Fact Sheet

Human Factors in Urban Water System Safety

In recent decades the attribution of incidents and accidents to human or organisational error has steadily increased. This rise can be explained by the impact of technological advances on human operators. Modern systems managers can be put at risk from increased reliance on mechanical, electrical and information-processing components of systems, along with increased system complexity coupled with the poorly-defined role of human operators in the control loop. Therefore, the human element in complex socio-technical systems is rapidly gaining greater importance to the study and application of risk and safety management.

Contemporary thinking in human factors characterises human error as a consequence, rather than a cause, of system failures. Analyses of industrial accidents with human error contributions always show that multiple safety barriers at organisational, technical and operational levels are breached before fragments of human error can take place.

Many industries now recognise the need to integrate human factors research and principles into their overall risk management schemes, especially in relation to operational judgments and behaviour concerning risk perceptions and responses.

The Urban Water Security Research Alliance (the Alliance) was engaged to examine the interactions of human operators and technology in the South East Queensland (SEQ) Water Grid.

A clear need for this research was highlighted by circumstances surrounding organisational changes to the ownership and operation of SEQ Water Grid assets. It was also spurred on by the occurrence of recent incidents reported by the SEQ water sector in which human error was identified as a contributory factor. These incidents were the North Pine Water Treatment Works Fluoride Dosing Incident in April 2009, and the Pimpama-Coomera Dual Reticulation cross-connection incidents of December 2009 and January 2010.

Fortunately, no significant compromises to public health and safety resulted from these events, but they have revealed potential vulnerabilities in the sector and provided opportunities for investigation from a human factors perspective.

Background

The study into human risk factors is becoming a popular approach in many industries, but to date, there has been limited exploration of these issues within the water sector. This Alliance project sought to obtain a better understanding of the human element in the water sector, thus leading to better risk management practices and making a valuable contribution to research literature.

The SEQ urban water system has undergone rapid organisational, technical and planning system changes in recent years due to the Millennium Drought and the growing pressures of economic growth and urbanisation in SEQ. Coping with growth, new technologies and with the implementation of new standards, has placed pressure on water professionals.

The restructuring of organisational roles added additional issues, such as clarity of roles at each organisational level of the system and the need for shared capabilities in rapid and coordinated responses.
This project was conducted through two stages to address the changing character of the urban water system in SEQ and the types of risk factors that may be linked to the organisation of work processes.

First, the project team examined a range of key research questions and developed a program to address relevant issues. Their aim was to increase productivity and efficiency, as well as maximising the safety and health of teams who work within the water sector’s highly pressured environments.

Alliance researchers compiled a targeted literature review on human factors practices in the water sector, utilising internal documents and incident reports. They also conducted interviews with key representatives of relevant water organisations, as well as with control room staff during an observational tour at the Mt Crosby Eastbank water treatment facility.

The initial research assessed elements such as communication and training, supervision, responsibilities and procedures.

The possibility that the urban water system could learn important lessons from this work led to the second phase of our project, which focused on interactions between humans and technology.

This research targeted operations in control rooms for both water treatment and distribution, with a particular focus on the operators’ experiences with alarm systems, human machine interfaces and automation, to help better manage and understand risks associated with the human element.

The output included a review of best practice for interface design and integration for automation and new technologies in other high reliability industries such as power generation or food manufacturing. The issues of older and younger workers and the potential problems with information overload from multiple alarms and warnings were also reviewed.

Results indicate several opportunities for improving aspects of control room design and work practices, which would bring the SEQ Water Grid into line with best practice in other process-control industries. Implementing these changes would ultimately reduce the likelihood of human error.

Research outcomes to date

The Alliance determined that the impact of human error on the water sector is similar to patterns of risk in other high-hazard, high-reliability industries.

The first phase of this project provided an overview of human factors issues in the urban water sector. The research found little published research literature that considered human element issues in water systems. Despite this, there has been a great deal of potentially useful human factors work done examining system safety in other domains.

Vulnerabilities at all levels of participation in the sector were revealed. At higher levels, a pressing concern was communication, both within and between water grid entities. The perception among interviewees was that this deficiency in communication stemmed from rapid organisational change, namely, changes in asset ownership and the creation of new roles, as well as shifts in responsibility for strategic and operational decision-making.

Such change had created an environment of relatively low trust and left many in the sector unsure of the limits of their authority. Communications with, and between, stakeholders was identified as a concern among a majority of interview participants.

Concerns were also expressed over the:

- size of the current SEQ water grid;
- potential redundancy of many smaller-capacity water treatment plants;
- post-amalgamation consideration of the possible decommissioning or integration of assets; and
- complexities of connecting grid assets to an integrated distributed control system, or at the very least, facilitating communication between independent control systems.

Technology-related factors raised included potential system vulnerabilities from the variations in age, quality and sophistication of treatment technology.

The research focused on operator experiences with alarm systems, human machine interfaces and automation to help better manage and understand risks associated with the human element.
During the more detailed second phase of this project, the key topics addressed by Alliance researchers included an operator’s response to alarm systems, elements of human-computer interaction and the influence of the extent of automation.

The research found considerable room for improvement in human factors issues such as alarm handling and interface design.

They found that there is considerable room for improvement in human factors issues such as alarm handling and interface design. The socio-technical reach of operations varied depending on the age and modern sophistication of the technology, the nature and complexity of the operators’ roles, and – importantly – the necessity and urgency of change.

A human factor element in need of significant attention to improve water grid efficiency and reduce risk is the operator interfaces that suffer from a lack of consistency and integration.

Also of concern were scenarios when tasks were not appropriately delegated to human operators and system automation. For example, up to 50% of an operators’ time was spent manually maintaining an inefficient and potentially highly disordered log.

Alliance research has helped advanced knowledge of the role, importance and risk mitigation of human factors in urban water system safety, which should lead to improvements in efficiency and stability of system function.

Future research opportunities

This project provided an encouraging initial assessment, but it is recognised that an ongoing process is required to optimise the way in which workers interact with broader system components, especially in times of rapid change in the industry.

Further task analyses, participatory designs, application of human factors expertise, and iterative testing are needed.

Many other facets of risk management in the water sector deserve further scientific attention. Selected opportunities specific to urban water systems include:

Communication – Inter- and intra-organisational communication issues need to be further assessed to clearly understand the perceived impact of broader organisational factors, especially in the context of restructuring. The efficiency of communications, the sharing of information across entities and the procedures for communication between maintenance and operations staff were noted as key issues worthy of further investigation.

System integration – Studies could be pursued to identify potential system vulnerabilities arising from the improper integration of new or different technologies, which is also linked to organisational changes. Integration of different technologies, the appropriateness of alerting systems in control rooms, the investigation of operator error both retrospectively (through incident reports and detailed interviews) and prospectively (through human error audits).

Best Practice transferable from other industries – Initial Alliance research determined that the impact of human error on the water sector is similar to patterns of risk in other high-hazard, high-reliability industries. Therefore, the water sector would benefit from a comprehensive review of best practice in other industries.

Testing of Emergency Procedures – A review of documented emergency management procedures could be undertaken relatively easily, testing procedures through desktop simulations.

Further information

More detail on the above research can be found in a number of publications at www.urbanwateralliance.org.au

Contact details
Professor Brian Head
The University of Queensland
Ph: +61 7 3346 7450
Email: Brian.Head@uq.edu.au