

An AcciMap of the Esso Australia Gas Plant Explosion

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Abstract

This paper presents an AcciMap (causal diagram) of an accident at Esso's gas plant at Longford in Victoria. The AcciMap is used to show how factors quite remote from the immediate accident sequence contributed to the accident. Parties at the Royal Commission which investigated the accident were quite selective in the causes they emphasised. The paper identifies three principles of selection which were used: self-interest, accident prevention and legal liability. The interested reader will find full details of this accident in my book (Hopkins, 2000)

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On 25 September, 1998, an explosion occurred at an Esso gas plant at Longford, near Melbourne, which killed two men and interrupted the gas supply to the state of Victoria for two weeks. Because of the economic cost of this disruption the state government set up a Royal Commission - the most powerful inquiry possible. The inquiry uncovered an intricate causal network, ranging from front line operator error right back to company and even government policy. This paper will outline the causal network by providing an AcciMap of the incident (Rasmussen, 1997). A number of features of the map will be explained in the next sections. The paper will then examine the strategies of causal explanation used by the parties represented at the inquiry.

The accident sequence

Level 1, the bottom level of the diagram, lays out the events - physical processes and operator actions - which constitute the accident sequence. The two irregular stars represent the critical outcomes - explosion and loss of gas supply. The circles represent the operator errors which contributed to the accident. The sequence starts with the incorrect operation of a bypass valve which allowed condensate to spill over into other parts of the system eventually causing the failure of the warm oil pumps. This led to a metal heat exchanger becoming super cold and therefore brittle. Operators then made the error of restarting the warm oil flow which caused the heat exchanger to fracture, allowing a large volume of gas to escape and ignite. Two men were killed and eight others injured. Two other gas processing plants on the same site were not effectively isolated from gas plant 1 where the accident occurred, with the result that gas supply from all three plants at the site ceased. And because there was no alternative supply, Victoria was in chaos for two weeks.

Increasing causal remoteness

The vertical axis involves a series of levels, increasingly remote from the accident sequence just described. There is a certain amount of arbitrariness in the division into five discrete levels, but the basic principle is - the more remote the cause, the higher up the diagram it is located. The five levels are physical, organisational, company, government/regulatory and societal.

The causal connections

The arrows in the Figure 1 are to be understood as meaning cause in the following sense. One thing is said to be a cause of another if we can say: *but for* the first, the second would not have occurred.

Defining cause in this way has various consequences. First, there is a theoretically unlimited number of factors or circumstances giving rise to any particular event; those represented here are ones which came to light at the Royal Commission. It should be acknowledged, too, that not all the causal factors identified in the inquiry are dealt with here. In particular, metallurgical causes have not been included.

Second, the definition implies that had any one of these causal pathways in the diagram been absent the outcome would probably not have occurred. In particular, where more than one arrow enters a box, all are necessary preconditions. There is an implied logical AND in the diagram at such points.

Third, this notion of cause involves imagining an alternative (counter-factual) situation and inferring how things would have turned out had this imagined situation existed. Obviously this is a speculative exercise and we are strictly only justified in speaking about likely or probable outcomes. Most of the causal statements implied in the diagram need to be understood as qualified in this way.

Drawing an AcciMap has the particular advantage of clarifying the nature of the causal chains leading to the accident. It shows precisely how events or conditions quite remote from the accident amounted to essential preconditions. In the next section of the paper I should like to trace some of these chains, and readers will need to refer continually to figure 1. I shall not provide a complete explanation of the diagram; readers wanting more detail should consult Hopkins (2000)

The absence of engineers

Bourrier (1998) has shown how one way of ensuring high reliability operation in hazardous facilities is to maintain relatively large numbers of engineering staff to oversee the work of plant operators. Where procedures need to be modified to get the job done, engineers can supervise the modifications to ensure that there are no unintended consequences. Where qualified engineering staff are absent, plant operators are likely to modify procedures themselves in ways which may not be optimal and which may lead, in the long run, to disaster.

This is what happened at Longford. Engineers who had been previously been employed on site were withdrawn in 1992, as part of a cost cutting strategy. Changes to plant design, which were made after that time, turned out to have problems, which were not properly addressed by engineers from head office in Melbourne. Moreover, the absence of engineers meant that plant operators were not properly supervised. The result was that in order to deal with the problems they were encountering, operators were forced to run the plant routinely in alarm mode. This de-sensitised them to the significance of alarms and led to an operator error, "incorrect bypass valve operation", which initiated the accident sequence.

A further consequence of the absence of engineers on site was that there was no-one to warn plant operators against reintroducing warm oil into the super cold heat exchanger.

The AcciMap, then, shows how the absence of engineers contributed in a complex and multi-stranded way to the explosion.

Focus on LTIs

Esso measured safety by its lost-time injury rate. It was extraordinarily successful in reducing this figure effectively to zero. But the consequence of this emphasis was that the company paid insufficient attention to the management of major hazards. The AcciMap highlights just how this focus on LTIs led to the accident.

First, it distorted maintenance priorities. Equipment which was judged to be safety-critical was given a high priority. But since the safety focus was on LTIs, the judgements were about whether the equipment breakdown was likely to cause routine slips, trips and falls. No attempt was made to ascertain whether the breakdowns might affect plant safety. The result was that a valve which was critical for plant safety was left unrepaired for two weeks, requiring operators to operate a bypass valve manually. Incorrect manual operation began the accident sequence.

There was a second way in which the focus on LTIs contributed to the accident. The incident reporting system was used to report incidents which caused or had the potential to cause LTIs. It was not used to report process upsets which had the potential to endanger the whole plant. Thus, one month before the accident, there was an incident involving loss of warm oil flow and abnormally low temperatures, so low that ice formed on pipes normally too hot to touch. By good luck rather than good management, this incident did not lead to disaster. Unfortunately, it was not reported in the incident reporting system. Had it been, it would have been thoroughly investigated and steps taken to prevent a recurrence. The steps would have involved new procedures about what to do in the event of loss of warm oil flow, and training in the those procedures. Had this training and been provided, the crucial mistake of restarting the warm oil system would not have been made on the day of the accident.

Poor auditing

A major audit by Exxon prior to the explosion gave Esso a clean bill of health. It was an audit which failed to convey any bad news to Esso's board of directors. Any audit which conveys only good news is a bad audit. Two particular failures will be mentioned here. First, although the audit examined the incident reporting system, it failed to notice that the system was not being used to report major process upsets, not even system shutdowns.

Second, the audit failed to pick up that a basic hazard identification procedure, called a HAZOP (hazard and operability study), had not been carried out at gas plant 1 where the accident happened. The two other gas plants on the site had been HAZOPed, but despite an Exxon policy introduced in the early 90s in favour of HAZOPing all existing plants, Esso deferred indefinitely a plan to HAZOP gas plant 1, on the grounds of cost.

Had this HAZOP been carried out, it would have identified the possibility of the loss of warm oil flow and the consequent embrittlement of certain metal pressure vessels. The

recognition of this danger would have led to the development of procedures and training to deal with the possibility, and this certainly would have precluded the operator error which triggered the explosion.

Exxon control failure

Exxon operated a policy of decentralising responsibility for safety. Although it encouraged Esso to HAZOP its plants it did not exercise any control over subsidiary companies in such matters and so, Esso was free to defer the HAZOP of GP1 indefinitely.

Furthermore, gas plants 1, 2 and 3 were tightly connected and the explosion at the first put the other two out of operation for two weeks. This led to total loss of gas supply to the state of Victoria for two weeks. Esso had failed to identify the hazards of interconnection and Exxon had failed to instruct its subsidiary in this regard. The hazards of interconnectedness were highlighted in the Piper Alpha explosion, where gas from other platforms fueled the fire on Piper Alpha. This is exactly what happened at Longford: gas from other plants fueled the fire in gas plant 1. Exxon's policy of decentralising responsibility for safety meant that Esso Australia was free to ignore this critical lesson from Piper Alpha.

The inadequate regulatory system

To claim that a regulatory system was a cause of an accident may seem artificial. I shall show in what follows that it was, indeed, a cause in the "but for" sense. The legislation which applied at Longford was the Victorian Occupational Health and Safety Act which emphasises self-regulation and seeks to minimise prescription. On the other hand, both upstream of Longford, in the offshore oil fields, and downstream of Longford, in the Victorian gas pipeline system, safety case regimes applied. A safety case regime requires that employers make a case to a regulatory authority showing how they have identified all hazards and describing the control strategies which have been adopted. Had such a regime been in place at Longford itself, it would almost certainly have resulted in Esso carrying out a HAZOP of gas plant 1 which would have identified the hazards which led to the explosion. Moreover, the federal government had recommended the safety case regime be implemented at major hazard sites like Longford, but the state government had not done so. It is on this basis that it can be said that: but the failure of the state government to impose a safety case regime on Esso at Longford, the accident would not have occurred.

Government failure to provide alternative gas supply

Esso was the only supplier of gas to the state of Victoria and the state was therefore very vulnerable to any loss of supply from Longford. Although the government accepted responsibility for security of supply, it had not developed storage reservoirs in Victoria or any pipeline connections with suppliers interstate, which would have enabled temporary interruptions of supply from Longford to be dealt with. One party at the Commission

argued that the government's failure in this respect was due to its ideology of privatisation and small government. This particular argument was not supported by the evidence and is indicated by a dotted line in the diagram.

Market forces

At the top of the diagram, is what I have termed the societal level. We live in an increasingly global, capitalist society in which competition and the market affect most aspects of our lives. Market forces generated sustained cost-cutting by Esso throughout the 1990s which contributed to the accident in a number of quite specific ways. It was the reason engineers were withdrawn from the Longford site; it was the reason for the maintenance backlog; and it was the reason why the HAZOP of gas plant 1 was deferred indefinitely. Each of these contributed to the accident in ways which have already been discussed.

The impact of market forces on safety at Esso's Victorian gas plant was part of a much broader pattern. In the UK, the oil industry formalised its drive to reduce costs in what was called the Cost Reduction in the New Era (CRINE) initiative. CRINE sources asserted that "capital and operating costs have continued to escalate ... (and) unless urgent action is taken to reverse this trend, the future of oil and gas development in the UK North Sea will be in serious jeopardy" (quoted in Whyte, 1997:1151). The threat was from the international market place, in particular, cheaper production costs in Mexico, Vietnam, the Maldives, China, Indonesia and Malaysia. Toombs and Whyte (1998) argue that that resources available for safety in the North Sea increased in the aftermath of the Piper Alpha disaster in 1988 but that the cost cutting associated with CRINE saw a reduction in safety-related spending and a consequent impact on safety.

Moreover, the cost-cutting imperative drove large corporations in the 1980s to decentralise (Baram, 1997), which meant that head offices handed over responsibility for safety to operating subsidiaries. Consequently, in matters of safety, companies like Esso Australia were not subject to effective control by their parent company.

Principles of Selection

Numerous parties were represented at the Royal Commission and none of them acknowledged all the causal factors identified above. In their closing submissions, each emphasised particular causes. The rest of this paper explores the principles of selection, or "stop rules" (Rasmussen, 1990) which they used. Three distinct principles will be discussed below and can be summarised here as follows.

- * Self-interest: select causes consistent with self-interest
- * Accident prevention: select causes which are most controllable
- * The legal perspective: select causes which generate legal liability.

self interest

Where parties had financial or reputational interests at stake, this guided their selection of cause above all else. In particular, those seeking to avoid blame or criticism focussed resolutely on factors which assigned blame elsewhere, and denied, sometimes in the face of overwhelming evidence, the causal significance of factors which might have reflected adversely on themselves. Esso blamed the whole accident on errors by plant operators and denied that any of the organisational failures uncovered by the Commission played any role in causing the accident. On the other hand, counsel for Esso's workforce blamed the whole accident on Esso's negligence.

The Insurance Council of Australia was likewise guided by financial interest in identifying negligence by Esso as the cause of the accident. The interruption of gas supply to Victorian industry had caused more than one billion dollars worth of damage, and much of this was borne by insurance companies. They were thus out to recover from Esso and had a strong interest in a finding of negligence against Esso by the Commission. They therefore emphasised causes at level 2 of the diagram

Finally, the Victorian government was politically vulnerable to any criticism that government policy might have contributed to the loss of supply. Both the government and the regulatory agency responsible for health and safety were represented at the inquiry. Both argued that Esso alone was responsible for the accident and that neither the government, nor the regulator, nor even the regulatory system was in any way to blame. Again the causal focus was at level 2

It is obvious that parties with direct interests will be guided by these interests in their selection of causes. Only where the participants have agendas not based on immediate self-interest, can other principles of causal selection come into play.

accident prevention

A second principle was followed for participants whose primary concern was accident prevention. It was to focus on causes which are controllable, from the participant's point of view. Counsel Assisting the Commission adopted the accident prevention approach and viewed the task of prevention from the perspective of management. He therefore emphasised causes at the organisational level, since these are within the capacity of management to control. He had little to say about causes at higher levels and, interestingly, nothing to say about the physical causes at level 1.

The peak labour council in Victoria was also concerned about accident prevention. It had no direct influence over Esso and therefore no capacity to bring about the kinds of management changes in Esso which might prevent a recurrence. However, it did have the potential to influence government and government agencies. Its strategy, therefore, was to seek changes in the regulatory system which would compel Esso and similar companies to improve their management of safety. This was the point in the causal

network where its intervention was likely to be most effective. Hence it emphasised the inadequacies of the regulatory system as the cause of the accident.

The legal perspective

The Royal Commissioners themselves adopted a third principle of selection, namely to focus on causes which generate legal liability. The Commission was asked under the terms of reference to consider whether breaches by Esso of relevant legislation had contributed to the accident. The factors which most directly created legal liability under the Victorian OHS Act were lack of appropriate training and procedures to deal with the problem of loss of warm oil flow. Accordingly, the Commissioners found that these were the “real causes” of the accident. The special status of these causes is indicated on the AcciMap by the use of an octagonal box. The Commissioners recognised most of the other factors sketched on the AcciMap, but they described them as “contributing factors”.

It needs to be noted that, for some parties, more than one of these principles was at work. For the Insurance Council of Australia, for example, the principle of self-interest coincided with the principle of selecting causes which generated legal liability.

Exclusions

Principles of selection are necessarily also principles of exclusion. Two causes identified above were not selected for emphasis by any of the participants - market forces and Exxon’s hands-off approach. This is worth elaborating.

Exxon was not a party to the proceedings, nor was its contribution to the accident investigated, partly because of the way the terms of reference for the inquiry were drawn. Although Exxon’s management style was, as I have argued, a critical contributing factor, none of the three principles invited a focus on Exxon’s contribution by any of the parties.

The other factor ignored by all parties, despite the fact that, in an important sense, it was the ultimate cause of the disaster, was the market. There are obvious reasons for this blind spot. Capitalist society is a given – the taken-for-granted context of the world of work. There is no realistic prospect of cutting ourselves off from global, market society in the interests of accident prevention. Moreover, many would argue that, for other reasons, such a course of action is not even desirable. There was therefore nothing to be gained for any participant by drawing attention to this ultimate cause.

However, the market is a cause which governments motivated by accident prevention concerns would do well to acknowledge. Cost-cutting pressures stemming from market forces are pervasive and inevitable. It is these pressures which led to the organisational failures which have been identified. Safety depends, therefore, on bringing to bear countervailing pressures, and this is the role of government, via its regulatory system. It is vital that governments adopt regulatory strategies with the potential to over-ride cost-cutting imperatives so as to ensure that companies adopt and effectively implement the necessary management systems.

Conclusion

This paper has demonstrated the value of the AcciMap in describing the chains of causation which led to the accident at the Esso Longford gas plant. It has shown, too, that interested parties chose from among three principles in deciding which causes to emphasise: self interests, accident prevention and legal causation.

The strict “but for” logic used in constructing this particular AcciMap means that breaking any one link in the network of causation would probably have averted the accident. AcciMaps constructed according to this logic are therefore useful tools for anyone interested in accident prevention. They suggest a wide variety of ways in which accidents can be prevented. Moreover, they suggest ways in which people at many different locations both inside and outside the organisations concerned can contribute to accident prevention. Some writers have argued that the complexity of the accident causation process makes accidents inevitable (Perrow, 1999). The implication of the AcciMap analysis is that this very complexity is what makes accidents so preventable.

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Figure 1 - AcciMap of Esso Gas Plant Accident

