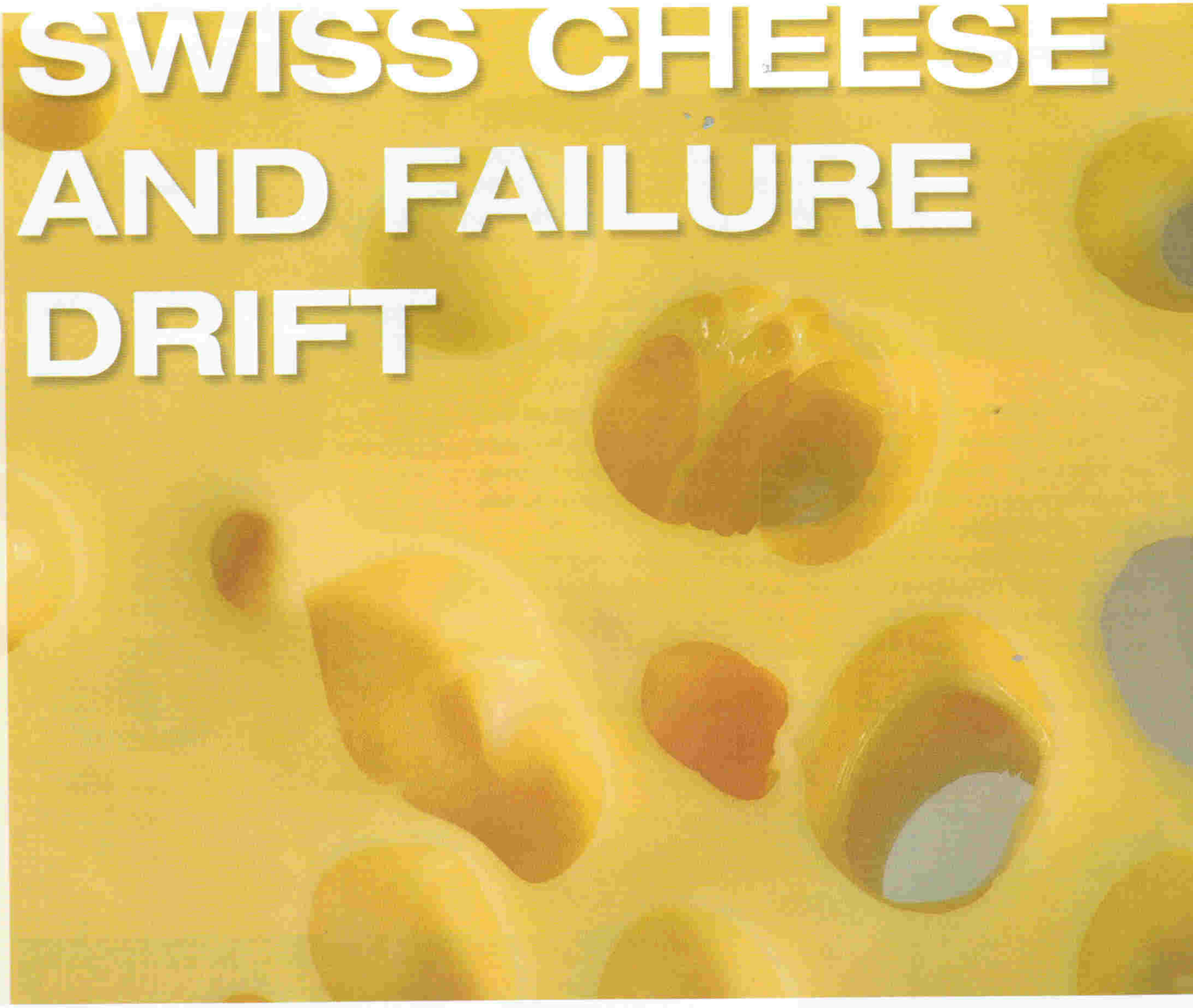
SWISS CHEESE AND FAILURE DRIFT



LEARNING FROM OUR MISTAKES

What do the Erebus plane crash and leaky building syndrome have in common? Both are "organisational accidents" with many contributing causes. Andrew McGregor tells CHARLOTTE STAPLETON how understanding these causes can help us prevent accidents in other organisational contexts.

ENGINEERS INVESTIGATE ACCIDENTS, engineering failures and mistakes to assist the process of apportioning loss or preventing a recurrence. Andrew McGregor MIPENZ, a consulting mechanical engineer and experienced accident and engineering failure investigator, says that "people naturally assume that there is always a 'root cause' and a single person or entity to blame". His experience as an accident investigator suggests otherwise: "there is seldom a root cause and, contrary to initial appearances, there can be many significant causes which are generated within the depths of an organisation or regulatory body". Regrettably, however, it is often easier to blame and take action against individuals rather than organisations.

Recent advances in the field of accident causation have yielded two models that help us understand why large organisational accidents happen: James Reason's "Swiss Cheese" model and Sydney Dekker's "Failure Drift" model.

Models

Both models maintain that large organisational accidents have several causes rather than a single, root or primary cause.

In the Swiss Cheese model, an accident occurs when successive defences are penetrated. Defence deficiencies are like the holes in layers of Swiss cheese – they must all line up for anything to pass right through, that is, for an accident to occur. Many of these "holes" represent underlying or latent causes which begin early in the life of an organisation and may lie dormant until the final catastrophic event (or active cause) occurs.

Failure Drift highlights the insidious and incremental nature of these causes. This model emphasises that human error is a symptom of trouble deeper inside a system. It is necessary to understand how people's assessments and actions would have made sense at the time, in the particular circumstances. Investigators must reconstruct the mindset of the organisation and individuals concerned.

The Erebus plane crash and leaky building syndrome (LBS) are both organisational accidents with multiple incremental and insidious causes. Although they occurred in entirely different contexts in different eras, their causes still have remarkably similar features.

Erebus

The Erebus crash in November 1979 emerged as one of the world's first acknowledged "organisational accidents". During the investigation process the causal model changed from an individual or root cause model, to one acknowledging multiple causes, reflecting a paradigm shift that is still in process today.

The Erebus accident was first investigated by the Ministry of Transport. This investigation attributed the cause of the accident to the captain descending below the minimum safe altitude of 16,000 feet, and continuing the flight in poor visibility when he was unsure of the aircraft's position.

Soon after, the government commissioned a Royal Commission of Inquiry. Justice Peter Mahon's findings not only disagreed with the Ministry's report but cleared the captain of blame, attributing it to Air New Zealand. He accused Air New Zealand's management of conspiring to lie, coining the famous phrase "an orchestrated litany of lies".

In contrast to the Ministry's report, Justice Mahon concluded that the weather was fine at the time, atmospheric visibility was good, and Mt Erebus was not shrouded in cloud. Moreover, Air New Zealand had altered the course that was programmed into the aircraft's navigational computer without advising the captain of the change.

Believing the aircraft to be in McMurdo Sound, the pilots interpreted the geographical features around them in relation to what they expected to see. This mindset, in conjunction with the whiteout phenomenon that rendered Mt Erebus invisible, allowed the crew to mistake their position, fail to see the mountain in clear air ahead of them, and crash into it. In essence, the pilots couldn't see that they couldn't see.

In all, Justice Mahon cited as many as 10 factors that contributed to the crash, any one of which could have prevented the accident. Although he specified a primary cause – the airline's act of changing the aircraft's programmed course without telling the crew – he found that the blame rested with the organisation, not an individual.

Although the Privy Council to some extent negated Justice Mahon's conclusions, they have been accepted by the International Civil Aviation Organisation, which is responsible for regulating international aviation.

Leaky building syndrome

Mr McGregor says that the Swiss Cheese and Failure Drift causation models can also help us understand the organisational and human factors that contributed to LBS, which last surfaced in the 1990s.

LBS is caused by the ingress of moisture through a building's external membrane into its timber framing, leading to fungal activity, timber decay and health risks for the building's users. Mr McGregor estimates its final cost to industry is difficult to ascertain but is likely to be in the order of $10 billion, not $1 billion as is frequently asserted in the media.

In leaky buildings, water penetrates the Swiss Cheese "holes" created not just by untreated timber, but also by an absence of eaves, cracking of plaster cladding at the joints, absent or inadequate flashings, and walls that do not incorporate a free drainage cavity between the cladding and supporting framework.

This is not the first time the country has experienced leaky building problems – they've spanned several decades of

New Zealand's history. During the 1920s, houses were lowered to emulate the Californian bungalow – unfortunately, to the extent that under-floor ventilation was compromised. While this problem was fixed, a large number of homes deteriorated extensively.

In the '20s and '30s, the supply of native timbers began to be depleted, forcing the building industry to consider using inferior timbers such as radiata pine. In 1939 the Department of Scientific and Industrial Research investigated options for treating radiata pine against wood rot and insect attack. Subsequently treatment of radiata pine timber framing with boron was introduced.

Stucco plaster claddings became popular in the 1940s and 1950s. However, many houses with these claddings leaked at cladding joints and those without eaves leaked the most. Architectural preference then shifted to brick and tile buildings, which were comparatively weathertight because of their relatively wide eaves and the clear drainage space between the brick walls and structural frame.

During the oil crisis of the 1970s, building insulation was inserted into the walls of buildings to conserve energy. However, this reduced the drainage and ventilation effect of the wall cavity. By 1990, the requirement for wall ventilation was removed from New Zealand Standard 3602.

In the mid-1980s, the Timber Preservation Authority, which regulated the treatment of timber, approved an alternative ammonia-based timber preservative for decking. This failed and resulted in hundreds of rotting decks. In the context of increasing deregulation the Authority was disbanded in 1987, limiting any future government liability. During this period funding to the New Zealand Standards Association was also significantly reduced; and to this day professional contributions to the Association are still made on a voluntary basis.

In the mid- to late-1980s, several New Zealand commercial buildings suffered weathertightness problems related to aluminium curtain-wall joinery. Polystyrene-based claddings were also introduced, followed by the re-introduction of stucco and the development of fibre-cement coatings.

In the early 1990s the Building Industry Authority was set up to monitor the building control system established by the Building Act 1991. It was involved in promulgating the Building Code, accrediting building products and processes, and approving building certifiers.

During the same period sought-after internal finishes required timber framing to be kiln-dried to reduce its moisture content from 24 per cent down to 16 per cent. With such a low moisture content, the risk of borer attack or wood rot was deemed negligible, and boron treatment was considered unnecessary.

In August 1995, NZS 3602 (1995) permitted the elimination of boron timber treatment. This last incremental step in the Failure Drift process precipitated the nationwide problem that we know today as leaky building syndrome.

Lessons

Both the Erebus crash and LBS demonstrate how multiple factors contribute to organisational incidents.

The whiteout phenomenon that deceived the Erebus pilots exemplifies the insidious nature of Failure Drift. In the case of LBS, Failure Drift spanned the best part of a century and extended beyond the lives of the various bodies set up to prevent it. "These were cut short by political restructuring and mercenary cost-cutting," says Mr McGregor. As a result, regulators and code writers were unable to preserve and promulgate the lessons learnt by their predecessors, and therefore lacked the vision necessary to mitigate the incremental failure risks of actions such as relaxing boron treatment.

Mr McGregor argues that in attempts to address LBS, new legal controls have been implemented without a comprehensive analysis of its underlying causes. The introduction of new laws implies a belief that LBS was caused by the negligence of industry practitioners, not the absence of comprehensive design standards and specifications which the industry looks to for guidance, and which could have been supplied had the government provided sufficient resources.

Charlotte Stapleton *is Subeditor at IPENZ Engineers New Zealand.*

The ideas presented in this article are explored in more detail in *Accidents, Failures, Mistakes and Leaky Buildings* which can be downloaded from www.prosolve.co.nz