# Of fires and explosions, trains and boats

*The trains and boats …*

*Took you away, away from me.*

(Bacharach, 1966)

### *The Canadian disaster*

The build-up to the disaster was, as usual, spread over months. Perhaps years.

Regulatory agencies didn't notice the changes in the transport of dangerous goods (their nature, quantities, etc). Those responsible for the cargo and its transport didn't carry out an adequate risk assessment – if they had even heard of the term. The emergency services had no idea what they might face and how best to respond to an emergency. Politicians thought they were "doing the right thing". And none of the people living in the Canadian town were aware of the looming combination of causes.

But the final few minutes of the build-up must have been like slow-motion in a disaster film.

On 7 December 1917, two ships, the *Imo* and *Mont Blanc*, collided in the narrows leading to the port of Halifax in Nova Scotia. A small fire was ignited and rapidly involved the explosives and other munitions on the *Mont Blanc*. Within minutes, nearly 3,000 tonnes of mixed explosives detonated resulting in perhaps 4,000 deaths and many injured, severe damage all buildings within 1600 metres, two tornadoes and a tsunami. The tsunami washed away a nearby settlement and burning debris from the blast set fire to other buildings. The *Mont Blanc* was all but destroyed and other ships were severely damaged (Cawthorne, 2004; Kennett, 1975; MacDonald, 2005).

Lessons were learned, and after the war maritime rules about dangerous cargoes were strengthened and other rules about the control of ships clarified; stricter requirements for the storage of munitions were also introduced.

### *The train disaster*

With maritime transport differing from rail transport should we expect it to have a better safety record? Given the record of derailment and disaster, perhaps not.

The train was travelling at speed when it derailed at about 11.48 pm. One tank was punctured by an I-shaped steel bar and the contents spilled, flowing downhill into basements, cellars and drains. Within a few minutes an explosion and severe fire destroyed houses and other buildings, killing 31 people.

The cause of this train crash in Viareggio, Italy on 29 June 2009 seems not to have been finally confirmed. Suggested causes include an axle failure, damaged tracks, defective brakes and poor maintenance of the tank wagons (Brambilla & Manca, 2010; Landucci et al, 2011; Manca & Brambilla, 2010). However, the tragedy illustrates some of the risks of carrying LPG and other dangerous goods by rail.

Wikipedia has more details at *http://en.wikipedia.org/wiki/Viareggio_train_derailment*.

For New Zealand readers, the Viareggio disaster should cause some discomfort: four local derailments of LPG rail wagons have happened over the past 10 years, one in the centre of Dunedin. Readers elsewhere may find their own examples of derailments of wagons carrying dangerous goods.

### *Lac-Megantic, Quebec, Canada train disaster*

And so we come to the July 2013 Lac-Megantic disaster. At the time of writing, investigations were in progress and legal action still to start. So the following thoughts are adapted from media reports and very preliminary; they may need revision when the full facts are available (Anon, 2013; Crary, 2013; Gordon, Ljunggren, & Guttsman, 2013; Ljunggren & Haggett, 2013; Valdmanis, Huffstutter, & Gordon, 2013).

The reported facts seem simple. The 500 metre-long freight train of 72 tank cars pulled by five engines was loaded with crude oil. It was parked overnight on a gently sloping track near Lac-Megantic. As usual, the train operator set the handbrakes on the five engines and left one of the five engines running to power the air compressor that fed air to the air brakes. That engine caught on fire and the local fire brigade attended, turned off the engine and extinguished the fire. Reportedly, they also told the railway company despatcher about the fire. Shortly afterwards, the train began rolling

down the slope toward Lac-Megantic, 11 km away. By the time it reached a bend with a 15 km/hr speed limit it was estimated to be travelling at 100 km/hr. The train derailed and tank cars piled on top of each other; some were three deep. At least one must have been punctured and volatile gases or oil ignited. Perhaps some of the five or six explosions reported were due to overheating of intact tanks "cooked" by burning oil spilled from one or more punctured tanks.

Wikipedia has more details at http://en.wikipedia.org/wiki/Lac-M%C3%A9gantic_derailment.

The fault tree in Figure 1 represents some of what is known about the Lac-Megantic disaster. Comment on the fault tree follows.

The top event was the fire and explosions following derailment. Using the "triangle of fire", we know that a fuel must combine with an ignition source in the presence of oxygen if a fire is to occur. In this case it was a given there would be an ignition source somewhere in Lac-Megantic. Oxygen was freely available and also a given. The nature of the crude oil in the 72 tank wagons is uncertain but once spilled was the fuel. Thus, there was a high probability a spill of oil would be ignited resulting in a fire. Once the spilled oil was burning some of the intact tanks may have "cooked" until they exploded.

The cause of the derailment? The train was travelling at about 100 km/hr when it reached a bend with a 15 km/hr speed limit. It therefore had considerable kinetic energy. Why was it going so fast? The hand brakes and air brakes had failed, either because of a mistake, a skill-based error or a rule violation (Reason, 1990, 1997). There has also been a suggestion the handbrake was tampered with.

In a 1991 US Department of Transport study such tanks were reportedly found to be prone to puncturing in a derailment. Subsequent research for the US National Transportation Risk Assessment highlighted risks associated with bulk rail and road transport of toxic, flammable and explosive materials (Hwang, Brown, O'Steen, Policastro, & Dunn, 2001). This 2001 study confirmed earlier findings by Glickman & Rosenfield (1984) who looked at catastrophic release of hazardous goods following derailment. Did anyone connect these studies and ask "could a rail tanker carrying flammables travel uncontrolled at speed, derail, and the tank contents ignite and/or explode?".

Hindsight here is cheap, perhaps another example of Taleb's black swans?

> *First [the black swan] is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact .... Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable.*
>
> *[To] summarise the triplet: rarity, extreme impact, and retrospective (though not prospective) predictability. (Taleb, 2010, p. xxii)*

And yet, Annex A of ISO 31000 includes as attributes of enhanced risk management:

> *A.2.1 The organisation has a current, correct and comprehensive understanding of its risks.*

Surely, if an organisation transports dangerous cargoes it carries out modelling of the outliers and considers disasters that have occurred as well as the implausible that have yet to occur? And what about applying Structured-What-If-Then analysis for the consequences of foreseeable events?

Discussion has already started about safer ways of transporting bulk hazardous substances. The Canadian rail regulator now requires trains carrying dangerous goods to have a two-man crew and parking such trains unattended on a main line has been prohibited.

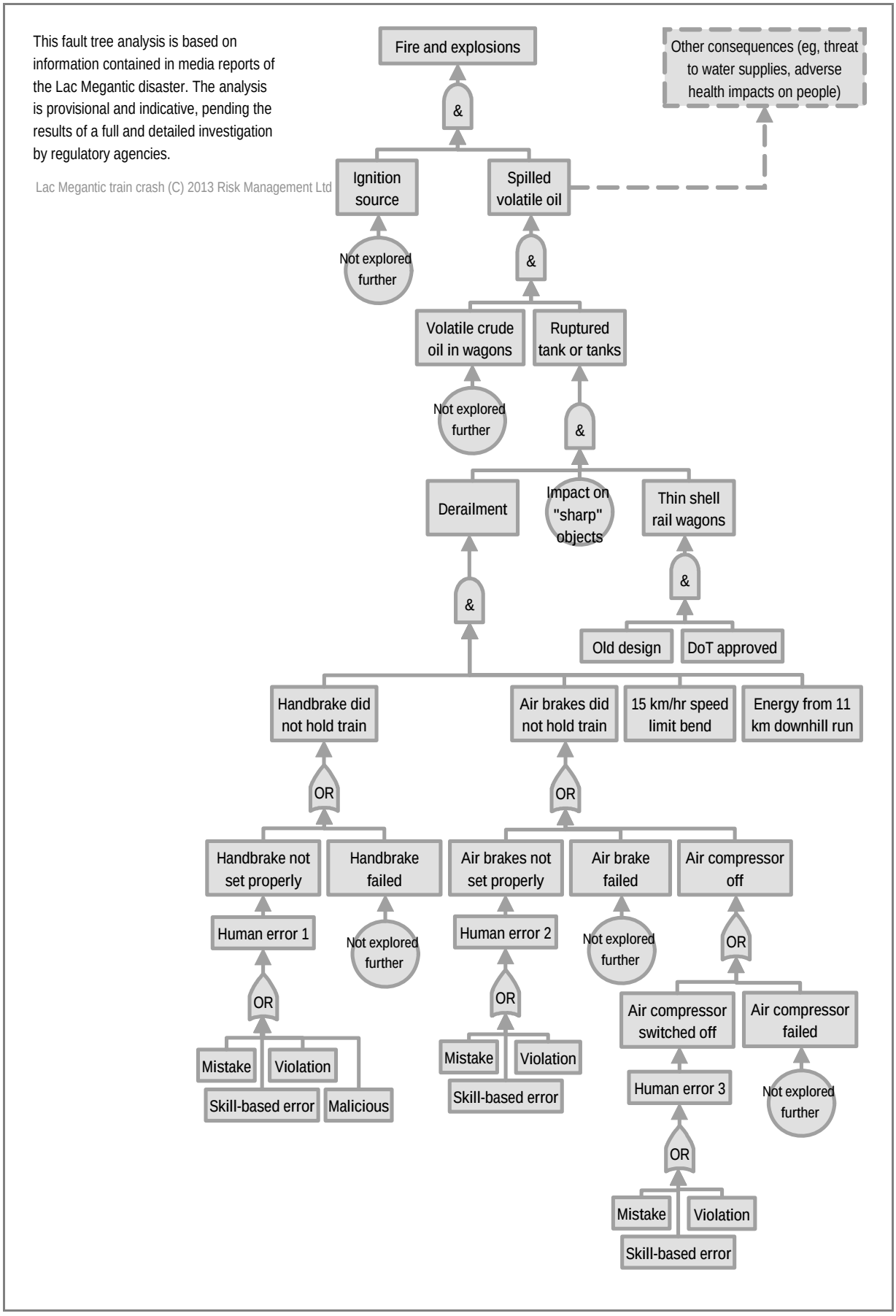
But will politicians have the courage to either prohibit transport of dangerous cargoes by rail through towns or to require the construction of pipelines for goods such as crude oil and LPG?

### *The past revisited – again*

So we come to Santayana (1905).

"Those who cannot remember the past are condemned to repeat it".

**Figure 1. Tentative fault tree analysis for the Lac-Megantic disaster**



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