Technical expertise as a contributing factor in three disasters

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Serious questions about the way some engineering activities were managed have arisen from coronial inquiries and government investigations into three major fatal accidents — the Royal Canberra Hospital implosion, the fire on the HMAS Westralia, and the gas explosion at Esso's Longford facility. Analysising the reports reveals that a lack of technical expertise, a failure to assess the competencies of contractors, and inadequate engineering practice were contributing factors in each of these accidents.

While this paper has an engineering and contracting focus, this does not mean that these were the only or even the most critical factors contributing to the disasters. As with most accidents, the failure cannot be attributed to one individual or group. Instead the system failed and the failures involved many players and factors.

However this does not diminish the importance of the lessons drawn from this analysis. Every group of specialists should analyse the causes of the diasters from their perspective and publicise their findings. This way individuals working in any area can identify the lessons that have the most relevance for them.

What went wrong

A brief summary of each disaster is provided below.

Royal Canberra Hospital implosion

On 13 July 1997, the Royal Canberra Hospital was demolished by a planned implosion. A 1kg fragment of steel expelled during the implosion killed a spectator who was 430 metres away from the hospital among a watching crowd of over 30,000. The project director was the government-owned enterprise Totalcare (TCL), the project manager/contract superintendent was Project Coordination (PCAPL), the demolition contractor was City & Country Demolitions (CCD), and the explosives sub-contractor was Controlled Blasting Services (CBS). The CBS explosives sub-contractor and shot-firer, Rodney McCracken, was committed for trial for manslaughter by gross negligence in December 1999, and the CCD demolition contractor, Tony Fenwick, was committed for trial in February 2000 for being knowingly concerned in the commission of that offence by Rodney McCracken.

HMAS Westralia ship fire

A fire occurred in the main machinery space of HMAS Westralia on 5 May 1998, which resulted in the death of four personnel. The fire was caused by diesel fuel from a burst flexible hose spraying onto a hot engine component and then igniting. The hose was one of a number of new flexible hoses supplied by the ship's support contractor, ADI Limited, to replace the original rigid pipes (Department of Defence, p. 216).

Esso Longford explosion

On 25 September 1998 at 12:26pm, a heat exchanger in Longford's Gas Plant 1 fractured, releasing hydrocarbon gases and liquid. The resulting explosions and fire killed 2 Esso employees and injured 8 others. The heat exchanger failed when hot lean oil at 230°C was reintroduced to the chilled vessel, which had fallen to −48°C. The introduced lean oil set up stress and caused a brittle failure. Full gas supply to customers was not restored until 14 October 1998 (Parliament of Victoria, pp. 11-12).

Lack of technical expertise

In all three accidents, a lack of technical expertise was identified as contributing to the tragedies. The expertise was either lacking in the contract managers and contractors, or unavailable when required.

RCH Implosion

In the hospital implosion, the ACT Coroner found that the officers appointed by the government-owned project director, Totalcare (TCL), to manage the contractor were asked 'to undertake a function well beyond their experience, qualifications and skills' (ACT Coroner 1999B, p. 41). Specifically, the Coroner found that the representative of TCL '…was nominated as a supposed expert and was under significant pressure from certain Government officials to provide advice particularly as to the viability of the implosion being staged as a public event' (ACT Coroner 1999A, p. 655) however he did not '…have the requisite technical experience to be providing sound and reliable advice' (ACT Coroner 1999A, p. 655). This was despite the Coroner's view that '…TCL had the technical expertise or at least were in a position to acquire that degree of expertise for the project' (ACT Coroner 1999A, p.393).

The lack of expertise is vividly illustrated in the risk assessment document prepared by the Project Manager in consultation with TCL staff. The Coroner said that: 'None of those persons possessed any knowledge or experience in the implosion technique and [they] were unqualified to prepare a true risk assessment of the demolition. The so-called risk assessment plan was a failure. The plan did not address the issues that were required by such a scheme, e.g. the specific methodology to be used, the experience of the contractor in undertaking similar implosions of similar buildings and finally, the protective methods intended to be used. The risk assessment plan assumed that the implosion would be safely conducted because other implosions had been safely conducted'(ACT Coroner 1999A, p. 268).

HMAS Westralia fire

In analysing the decision to replace the rigid fuel pipes with flexible hoses on HMAS Westralia, the Naval Board of Inquiry found that there was no competent authority either within the Royal Australian Navy or the Project Manager, ADI, which 'critically examined the wisdom of the intended course of action' (Department of Defence, p. 197).

It concluded that: 'Key personnel within the RAN, and more particularly ADI Limited, were not adequately trained or qualified for the responsibilities placed on them' (Department of Defence, p. 216). For example, the Westralia officer who was responsible for management of HMAS Westralia's maintenance had not been trained in contract administration and had only completed a 2-3 day financial training course and a basic purchasing course (Department of Defence, p.194).

Longford Explosion

In analysing the Esso Longford explosion, the Royal Commission identified that access to technical expertise was limited and this may have contributed to the explosion. In 1992, Esso relocated all its plant engineers to Melbourne as part of restructuring. The Royal Commission noted that: 'The change appears to have had a lasting impact on operational practices at the Longford plant. The physical isolation of engineers from the plant deprived operations personnel of engineering expertise and knowledge which previously they gained through interaction and involvement with engineers on site. Moreover, the engineers themselves no longer gained an intimate knowledge of plant activities' (Parliament of Victoria, p. 209). The Royal Commission concluded that: 'The reduction in supervision at Longford, including the transfer of engineers to Melbourne, necessarily meant a reduction in the amount and quality of the supervision of operations there. There was a correspondingly greater reliance by Esso on the skill and knowledge of operators. While it is not possible to discern any direct connection between the level of supervision and the accident on 25 September 1998, the Commission considers that it was probably a contributing factor' (Parliament of Victoria, p. 236).

Failure to assess the competencies of contractors

The failure to fully assess the competencies of contractors and sub-contractors was identified in both the hospital implosion and HMAS Westralia fire reports.

During the examination of the hospital implosion, the ACT Coroner strongly criticised the selection process of the contractors and subcontractors. He found that the government-owned Project Director, Totalcare, 'should never have allowed the Project Manager, PCAPL, to proceed beyond the expressions of interest stage without ensuring it had the credentials to assess the quality of tenders, especially in the implosion method' (ACT Coroner 1999A, p. 121). The Coroner reinforced this view when he wrote that the advertisement placed by PCAPL calling for expressions of interest in the hospital demolition 'was not only narrow but poorly worded in so far as it did not contain words that might attract experts in the implosion method' (ACT Coroner 1999A, p. 153) and this 'reflects the poor decision made by TCL in permitting a continuation of PCAPL as the Project Manager into a realm where the company had no experience'.(ACT Coroner 1999A, p. 154).

The Project Manager, PCAPL, was also critised for its selection process failure. The Coroner stated that '…TCL did not, as a matter of procedure as a Project Director, impose any external checks on the expertise or ability of the proposed successful tenderer, prior to accepting PCAL's recommendation. … TCL and PCAPL failed as a matter of procedure and care to vet or require appropriate level of information from those tendering. These failures should never again be allowed to occur' (ACT Coroner 1999A, p. 172). 'There was a failure on the part of everyone present [TCL and PCAPL] to ensure that adequate objective checks of the contractor and explosives expert had been undertaken prior to approval of PCAPL's recommendation of the successful tenderer.'(ACT Coroner 1999A, p. 173).

Another example of the failures was that 'PCAPL and TCL failed to ensure as they had directed that the new engineer had experience in the implosion techniques using explosives. No independent check was made as to who the engineer was and his qualifications' (ACT Coroner 1999A, p. 329).

The net result was that the contractors did not have required skills. The ACT Coroner summed this up by stating that: 'There is no escaping the fact that the project did not have the benefit of the relevant expertise in explosives or engineering capabilities'(ACT Coroner 1999A, p. 157).

The Coroner linked the death of the spectator with the selection process for contractors and sub-contractors when he wrote that: 'The process by which those persons were appointed, was connected to that death' (ACT Coroner 1999A, p. 182). 'Although there were varying degrees of responsibility the inescapable conclusion is that these poor work practices of PCAPL and TCL in the appointment process permitted two persons to be assigned to the demolition project who were entirely unqualified for the task' (ACT Coroner 1999A, p. 182).

In analysing the HMAS Westralia fire, the Board of Inquiry concluded that the contractor may have not given the competency of the sub-contractor the appropriate attention. This was because the sub-contractor presented himself as a representative of a franchising hydraulic hose fitting organisation which was known to be a supplier of high performance industrial hoses and held a quality system certification to Australian Standards AS3902 (Department of Defence, p. 182). The representation 'implied a depth of expertise and knowledge which the Sub-contractor could not, and did not, provide' (Department of Defence, p. 187), according to the inquiry.

Inadequate engineering process

In both the hospital implosion and HMAS Westralia fire, contractors failed to deliver accepted engineering process. This is illustrated in the examples below.

In analysising the HMAS Westralia fire, the Board noted that the decision to replace rigid fuel lines with flexible hoses should have been processed through the Royal Australian Navy's configuration change process as well as being approved by the ship's classification society, Lloyds Register. According to the Board, 'both processes were bypassed, largely as a result of ignorance and incompetence' (Department of Defence, p. 216).

The report noted that 'the formal RAN configuration change process is circumvented at times, generally by well intentioned personnel, and this can have a severe impact on safety' (Department of Defence, p. 198). However 'to be on the safe side, all changes to ships should be subjected to a rigorous change process, but this approach ignores the imperatives of schedule, common sense and initiative' (Department of Defence, p. 197).

It advised that 'the key to the right approach is good professional engineering judgement. Ideally, this would be exercised in the first instance by the initiator of the potential change but a professional engineering authority should validate it before work is set in train.' (Department of Defence, p. 197). As a result of the inquiry, it was recommended that all engineering work should only be authorised by a competent professional engineering authority.

Regarding the hospital implosion, the ACT Demolition Code of Practice required that an independent structural engineer and an explosives demolition expert be engaged on the hospital implosion project. This was ignored which meant that no independent cross checking of the work on the contractor and sub-contractor was carried out.

This failure was also identified by the ACT Coroner as contributing to the disaster.'The Acton Peninsula project failed systemically in that: … (e) the project did not have the benefit of a structural engineer and an explosives demolition expert in accordance with the Demolition Code of Practice both independent of the contractor, sub-contractor, project director and manager – that is two experts at arm's length from the total demolition process.' (ACT Coroner 1999B, p. 40).

Lessons learned

From a contracting and engineering perspective, there are five significant lessons to be learned from the disasters.

Lesson 1: be an informed buyer

The disasters have highlighted the need for the buyer to be informed. This is essential so that the buyer is able to select and justify the option which offers best value for money; manage risks; select and justify an innovative solution; and prevent unscrupulous contractors taking advantage of the buyer's lack of knowledge.

Being an informed buyer requires two distinct skill sets: contracting expertise and subject matter expertise. For engineering goods and services, the subject matter knowledge required is engineering technical expertise. Access to technical expertise is becoming more critical with the general reduction in technical staff within organisations, and the devolution of power to individual plants and individual staff. In addition, with the increase in the size of contracts due to cluster contracting and the increasing technological complexity of operations, there is a corresponding increase in the financial loss that can result from uninformed decisions.

For engineering contracts, different types and depths of technical expertise are required for each stage of the contracting process. For example in the first stage of a contract, which involves identifying the activity to be contracted, technical expertise is essential to rigorously identify the desired functional levels, performance levels and constraints; identify the full range of probable technical solutions; and advise on the risk, cost and functional/performance tradeoff of all options. When the project moves to developing the tender documents, technical expertise is necessary to develop appropriate criteria so that a trade-off can be made between the functionality, performance, risk and cost of each proposal.

The need for technical expertise does not necessitate that an engineer is the contract manager. The view that engineers must manage technical contracts as they are the only ones to understand technical issues does not address the fundamental issue. Nor does the counter argument that engineers who manage technical contracts always strive for gold-plated solutions. The discussion needs to move past these stereotypes to recognise that both contracting skills and technical skills must be brought to bear in all contracts and this is the only way to maximise value for money.

Similarly the debate on where it is best for organisations to obtain technical expertise — either in-house or to contract it in — is not productive.

Making technical expertise readily available in the most cost-effective manner involves four stages:

- examine the good or service to be procured to determine the level of technical expertise required to be an informed buyer
- evaluate the relevant existing level of in-house and external technical expertise available
- undertake a cost benefit analysis of in-house versus contracted-in expertise at each stage of the contracting process
- obtain and where appropriate, retain the required expertise

The critical issue is that the client must have access to technical expertise when it is required and that they realise when they do not have the necessary expertise and should contract it in.

Lesson 2: ensure technical advice is utilised

It is obvious that technical expertise is of no benefit unless it is used. There are a number of reasons why engineering expertise may not be sought or utilised and these include that the advice will not be understood, that the advice will advocate a 'gold-plated' technical solution which ignores commercial realities, and that the organisation's structure will prevent expertise from being accessed by other parts of the organisation.

An example of the last reason was identified in the Federal Government inquiry into the unsatisfactory Collins-class $4.3 billion submarine project. 'The technical competencies required for the project are generally available, but in certain areas, have been made unavailable by the structure of the contract or the interests of the parties...' (McIntosh, p. 8).

Lesson 3: undertake comprehensive competency assessment of contractors

The reports into the disasters identified the need to ensure that only competent contractors and sub-contractors are selected. The ACT Coroner recommended that to minimise the risks to public safety in future public works projects '…any claims made by the tendering body as to their ability to meet any special requirements must be independently and objectively checked before the letting of the contract'.(ACT Coroner 1999A, p. 495-6). The Federal Government report into the Collins class submarine project stated that one of the lessons learned was the need to validate the technical expertise of contractors. 'Defence should ensure that the prime contractor and the subcontractors have the technical, financial and managerial expertise to carry out the project and to respond to likely risks' (McIntosh, p. 38).

There appear to be several reasons why competencies are not checked or inappropriate contractors are chosen. These include a lack of time, a lack of effort, inappropriate selection criteria and choosing contractors on price alone.

In the case of the hospital implosion contract, a lack of time for contractors to assemble the information required to make an informed tender bid was clearly identified. According to the Coronorial report: 'The tenders for Stage 1 of the project opened on 3rd March 1997 and closed on 18th March 1997. It was not until 13th March 1997 that the structural drawings provided to those on the short list were made available by way of addendum to the tender documents…It will be recalled that Canberra Day was a Public holiday and fell on Monday 17th March 1997. Effectively this meant that the tenderers had only one working day after the probable receipt of the structural drawings, to inspect the site in any depth as to the steel mentioned in the columns and then to price their tender to take account of the size and quantity of steel in the columns in Stage 1. In the circumstances this was clearly an inadequate amount of time.' (ACT Coroner 1999A, p. 163-4).

Selecting contractors on the basis of lowest price is a major problem for government contracts and probably private sector contracts also, as identified in a survey undertaken by the IEAust in January 2000 (IEAust, p. 3).

According to public servants involved in engineering contracts, 10% of contracts worth a net value of $7 billion were awarded on the basis of lowest upfront cost.

Industry tendering to government believed it was actually 4 times higher at 33%. There are a number of methodologies designed to ensure that the prime selection criteria is overall value for money rather than lowest cost. These include Value Management, Qualification Based Selection, pre-qualification schemes and registration schemes. Value Management does this by providing a flexible process for contract delivery that allows and encourages contract changes to be made easily and as early as possible, if they can improve the contract's value for money. Qualification Based Selection (QBS) does this by determining the price only late in contract negotiations. Pre-

qualification schemes do this by limiting the potential contractors to those who meet range of agency-determined attributes. Registration schemes do this by ensuring that potential contractors are competent and ethical.

Lesson 4: follow proper engineering process

The disasters illustrated the consequences of not following proven engineering, contracting and safety processes. These processes, such as risk management or OH&S regulations, were invariably developed after years of experience and thoughtful improvement. Bypassing these proven processes or rationalisating them by eliminating cross-checking and supervision to save time and money can have exactly the opposite effect. The consequences of failing to follow established safety procedures are seen in both the hospital implosion and Esso Longford explosion.

In the hospital implosion, ACT WorkCover did not follow established safety processes when it failed to ensure that the explosive workplan required by the Demolition Code of Practice was met, and that it failed to scrutinise departures from the original demolition workplans and to issues appropriate prohibition notices in accordance with the OH&S Act to ensure the methodology was safe not only to the workplace employees but also to the public at large (ACT Coroner 1999A, pp. 273-274). As a result of these findings, a review of WorkCover occurred.

According to Tom Sherman, who was commissioned by the ACT government in December 1999 to assess the ACT Government response to the Coroner's Report, 'WorkCover now has good procedures in place for monitoring the use of explosives in the ACT. Blasting Plans have to be submitted and those plans are vetted by an independent expert. Post-blast reports are also required.

I am reasonably confident that the procedures, skills and culture now in place in WorkCover provide good prospects for effective regulation of the use of explosives' (Sherman, p. 33). However he noted that changes to a system alone are not sufficient to ensure that established processes are followed. 'The best legislation and contracts will be of little use if those responsible for the monitoring compliance with workplans fail to carry out their tasks' (Sherman, p. 343).

In the Esso Longford explosion, there was a failure to carry out a Hazard and Operability Study (HAZOP) which was common practice in the process industry. 'Esso recognised the particular significance of a HAZOP study for Gas Plant 1 (GP1), given the age of the plant, the modifications made to its initial design and the changes to design standards since the plant was built. These reasons grew stronger with the passage of time. Indeed, a HAZOP study for GP1 was planned to take place in 1995 and the cost of such a study was included by Esso in successive budgets during the years 1995 to 1998' (Parliament, p. 203). The Royal Commission identified that the failure to undertake this process was a contributing factor to the disaster. 'The failure to conduct a HAZOP study or to carry out any other adequate procedure for the identification of hazards in GP1 contributed to the occurrence of the explosion and fire.' (Parliament, p. 235).

Lesson 5: contractors may have a broader responsibility than the specific wording of their contracts

The findings on the hospital implosion and HMAS Westralia ship fire have indicated that individuals and contracting organisations may have a broader responsibility than the specific wording of their contract. The inquiries' views on this issue are far from clear cut. They depend very much on individual circumstances and are yet to be tested in court.

In assessing the work of the structural engineer in the hospital implosion, the Coroner concluded that 'it is no excuse to simply make the claim that his role was one of a consultant and not that he was engaged or retained in a supervisory role' (ACT Coroner 1999A, p. 372). One of the recommendations of the Coroner was that this engineer's 'right to practice as a professional engineer be further examined by the appropriate professional body' (ACT Coroner 1999A, p. 374). The IEAust noted that the engineer was neither on the National Professional Engineers Register nor a member of the IEAust. Therefore he is not bound by the IEAust's Code of Ethics nor subject to the IEAust disciplinary processes, which means it is not possible for the IEAust to review his right to practice. This may not be the end of this issue as the Sherman report which assessed the ACT Government's response to the Coroner's Report, released on 14 February 2000, noted that 'I recently discussed this matter [i.e. the engineer's right to practice] with the Director of Public Prosecutions. He advised me that he proposes to refer this matter in the near future' (Sherman, p. 22).

The Sherman report also contained some opinions on the responsibilities of various parties in cases where the contract is unclear. 'It is evident from a reading of the Coroner's Report that there was much confusion and disagreement on the roles and responsibilities on the Action Peninsula project. The Project Manager in construction/demolition contracts has the responsibility to engage and supervise the work of contractors. Equally, Project Directors and clients cannot completely shed their responsibility. If a Project Manager is not ensuring that contractors are appropriately qualified and skilled and is not ensuring the contractors are doing their work as the contract requires, then Project Directors and clients must bring them to account or at least have expert consultants who are capable of doing so. It is important that contractual provisions set out the roles and responsibilities of the parties clearly. But no contract, however well drafted, guarantees that work will be done properly. Contracts have to be managed and supervised properly. Also I don't believe it is productive to engage in lawyer-driven correspondence on the meaning of contractual provisions. There are circumstances where this may be appropriate but in most cases a more effective result is likely to come from discussion of problems.' (Sherman, pp. 32-33).

In the HMAS Westralia inquiry, the Navy Board noted that while the contractor was not specifically requested to do an engineering analysis in replacing the rigid hoses with flexible ones, the contractor 'had a general obligation as the engineering contractor to make a proper engineering assessment of the proposal taking all factors into account. The standard of that consideration should have accorded with the engineering expertise and 'world class' which ADI claims.' (Department of Defence, p. 179).

Although not a contractual issue, the Code of Ethics for professionals may have a bearing on interpretation of their responsibilities, regardless of the contractual wording. For example, the Tenets of the Code of Ethics for the Institution of Engineers, Australia's include 'members shall at all times place their responsibility for the welfare, health and safety of the community before their responsibility to sectional or private interests' and 'members shall apply their skill and knowledge in the interest of their employer or client for whom they shall act as faithful agents or advisers, without compromising the welfare, health and safety of the community'.

This broad interpretation of what is expected of contractors, despite the

wording of their contracts, means that they need to keep an eye on the overall project as well as undertake their own work. The implications of this include that a defence based on the strict wording of a contract may not always be accepted, contractors should only practice in their area of competence regardless of what the client may want, contractors must document any concerns they have about their work, and contractors must insist that proper engineering processes are followed.

The view that contractors may have a broader responsibility than the specific wording of their contract has profound implications. Resolution on this issue in a general contractual sense will take many years.

Conclusion

This paper has identified a number of common factors from an engineering and contract management perspective in the Royal Canberra Hospital implosion, the fire on the HMAS Westralia, and the gas explosion at Esso's Longford facility.

In addition, these disasters raise a number of broad issues about engineering management not addressed in this paper. These include questioning accepted management wisdom such as the use of non-technical generalists to manage technical activities; reducing the number of specialists on the basis of often arbitrary benchmarking; and solely relying on quality assurance rather than supervision.

Many other non-technical issues have also been identified as contributing to the disasters including a lack of operator knowledge, failure to undertake systematic hazard identification, and the employment of inadequate incident report systems which focus on high frequency low severity events while ignoring low frequency high severity incidents.

Much more work needs to be done to analyse these disasters from a range of specialist perspectives. While these disasters have been tragic, a far greater tragedy will result if more analysis is not done and we all fail to learn from these failures.

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A more detailed examination of the issues raised in this article can be found in the publication, 'Government as an informed buyer: Recognising technical expertise as a crucial factor in the success of engineering contracts', published by the IEAust in January 2000, and available from *www.ieaust.org.au/government.* Athol Yates is currently compiling a database of contracting, policy and regulatory disasters where a lack of specialist advice was a contributing factor. If you have Australian examples of these, please contact him.

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