

**Road Safety Audit:
The South East Transit Busway Project Experience**

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Abstract

Road safety audit has been introduced to Australia since the early 1990s and it is now well accepted by road authorities. Since that time, many safety audits of various stages have been conducted in Queensland. However, the safety audit of the South East Transit Busway Project, with a project cost of more than \$300 million, from design to completion is probably the single largest project ever safety audited in Queensland.

This paper describes the safety audit process adopted for the South East Transit Project and provides an overview of some of the more major findings of and the experience gained from the audits conducted.

1 Introduction

Road safety audit has been introduced to Australia since the early 1990s. Since then, the road safety audit practice has been well accepted by road authorities in Australia.

With the publication of Austroads guide on road safety audit and the conduct of international Road Safety Audit Forum in Melbourne in recent years, Australia is amongst the world leaders in the area of road safety audit.

This paper presents a brief overview of the road safety audit process and some of the experience gained from auditing the South East Transit Busway Project in Queensland.

2 South East Busway

2.1 What is the South East Busway?

The South East Busway is a two-lane roadway used exclusively by buses, and when necessary by emergency vehicles. The busway runs from the Brisbane Central Business District via South Bank, Mater Hill and Woolloongabba to Eight Mile Plains along the Pacific Motorway corridor. Buses will then use the Pacific Motorway to service the stations in Underwood and Springwood. Busway stations and associated infrastructure at strategic locations are provided along the route. A schematic layout of the Busway and Transit Lanes is given in Appendix A.

Included in the project are upgrading of service roads, access ramps to and from the Pacific Motorway and the addition of Transit Lanes along it between Klumpp Road in Mt Gravatt and the Logan Motorway in Loganholme. This necessitated the widening of this existing section of the motorway to cater for the Transit Lanes.

In addition to ensuring the safe operation of the busway, the transit lanes and the associated facilities, the Project Director also has to ensure that the safety factors of all the affected roads are fully considered during all stages of the project. To this end, the Project Director has ordered that road safety audit be conducted at various stages of the busway project.

2.2 Staged Construction

The entire South East Busway is scheduled to be completed by the middle of 2001. However, it is being constructed in stages to provide relief in those areas that experience the most traffic congestion. Thus, the entire busway does not need to be completed before running bus services on it. The section of the busway from South Brisbane to Woolloongabba was open to bus services in September 2000.

3 Road Safety Audit

3.1 What is Road Safety Audit?

The Austroads Road Safety Audit Guide defines road safety audit as “a formal examination of an existing or future road or traffic project, or any project which interacts with road users, in which an independent, qualified examiner reports on the project’s accident potential and safety performance.” Road safety audit considers all road users, including various pedestrian groups, cyclists, motorcyclists, heavy vehicles etc. It relies heavily on established guidelines and standards, and also on the ability of the auditor to recognise a potentially hazardous combination of elements which may not be covered by specific guidelines.

The output of a road safety audit is a road safety audit report which identifies any road safety deficiencies and makes recommendations, where necessary, for rectifying the deficiencies.

3.2 Why Should Road Safety Audits be Conducted?

The main reason for conducting road safety audits is to prevent road crashes by identifying potential safety problems for corrective action consideration.

Road safety audit seeks to ensure that, as far as practicable, road and traffic schemes are safe and fit for the purpose for which they are intended. Consideration should be given to safety aspects throughout a project, from planning to operation. This may be achieved by ensuring that:

- (i) elements which could cause crashes (e.g. road furniture near the edge of traffic lanes) are not present in the completed works ;
- (ii) elements which could reduce the risk of road crashes (e.g. anti-skid surfacing) are included in the completed works; and
- (iii) elements which reduce the severity of road crashes (e.g. frangible poles, crash barriers) are included in the completed works.

Other important objectives which flow from this are to minimise the risk of crashes on the adjacent road network, and to enhance the importance of road user safety when constructing and operating roads.

Safety audit of new schemes allows any deficiencies to be corrected before road users travel the road. The aim of such an audit is to “get it right the first time”. The cost of a road safety audit and the consequent cost of changing a design are significantly less than the cost of remedial treatments once the works are constructed.

3.3 When Should a Road Safety Audit be Conducted?

A road safety audit can be conducted at the following stages:

1. Feasibility Study (Concept Design);
2. Preliminary Design;
3. Detailed Design
4. Construction
5. Pre-Opening to Traffic; and
6. Existing Road Audit.

Stage 1 - Feasibility Study / Concept Design

Route options, layout options or treatment options (e.g. a roundabout vs traffic signals) can be examined during feasibility stage audits. They allow an assessment of the relative safety performance of scheme options and identifying specific needs of various road users. By providing a specific safety input at this stage of a scheme, road safety audit can influence fundamental issues such as route choice, standards, impact on and continuity with the existing adjacent network, and intersection or interchange provision.

Stage 2 - Preliminary Design

At this stage of audit, issues to be considered typically include horizontal and vertical alignments, and intersection layouts. Where land acquisition is required, the draft design stage audit should be undertaken before the title boundaries are finalised. It should be noted that once this stage of design is completed, and land acquisition and other associated matters are finalized, subsequent changes in road alignment become much more difficult and costly.

Stage 3 - Detailed Design

This audit stage occurs on the completion of the detailed design but before the preparation of contract documents. Typical considerations include geometric layout, line markings, signing, delineation, traffic signals, lighting, intersection details, clearances to roadside objects (crash barriers / frangibility), landscaping and provision for vulnerable road users.

Stage 4 - Construction

Construction sites are often places of confusion where the traffic route and traffic control devices are changed from their usual state. It is important that good traffic control and guidance be given to motorists to safely guide them through the construction zone and to protect the road workers. Some of the concerns at road works include signing, delineation and roadside objects. Construction projects of substantial size should be safety audited by day and by night.

Stage 5 - Pre-Opening to Traffic

This stage of audit involves a detailed inspection of a newly completed work (new or modified scheme) prior to its opening to traffic. This usually involves inspection by the audit team as motorists and as pedestrians (where appropriate). If cyclists are to use the road, their needs and safety should also be considered. Inspections should be carried out by day and by night as some night time associated problems may not be obvious during the day. If opportunity arises, inspections during adverse weather conditions (e.g. rain, fog) should also be carried out.

Stage 6 - Existing Road Audit

A road safety audit of an existing road aims to ensure that the safety features of the road are compatible with the intended purpose of the road, and to ensure that these are at an appropriate level of safety. As the use of a road changes over time, this audit therefore also aims to identify any feature which may develop into a safety concern (e.g. visibility problems due to foliage). This stage of audit is independent of the first five as it can be carried out at any time on an existing road.

4 Stages of the Busway Project Safety Audited

By the time the decision was made to conduct road safety audit on the South East Transit Project, preliminary and detailed design of the project was already well under way. Thus, road safety audit of the concept design was not carried out on any section of the project. To date, the following stages of road safety audit have been conducted on the South East Transit Project:

- Preliminary Design
- Detailed Design
- Construction
- Pre-opening or post-construction.

These audits included the dedicated two-lane busway, part of the Pacific Motorway with High Occupancy Vehicle (HOV) Transit Lanes, surface streets which interact with the busway and the busway stations. These are discussed in the paper.

5 Conducting the Audits

5.1 Audit Teams

In line with the Austroads guidelines, all safety audits were conducted by audit teams consisting of at least two people. Audit teams were formed depending on the type of audit to be conducted and the type of expertise required.

In order to expedite the audit process, at least one person with a good knowledge of the project being audited was included in the audit team to guide the team through the audit. This is particularly important when conducting audits of design stages where there are large numbers of complex plans. By having someone familiar with the project leading the team through the plans and answering questions which may not be obvious to others, audits can be conducted with a minimum waste of time.

For the audit team to be independent, all team members need to be free of direct involvement in the project. Thus, no design team members were involved in the safety audits.

5.2 Audit Methodology

Once the audit team is formed, an audit can be conducted in different ways with varying degrees of efficiency and effectiveness. This is particularly true for large and complex projects. Methods used for conducting the road safety audits for the South East Transit Project are described below.

5.2.1 Design Audits

As some sections of the South East Transit Project have lengths of several kilometres, similar issues reappeared along the length of the section being audited. Unless a good method is adopted for auditing the schemes and reporting the findings, the audit process can be time consuming and the resultant report difficult to read. The following two methods were tried:

- audit all the issues at once at one point or over a short length of the project.
- audit one issue at a time from one end of the project to the other end and then back, noting the chainages and the direction.

After trying the first method for the first few audits and reviewing the feedback from the recipients of the audit reports, it was decided that the reports produced by this method was difficult to manage. The second method was therefore adopted for all subsequent audits.

5.2.3 Construction / Post-construction Audits

As the construction of the Busway and the Transit Lanes impacts on the surrounding road network along the route and along the Pacific Motorway where the Transit Lanes are being provided, safety audits of the traffic management of the affected sites were carried out to ensure the safety of both the road users and the road workers.

The method adopted for these audits consisted of examination of the traffic management plans and site inspections which included driving and walking where appropriate.

The site being audited is usually driven through a number of times at the prevailing traffic speed to observe the traffic management that has been implemented and to gain an appreciation of how drivers might perceive and drive through the site. Video recordings are made during the driving phase of the inspection for viewing during the preparation of the audit report. Still photographs are also taken of situations for inclusion in the report

Where site conditions permit, inspections would also be carried out on foot to give the auditors more time to assess the situation in detail.

In a Pre-opening or Post-construction Audit, the completed section of the project and its adjacent affected roads are audited to ensure their safe operations. Similar to Construction Audits, the site is driven or walked as appropriate. Again, video recordings are made and still photographs are taken.

A similar method of reporting to the Design Audits was adopted for the Construction / Post-construction audits.

6 Overview of Audit Findings

An overview of the audit findings for the different stages of South East Transit Project audit is given below. As there are so many detailed issues identified in the audits, the overview provides a broad description of them for illustration purposes only.

6.1 Preliminary Design Audit

As the Busway is a two lane road dedicated for use by buses and is designed to appropriate standards, only Section 2 (from Water Street in Woolloongabba to O'Keefe Street in Buranda) was safety audited at the Preliminary Design Stage for potential alignment problems. However, Sections 5, 6 and 7 of the South East Transit Project on the Pacific Motorway were safety audited at this stage as they involved the widening of the Motorway to provide a HOV Transit Lane in each direction. There are also many entries and exits within these sections of the Motorway which will be used by buses.

6.1.1 Section 2 (Busway): Water Street to O'Keefe Street

The safety audit identified that there was a horizontal curve with a design speed of 50 km/h at the end of a section with a design speed of 80 km/h. Owing to site restrictions, there was no potential to alter the Busway land corridor to remove this speed differential. Consequently, the audit recommended that appropriate delineation and advance warning of the speed through the curve be provided to highlight the severity of the curve. Furthermore, a 50 km/h speed limit was recommended to cover this section of the Busway.

6.1.2 Sections 5, 6 and 7 (Pacific Motorway)

Sections 5, 6 and 7 of the South East Transit Project involved the widening of the Pacific Motorway to provide a HOV Transit Lane in each direction. As the Busway terminates at the end of Section 4 in Eight Mile Plains, buses on the Busway will have to merge into the Pacific Motorway traffic at the beginning of Section 5 near the Gateway Motorway merge.

Some of the safety issues identified in this audit include:

- Possible head light glare problems between the Motorway and some of the adjacent service roads due to horizontal alignment of these roads.
- Inconsistent and narrow shoulder widths which could create a hazard to traffic, particularly when it is occupied by a disabled vehicle.
- Inconsistency in the treatment of weaving zones between HOV lanes and the general traffic lanes with variations in lengths and configurations along the Motorway.
- Inadequate length of some exit ramps to prevent queuing of vehicles back to the Motorway.
- Possible drainage problems across the pavement due to the very wide cross section of the Motorway.
- The need to provide emergency services access to and across the Motorway.

6.2 Detailed Design Audit

As the South East Transit Project is being designed and constructed in stages, some sections are still being designed at the time of writing of this paper. Consequently, the overview given below does not include Sections 6 and 7 of the Project.

6.2.1 The Busway

- There were concerns about the lack of adequate stopping sight distance on approach to the Mater Hill Busway Station from the north due to visibility restriction by a combination of the horizontal curve and retaining wall structure.
- The sign support mountings to the barrier systems in the Busway tunnel were hazardous to errant vehicles impacting the concrete barrier as the rigid sign support brackets were protruding from the face of the concrete barrier.
- In Melbourne Street and on the Victoria Bridge, the road is divided into two carriageways with buses running in both directions on one side and the general traffic running in both directions on the other side. This contra-flow / segregated traffic arrangements are quite unusual and therefore, there is a high potential for road users to become confused and/or misled (i.e. readability of the road is very ambiguous). The highest points of confusion / conflict are at the intersections, especially with turning manoeuvres. It is highly probable that motorists could turn into the wrong carriageway. Good signing and delineation are essential to clearly guide road users through this road section and intersections.
- Inadequate bicycle lane width along part of the busway and sudden termination of such lanes at places were identified as safety concerns.
- The lack of details on the treatment of the ends of the concrete barrier proposed to be constructed between the busway and the general traffic carriageways along the Victoria Bridge was of concern.
- Because of the noise barriers mounted on top of the crash barriers, the stopping sight distance was considered to be inadequate in some sections of the busway.
- In the original design, it was proposed to use a concrete barrier in the middle of the busway station to separate the approaching buses from opposite directions. The concrete barrier would also serve as a fence to prevent pedestrians from crossing the bus station at the platform level. To overcome the safety problems presented by the ends of the concrete barriers, crash cushions were to be used. The safety audit team questioned the appropriateness of such a design and suggested that the concrete barrier be replaced with a median separator with pedestrian fencing on it.

6.2.2 The Motorway

- Landscaping restricting sight distance on the Motorway and on the service roads.
- The back to back guardrail arrangements at a number of locations required a suitable end treatment as the intended treatment (double bull nose end) was no longer in use due to severe safety implications (spearing).
- On the Motorway where shoulders with chevron markings were to be converted into traffic lanes by grinding out of the markings, it was understood that the final pavement overlay in places was proposed to be delayed by 6 - 12 months. This was identified as a concern as the delayed pavement overlay would have the potential to create hydroplaning and ponding problems, and would have the potential to confuse road users, as old pavement markings would still be visible, particularly in wet conditions.
- At places on the Motorway, there was too much information (i.e. too many signs and too wordy) being presented to motorists at any one time.
- Emergency phones and stopping lanes/bays were proposed to be provided in both the central median (i.e. adjacent to the transit lane) and on the left shoulders. The use of emergency phones (i.e. persons out of vehicle) in a high speed environment, in the central median area, was considered to be potentially hazardous for the person involved.

6.3 Construction Audit

As the construction activities of the Busway interacted with the traffic on the Pacific Motorway and on the surface streets, the traffic in these areas operated under road work conditions. At some places, the travelled paths were severely altered by the use of temporary concrete barriers and delineators.

With high traffic volumes and speeds, the biggest safety implications were on the Motorway where it was being widened to provide a HOV Transit Lane in each direction. A number of traffic switches had to be made on the Motorway to allow construction activities to take place. These traffic switches created some severe changes in the direction of travel which included the diversion of the southbound traffic onto a completed section of the Busway and changing the Motorway exit at Logan Road from the left to the right hand side of the carriageway.

Some of the more major safety issues identified in the construction audits are summarised below:

- At the Logan Road Exit, through traffic was diverted to the left onto the Busway and the exit ramp was moved to the right hand side of the carriageway. This was a major safety concern as vehicles had to exit from the fast lane. In order to manage this situation, Advance Exit signs were prominently displayed prior to the exit and the speed limit of the section of the road just prior to the exit was reduced from 80 km/h to 60 km/h for about two weeks to allow motorists to become familiar with the changed conditions.
- As temporary concrete barriers were being used extensively throughout the project, there were some instances of the lack of proper treatment to the abrupt ends facing traffic.
- As construction zones are areas of confusion to motorists, good signing and delineation are very important for guiding them through these areas. There were many instances of incorrect or ambiguous signing through road work sites. However, most of these were resolved after the audits. The lack of adequate delineation in the form of line marking / reflectors was another major concern identified in the audits. For example, the temporary reflective raised pavement markers (RRPMs) did not work well by day or by night and the permanent RRPMs, while effective by night, were not effective by day due to the lack of surface area to simulate a lane line. In situations such as this, the audit recommendation was to provide a painted line and then use the RRPMs to enhance the line. However, this recommendation was seldom taken up by the contractors.
- Ground out pavement markings through work zones were identified as safety concerns in that they are rough and uneven to travel and the ground out lines can still be seen as lines particularly in the wet.
- Narrowness of traffic lanes and shoulders between temporary concrete barriers was of concern to the road safety audit teams. However, due to road width constraints, there was little that could be done apart from improving the delineation through these areas.
- Water draining from road work areas to the traffic lanes was of concern as a localised wet and sometimes slippery condition would not be expected by motorists.
- Old line markings misleading motorists through work zones were common at most sites.
- On the surface streets, there was often a lack of consideration given to pedestrians and cyclists through work zones.

6.4 Pre-opening or Post-construction Audit

A pre-opening audit is one that is conducted on a road that has not yet been opened to traffic. However, a post-construction audit is one that is conducted on a road that has been under traffic during construction.

6.4.1 The Busway

At the time of writing, only one short length of the busway (from Melbourne Street tunnel portal to the Woolloongabba Bus Station) was audited prior to its opening to traffic. The following are some of the more major safety concerns identified:

- Sign mounting brackets on the side of the concrete barriers were carried through from the design stage without modification as suggested in the Detailed Design Audit report.
- Some of the curves (both horizontal and vertical) appear more severe in real life than on paper during the design audit.
- The horizontal rails of the anti-glare screen fence mounted on top of the concrete barrier posed a hazard to errant vehicles impacting the concrete barrier with possible intrusion of the rails into the bus.

6.4.2 Surface Streets

Surface streets affected by the Busway Project were safety audited at completion. The most common problems identified in the audits include:

- Inappropriate signing
- Inadequate delineation
- Inappropriate finished details of safety barriers e.g. inappropriate transition from W-Beam guardrail to concrete barrier and the ending details of break away terminals.

7 Conclusion

The decision by the management of the South East Transit Project to have the project safety audited from the design stages to opening is a way for ensuring that safety is designed and built into the project. The stage by stage safety auditing has provided an opportunity to ensure that safety is carried through the whole project.

Of particular significance in the safety audit process is the conduct of construction audits on this project as such audits are not yet widely practised.

Many safety issues have been identified in the various safety audits and most of these have been addressed by the Principal. Undoubtedly, the safety audit process has and will improve the safety performance of the project.

8 References

- 1 Austroads (1994) *Road Safety Audit* (Austroads, Sydney).
- 2 Main Roads (1995) *Manual of Uniform Traffic Control Devices* (Main Roads, Brisbane).

Appendix A



Schematic Layout of the South East Busway and Transit Lanes