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Strategic Asset Management

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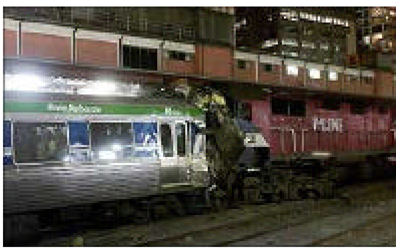
Columbia shuttle explodes!

Is it an accident at launch, or the age of the shuttle that is responsible? (Feb 1, 03)

Derailment at Waterfall kills 8

Is it speed, poor maintenance, design of the Tangara train, sabotage or heat-buckled tracks that is the answer as to why? (Jan 31, 03)



Driverless Train travels 15K,

crashes into stationary passenger train

How did it happen? Why did the fail-safe braking system fail? Why was the train not re-routed? Why were the passengers on the stationary train not disembarked? (Feb 2, 03)

Problem Solving

Should we be looking for a 'one point' solution?
In all of the media reporting there is a tendency to look for a 'one point' solution. But what if the problem is more complex than this? Infrastructure assets are complex systems and when they fail it is likely that they fail in complex ways.

Is it even clear what "the problem" is?
For example, in the Spencer Street Station "ghost train" that crashes into a passenger train, what is the problem—that the train was able to travel for 15K unattended? - that it was not re-routed safely? That the passengers in the train that was hit were not disembarked? What is the problem here?

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Case Study: Granville Rail Disaster, 1977

A study in forensic asset management

The Granville Rail Disaster in Australia on Jan 18, 1977, was not only the most serious in Australia's history, killing 83 and injuring more than 200 others, it was also the most well documented – the subject of a Railway Board Inquiry, a Judicial Inquiry and a Coronial Inquiry.

The conclusion of the early Judicial Inquiry was a typical 'one point solution'; it concluded that the derailment was caused by poor track maintenance. The Government voted $200M to be spent on upgrading the track. The subsequent Coronial Inquiry was a formality and expected to validate the earlier findings. It didn't. It showed it to be not the result of one factor, but many, acting together.

The story of Granville was made into an exciting rescue movie "The Day of the Roses". But even more fascinating than the heroic rescue efforts is the forensic asset management that determined exactly what did happen on that hot summer day in January, 1977 – and, more importantly, why! This is that story.

Background

The morning commuter train from the Blue Mountains into Sydney was an important train. The line to the Blue Mountain connected a number of marginal constituencies and transport was a major issue at the time. The state-run NSW railway was in a run-down condition and complaints about the service were frequent. Time keeping was also a problem, but this particular service was given a degree of priority and efforts were made to ensure that it ran to time. This required some very smart working of the train as other, stopping trains used the same path through Sydney's suburbs. At one point there was a margin of just 3 minutes between the Blue Mountains train and a stopping train. Just a short delay could mean that the local train went ahead and the express would be held up causing a late arrival of about 30 minutes. An expedient to help to avoid this was to impose an 80K speed limit at the curve into Granville that was 10 km/h higher than imposed on all other curves in NSW. (After the accident this was revised downwards to 60K and then 40K.)

Part 1: What happened

At 0609 on that Tuesday morning Train No. 108 left Mt Victoria, to the west of Sydney at the start of its regular (126 Km) journey into the city. The train, operated by the Public Transport Commission of New South Wales consisted of eight carriages hauled by electric locomotive No. 4620. Journey time was 2 hours and 20 minutes.

A signal check at Blacktown was the only impediment to otherwise good timekeeping. But it was the cause of the train being 3 minutes late departing from Parramatta for the non-stop run into Strathfield. With around 25 minutes journey time left and under clear signals, Train 108 accelerated to the maximum speed permitted for the line, (80 km/h).

Derailment

As the train entered a left hand curve the locomotive derailed. About 50 yards ahead was the Bold Street Bridge. This carried a road over the railway line and was supported at two points on trellises each consisting of eight steel stanchions. Without the constraints of the rails the locomotive started on a course that diverged from the line, causing the first and second carriages to become derailed and the coupling between them to

part. As the locomotive came to the bridge it collided with the northern supporting trellis knocking down each of its stanchions. With the first carriage still in tow the locomotive then struck a mast supporting the overhead power lines, causing it to shear near the base. The carriage collided with this mast, now suspended from the overhead power line. With 73 passengers inside, the mast tore through the carriage detaching its roof and tearing away the side walls. Eight of the occupants were killed and 34 were injured. The locomotive had come to a stop slightly ahead of the carriage at a point some 73 yards (67m) beyond the bridge, having fallen onto its right side. Neither the driver nor the second man were seriously injured.

Derailed carriage No 2 carried on under the bridge and finally came to rest against the northern retaining wall some distance beyond the first carriage. None of the 64 passengers in this vehicle suffered serious injury.

Collapse of the Bold Street Bridge

The other 6 carriages remained upright and on the rails and stopped with the rear part of the third carriage and the front part of the fourth carriage beneath the bridge. With the demolition of the its supports, the bridge was not stable and a joint in the "deck beams" soon began to give way. As a consequence of this, the steelwork carrying the road was pulled away from seatings on the northern abutment and crashed down onto carriages 3 and 4 beneath it. As it fell, it also brought down part of the central span. The total weight of these parts of the bridge was calculated to be some 570 tonnes. The carriages below offered no resistance to such a force and they were crushed reducing the height of the carriages in some parts to just a few inches. The consequences for the passengers was horrific. Over half of the passengers who were travelling in these carriages died.

Part 2: Why

The Coronial Inquiry found that the following factors contributed

- **Design and maintenance of the track**

Geometry of the curve and condition of the track (dog pikes worn, dog pikes missing, meant that the track was unstable)

- **Speed**

The driver of the train was exonerated: he was merely doing what the signals allowed, travelling the maximum allocated on that stretch of track, which in this case was 80 Kph (10 Kph greater than on any other section of curved track in NSW) because of the necessity to keep this train to schedule. The imperative of not being late into Sydney meant that the maximum allowable speed was chosen.

- **Design and maintenance of the Bold Street Bridge**

The bridge had a 100-ton concrete deck but this was lower than the roadway on either side and the Railways had levelled the deck by adding more concrete. The supports designed for 100 tons now had to carry 320 tons. The Inquiry established that the stanchions upholding the bridge had been crashed into twice before in the previous ten years by trains de-railed at that spot. Had they been moved, the accident may not have happened.

- **Design and maintenance of Locomotive 4620**

Perhaps the most contentious issue was the design and maintenance of the Locomotive. Its design was such that it was top heavy and had a tendency to push the track wide. The combination of the weight and worn front wheels caused the train to lift off the track and derail.

- **Individually, factors were 'within spec'**

At the Inquiry it was argued that the wear on the front wheels was 'within spec' – international standards had established a wear limit of 26 degrees and Locomotive 4620's wheels were only 22 degrees worn. International Standards also allowed for the degree of wear on the rail tracks of 16 degrees and the tracks on the curve at Granville were only 12 degrees.

- **In Combination, the result was a disaster**

The speed of the train, its top heavy design, the wear on the front wheels, the wear on the unstable track, all contributed to the derailment. The design of the bridge with its supports close to the track and the extra 220 tons of concrete, meant that the accident, when it occurred, was more serious.

(Part 1 of this story was adapted from an article by David Fry, for which many thanks, and Part 2 was written from the report of the Coronial Inquiry as reported in the filmed version "The Day of the Roses")

CONCLUSION

The Coronial Inquiry clearly demonstrated that this was not a simple 'one-point' problem of track maintenance but something far more complex. Whenever there is a major accident, the media and the politicians look for a 'one-point' solution. Minister Scully, in NSW, has quickly denied that track maintenance had anything to do with the Waterfall derailment (even though the inquiry he has established has yet to report what actually did cause it.) He favours 'driver error' which is convenient as the driver died! But look at the headlines for all three of the disasters on the front page of this issue. It seems everybody looks for "The" cause.

Below is a problem solving technique that recognises that problems – and their solutions – are multi-faceted, and shows you how to cope with this.

Tools & Techniques

Improve Your Problem Solving Ability
with
Root Cause Analysis (RCA)

This article is designed as a ***quick introduction*** to determine whether you wish to go into the issue in more detail. If you do, then you will find a number of references to useful websites dealing with root cause analysis in the library resource base on the Virtual Asset Management Community website, and you can search for them under ***"root cause analysis".***

RCA – An emphasis on the "Why" rather than the "What"

All approaches to root cause analysis take the view that you need to look behind the 'proximate cause' to find the roots of the problem. In other words, it is NOT sufficient to stop at the first "What", but rather go behind this into the "Why".

Where the various approaches seem to differ is in how they go about this inquiry. Some seem to treat it as a 'check the box' exercise; or to search for 'the one' root cause; or to encourage choice of a preset range of options that then determine the 'solution'.

Apollo RCA – Recognition of Complex set of Causes

I like the approach taken by Dean L Gano, the author of "Apollo Root Cause Analysis – A new way of thinking", because the logic is quite clear and the presentation is both reasonable and easy to follow. Moreover, it is the one approach I have found that best deals with the notion – so important to complex infrastructure assets – that ***when things go wrong, they go wrong for a complex of reasons.***

I also like the way that he focuses on identifying the supporting evidence and avoiding the all-too-easy adoption of bias and pre-set solutions.

It is his work that I refer to in these pages. (You can download a number of articles by Gano from the Apollo Root Cause website and even buy his book online- you will find the links in the ***Library.)*** I will illustrate Gano's approach with reference to the Granville Rail Disaster on the previous pages.

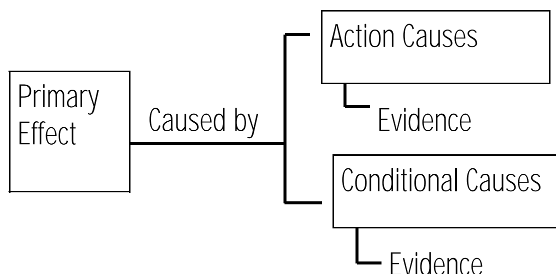
Gano's methodology is as much a philosophy as it is as set of simple tools and it does not require forms or checklists. He argues that, when fully implemented, it empowers everyone in the organisation to be effective problem solvers. People begin to realise that things do not just happen, and that everything has a cause. As a result, a pro-active attitude begins to develop,

A Four Step Process

Step 1: Define the problem by writing the:

What: Primary Effect (Noun verb)
When: Relative Time of the Primary Effect
Where: Relative Location in System, Facility, or Component
Significance: Why you are working on this problem.

Step 2: Create an Apollo Cause and Effect Chart:



For each Primary Effect ask why. Look for causes in Actions and Conditions. Connect causes with "Caused by" Support causes with Evidence or use a "?"

Step 3: Identify effective solutions:

Challenge the causes and offer solutions
Identify the best solutions—they MUST
- Prevent recurrence
- Be within your control
- Meet your goals and objectives

Step 4: Implement the best solutions

Lets examine these in a little more detail and then apply them to the Granville Case Study.
Problem Definition:

Lets start by defining what a problem is!   A problem is a gap between actual and desired. If the goal is to deliver passengers safely, efficiently and to time and someone is injured in the process, or the costs exceed available revenues, or the train is late—then there is a gap between actual and desired and you have a problem.   In groups, it is sometimes difficult to determine a common understanding of the problem. Every player tends to look at his own objectives. The way forward is to look at the 'agency's' objectives.

What? In the case of Granville, the problem was safety (or lack of it)

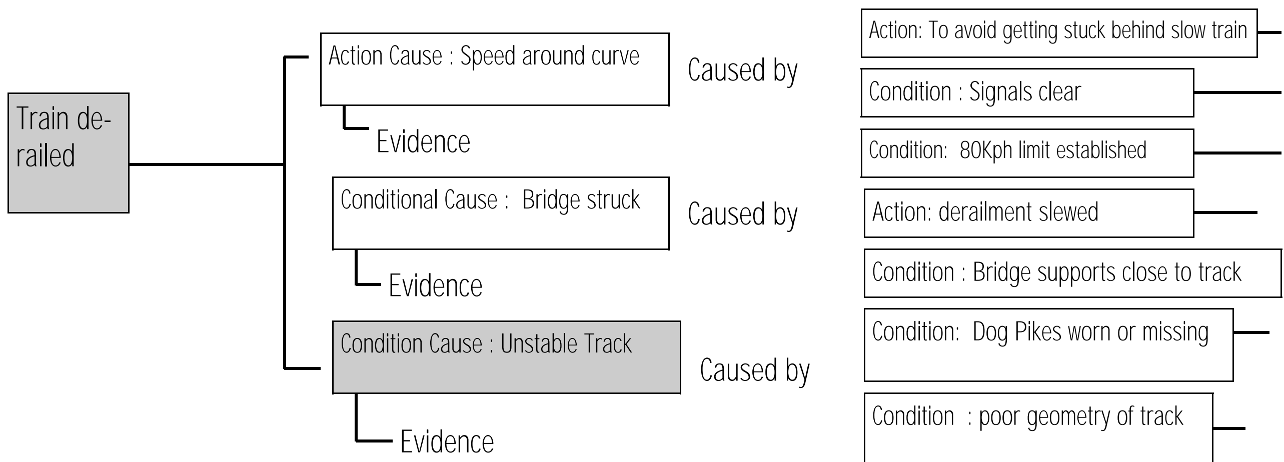
When? There are two parts to this; one is the date and time, , eg Jan 18th 1977, 8.14 am; the other is the relative time, e.g. in the early morning commuter rush on a hot day

Where? This should define the physical or process location of the incident or problem. A consistent approach of starting with the high levels of a system and stepping to the lower levels works well for developing a clear structure that captures the setting. Granville Station, derailment on curved approach, ..

Significance: The 'significance' section asks the question at the beginning of the analysis process; "why are we spending time and resources on this issue?" To take full advantage of the 'significance' it should relfect the overall goals of the organisation. The incident perspective should not be from any one group or individual, like the maintenance group or department manager, but from the stated goals of the company. This helps everyone to see the problem more accurately. Eg Major safety issue on a politically important line

Cause and Effect Charts start from the present, are multi-faceted, and use evidence to make causal connections (cf our Granville Story that starts back in time, is linear, uses inference to communicate causes)

There is not room to do more than start a Cause and Effect Chart for Granville here—



Creating a cause and effect chart: At each stage ask why (the 'caused by" link) - there will generally be at least two elements (an action and a condition).   Evidence is important. Without evidence we fall back on individual prejudices and biases. Keep asking questions until you come to ? (don't knows). If it is important to know, then persist. (The grayed areas indicate where the first Judicial Inquiry rested).

Do look up "Root Cause Analysis" in the Virtual Asset Management Community Library—I guarantee you will find it both fascinating and valuable!

The Sherman-Dergis Formula and Building Maintenance

Mathew I am looking for firm data to compare Dept of Defence's maintenance funding against comparable industry levels. For example, I have 1989 data: 'Sherman-Dergis Model' predicts maintenance expenditure of 2.6 per cent Gross Replacement Value over a 50-year life. Do you have any current information or suggestions?

Penny The Sherman-Dergis formula, developed at the University of Michigan, is not a MAINTENANCE prediction model but rather a formula designed to reflect the greater REPAIR AND RENEWAL (over and above maintenance) required as a building ages. It is apparently widely used in the US Education sector. The formula is based on a 'life' of 50 years for the entire asset. It makes no distinction between the longer living structural elements, the shorter living fit-out, and the medium term building and site services. The Sherman Dergis formula = Replacement Cost x 0.75 x (Age of Building/1275)

Other formulas assume a constant proportion of annual maintenance costs over the life cycle (which, to my mind, somewhat defeats the concept of a 'life cycle'!) and are derived as a simple percentage of building replacement cost. Figures range from 1.5% to 2% and sometimes more. These figures are merely assumed and there is no demonstration that they are appropriate - *just as the 50 year life is assumed in the Sherman Dergis Formula.*

The basic difficulty in comparing maintenance costs across agencies and industries is in knowing what is included as 'maintenance'. Where, for example, does something become repair or renewal rather than maintenance? Is cleaning included, or security?

A paper by Dr Wayne Stewart "Strategic Asset Management: Committing to the Cost of Owned Buildings" is well worth reading.

Table 4 on page 11 gives a range of figures for annual maintenance cost as a percentage of Current Replacement Value for different organisations.

Wayne Stewart claims that the Sherman Dergis formula works out at 1.3% per annum. (this is presumably a discounted value of the area under the curve—see fig 5 in his article.)

I have put a link to this paper in the Library on the Virtual Asset Management Community website (www.amqi.com) Search for it under "Stewart" or under "building costs".

What's new on the Virtual Asset Management Community Website?
www.amqi.com

Great Websites

We have been searching over the Summer break for really useful asset management websites for you and a few weeks ago we launched the "Great Websites" link on the Community Website. In the last week we have added three more, each are well worth a visit.

1. National Academies Press

There are over 2,500 Books to read on line – browse the 'engineering' category to find lots of publications on infrastructure, asset, maintenance, and facility management. True, pages can be slow to load but the search facilities are great and you know the site is continuously updated when you visit on Feb 3rd and find the following heading up its "Current Topics" list!

Upgrading the Space Shuttle
Committee on Space Shuttle Upgrades, National Research Council
82 pages, 6 x 9, 1999.

Have a look at the section on the life of upgrades!

2. **AAPPA—The** Australasian Association of Higher Education Facilities Officers (AAPPA)

For those whose interests lie in building assets and facilities management, this is an excellent site. It provides newsletters and full conference papers in html and pdf, and power point presentations for the last four years of its annual conference.

And this one is for my fellow model builders– a really interesting site that looks at many issues facing asset managers from a systems viewpoint.

3. Mental Model Musings

Gene Bellinger, OutSights

You can access all of these with ease from "Great Sites" on the www.amqi.com site