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CASE STUDY.

Tunnel - Risk Assessment & Mitigation Strategies

PREAMBLE

Risk assessment and mitigation strategies are developed through the EIS process.

In Australia, there appears to be no single agreed approach to tunnel design and fire protection. Even within the states there are different criteria and approaches. Compared with Europe, Australia has limited experience with long tunnels. Even so, Australian tunnels are unique. They provide deluge systems, which is not the norm overseas. They are also regularly subject to small fires, but there have been no recorded large fires to date. The performance of Australian tunnels for large fires appears to be empirically untested, which is also unique.

The conventional approach to tunnel risk management in Australia is exemplified by the "Emergency Response and Incident Management Plan" developed by the Roads and Traffic Authority of New South Wales. Risk assessment and mitigation strategies are nowadays developed through the Environmental Impact Statement (EIS) process and embodied in prescribed standards and services. For example, a 50 MW maximum single incident hydrocarbon fire is to be fully controlled by mechanical ventilation and smoke control systems.

The authors note that until recently, Australian road safety authorities have not adopted a risk-based approach. In addition to the generic Australian Risk Management standard ISO31000, reference can be made to transport domain standards such as AS 4292 (railways); the functional safety standard AS (IEC) 61508; tunnel specific standards such as NFPA and PIARC; the technological risk analysis standard AS/NZS 3931:1998 and the International dependability standards for failure mode and effects analysis, fault tree analysis, reliability block diagrams and human reliability as well as various defence standards applicable to the safety assessment process.

> R2A have been engaged to complete risk studies.

Over the years, R2A have been engaged to complete risk studies for a number of tunnel projects. We believe that the process successfully applied to the Tugun Bypass Tunnel in Queensland, is best practice.

BACKGROUND

> R2A conducted a due diligence review for fire scenarios in the tunnel.

In 2006, R2A were commissioned by Pacific Link Alliance (PLA) to investigate the credible fire scenarios associated with the Tugun Bypass tunnel under the Gold Coast Airport Runway. The purpose of the review was to establish and document a 'due diligence' argument as to why the Tugun Bypass Project Team could be confident that all credible fire scenarios in the tunnel could be managed by the tunnel's proposed fire protection system.

The Tugun Bypass was a new 7km stretch of motorway between Stewart Rd, Currumbin in Queensland and Kennedy Drive, Tweed Heads in New South Wales. It consists of a four lane motorway with a 330m tunnel under the extension of the runway at the Gold Coast Airport.

The tunnel comprises twin uni-directional carriageways separated by a fire rated dividing wall. It has a straight line of sight through the tunnel end to end. The tunnel and supporting services have been designed for three lanes of traffic in each direction however it has been initially configured for two lanes of traffic in either direction.

The review covered all safety aspects including pedestrian access, ventilation, fire protection, traffic management and communications.

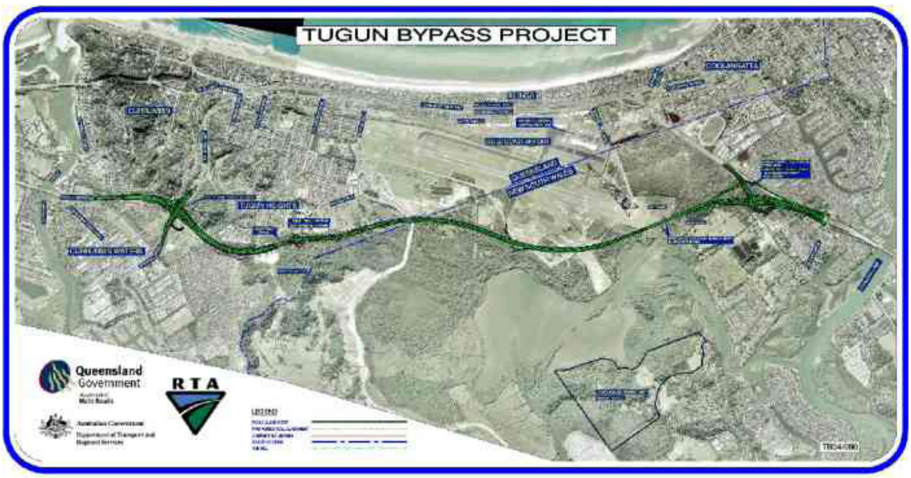
Emergency pedestrian egress passages between the two carriageways have been provided at 120m intervals. Doors are sliding and have a fire resistance level of four (4) hours. Emergency egress points are signed and in the event of an emergency a strobe light and down lights are activated. The tunnel also has a fire-resistant lining.

The tunnel has a ventilation and water deluge system for fire control and management. The ventilation system has been designed to control the smoke produced by a 100MW design fire using reversible jet fans installed in tunnel roof niches in each of the tunnel carriageways. These fans are also utilised for ventilation of the tunnel in congested traffic conditions.

The fire protection system consists of an automatic water deluge system that provides a water density of 10mm/m2/minute. A linear heat detection system is used to activate the deluge system automatically during a fire incident, after a defined period, as the failsafe mode of operation. The tunnel operator can also activate the system manually. Manual fire fighting equipment is also provided in the tunnel.

The tunnel is also provided with a traffic management system consisting of vehicle loop detectors, variable speed and message signs, lane use signals, tunnel swing gates, CCTV, vehicle over-height and weigh-in-motion detectors. Communications systems include radio re-broadcast and break-in facilities, PA, mobile telephone and two-way radio provisions. These systems assist in the management of traffic congestion and fire and traffic incidents.

The day-to-day operation of the bypass is managed, with the agreement of the NSW RTA, by QLD Main Roads through the existing Main Roads Traffic Management Centre (TMC) at Nerang for the first 10 years.



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TUNNEL RISK ASSESSMENT

Vulnerability Assessment

This was the key component for the Tugun tunnel risk assessment and involved all relevant stakeholders in Queensland and New South Wales. Vulnerability assessments form a top down completeness check. The central concept is to define the assets and all the possible threats to them.

In terms of tunnel risk management, the assets are typically defined as exposed groups. The threats are then systematically matched against the assets to see which is vulnerable to each threat.

A very reduced sample for a tunnel is shown in Table One overleaf.

> "The vulnerability as sessment was the key component for the risk assessment."

Table One: Criticality Scoring System

ASSETS	Travelling Public	Operator Staff	Emergency Services	Local Residents	Habitat/ Environment	Infra-structure & Third Party
	Including disabled, elderly, small children, people who behave erratically	Including contractors breakdown services	Fire brigade, ambulance and police		Air quality	
THREATS						
Motorcycle breakdown	x	x	-	-	-	-
Passenger car breakdown	x	x	-	-	-	-
Bus breakdown	xx	x	x	-	-	-
HCV load fire stationary vehicle in free flowing traffic	xx	xx	xxx	x	x	x
HCV vehicle fire burning vehicle in stalled traffic	xxx	xxx	xxx	x	x	x
Injury/entrapment accident - all lanes blocked	xx	x	x	-	-	-
Pedestrians in Tunnel on walkway	x	x	x	-	-	-
Cyclist in Tunnel	xx	x	x	-	-	-

xxx	Potential extreme consequence event. Many people at risk. Tunnel structure may be compromised.
xx	Potential major consequence event. Some people at risk. Tunnel services potential affected.
x	Potential moderate consequence event.
-	No vulnerability detected

TUNNEL RISK CONTROL

For each of the credible critical threats identified, an assessment of the proposed controls was then completed in a due diligence context.

> Risk control consists of three primary risk control regions.

Threat Reduction

Firstly, threat reduction, in this case reduce the source of fire, for example, banning of dangerous goods and combustible trucks with large combustible loads. Small fires in any vehicle may occur once every two months, in a heavy commercial vehicle, say once per 10 years and in stalled traffic say once in 100 years.

Precautions

Secondly, precautions such as deluge systems that can control fire before the normal air handling system is overloaded (small fires are safe fires). A further consideration is the size of the uncontrolled fire. If the environment can be designed to manage, say a 5 MW fire and, for example, the proposed deluge system could be relied upon to control the fire 99% of the occasions on which it is called upon to act. Automatic activation is probably required to achieve such reliability. In legal terms this may be considered to be beyond reasonable doubt?

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Vulnerability Reduction

> Threat reduction, precautions and vulnerability reduction are assessed.

And thirdly, reduce vulnerability by ensuring no one is present during a fire (minimal stalled cars) and the provision of emergency response, ventilation and evacuation systems.

Three key scenarios appear on the consequence side.

a) Low congestion meaning there are minimal vehicles around.

b) Some congestion meaning vehicles stop behind the fire but those in front of the fire drive out which makes the jet fan emergency mode desirable since the smoke can be blown away from the stopped traffic.

c) High congestion with stalled traffic meaning there are stopped vehicles both before and after the fire. This makes the use of the longitudinal (jet fan) emergency mode problematic since it would blow smoke over one column of stopped traffic hampering evacuation. That is, with stalled traffic and longitudinal emergency ventilation, a heavy commercial vehicle fire will expose a large number of people who would have to evacuate through a smoky environment on foot. To reliably achieve this is very, very difficult.

CONCLUSION

The use of vulnerability assessment supported by precautionary analysis to assess risk in tunnels seems a peculiarly efficient form of due diligence. Control focuses on prevention in the first instance which parallels the OHS hierarchy of controls: elimination/ engineering, administration and PPE (personal protective equipment). The latter can only be adopted if the other options are not viable. Viable in this sense seems to mean the common law test of negligence. That is, the balance of the significance of the risk verses the effort required to reduce it.

> Automatic deluge systems provide superior risk reduction for fires.

This approach shows that automatic fire control systems like automatic deluge systems provide superior risk reduction for fires in stalled traffic compared to manually activated deluge and emergency longitudinal air handling systems, which is the usual design for Australian tunnels.

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WHERE TO NEXT

Talk to R2A about your next project.

If you would like to know more about how to manage due diligence in your business you can:

- Contact R2A to organise a briefing for your executive management team.
- Book an In-House Course or Private Briefing.
- Buy a copy of the 9th edition R2A text: Risk & Reliability: Engineering Due Diligence. Order online.
- Receive R2A's email newsletter.
- Attend the two day Engineering Due Dilligence Workshop presented by Richard Robinson.
- Attend the one day Defensible Risk Management Techniques course presented by Richard Robinson on behalf of Engineering Education Australia.
- Enrol in the postgraduate unit 'Introduction to Risk and Due Diligence' Postgraduate Unit at Swinburne University, also presented by R2A.

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