. Taylor and Francis, London (1998)

4 Sanders, M. and McCormick, E. J. Human factors in engineering and design. 7th edition. McGraw-Hill International Editions, Singapore (1993)

5 Crofton, F. Sustainable development and engineering, Key Note Address at the Waves of Change: 10th Australasian Conference on Engineering Education, 28 – 30 September, (1998)

6 Johnstone, M. Occupational health and safety law and policy: text and materials. Law Book Company Limited, Sydney, (1997)

7 Jordan, P. W. An introduction to usability. Taylor and Francis, London (1998)

8 Mayhew, D. J. Principles and guidelines in software user interface design. Prentice-Hall, Englewood Cliffs (1992)

9 Blockley, D. I. Hazard engineering. in C. Hood, and D. Jones, (Eds). Accident and Design. UCL Press Limited, London (1996)

10 National Occupational Health & Safety Commission *Work-related fatalities associated with design issues involving machinery and fixed plant in Australia, 1989 – 1992,* National Occupational Health and Safety Commission: Sydney. (2000)

11 Johnstone, G. Now and then! *'In Quest', The Journal of the Australasian Coroners Society Inc*, Issue 1 pp 28 – 46. (2002)

12 Klein, J., Grossenbacher-Mansuy, W., Haverli, R., Bill, A., Scholz, R. Welti, M. *Transdisciplinarity: Joint problem solving among science, technology, and society*, Birkhauser: Basel (2001)

13 Johnstone, G. *Inquest into the deaths of Peter Brubeck Wilson and John Francis Lowery and the fire at Longford Gas Plant Number 1* , State Coroner's Office, Melbourne. (2002)

14 Toft, Y. *The relationship between professional engineering education and ergonomics,* Masters Research Report, School of Public Health, Queensland University of Technology. (1999)

15 ~~15~~ Johnstone, G. *Report*, State Coroner's Office, Melbourne. Retreived from http://www.coronerscourt.vic.gov.au/CA256902000FE154/Lookup/Coronial_Findings_of_Importance/$file/LintonWildfire.pdf) (2002)