The practice of road safety audits

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Abstract

In recent years, road safety audits have been introduced in a number of countries as a proactive means of improving road safety and rectifying potential safety deficiencies on the road. In contrast to the usual accident investigation procedure that is undertaken after crashes are observed, road safety audits seek to identify safety problems prior to crash occurrence and even before the road project is completed. This paper presents a brief history of the development in the practice of safety audits and outlines the common procedure undertaken in such audits. The benefits and liability concerns associated with such audits are also discussed. The paper also describes a methodology of risk assessment not found in the most manuals on road safety audits.

1 Introduction

For many years, safety researchers and practitioners have made concerted efforts to reduce crash occurrences on the roads. While there seems to be general improvements in safety standards in our vehicles and on the roads [1], the increase in motorization continues to inflict an unacceptable fatality and injury toll on road users worldwide.

Traditional safety programs tend to be reactive, i.e., safety improvement schemes are designed based on and following observed crashes. Such an approach is unlikely to result in substantial decrease in crash reduction occurrences and road casualties. In recent years, there have been calls by various authorities to achieve quantum reduction in fatality rates [2]. This has led many agencies to explore more proactive strategies to deal with the root causes of safety deficiencies in the road system.
In the 1970s and 1980s, there were various attempts in North America and Europe to examine traffic conflicts, which were considered to precede crash occurrences. Though more proactive than many accident investigation programs, traffic conflict studies still require road projects to be completed before actions can be taken.

It seems sensible that a more proactive road safety enhancement strategy is one that examines the crash risks or potential of road projects even before such projects are completed. This principle underlies the practice of road safety audits.

AustRoads defines a 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. Such audits were first introduced in the 1980s in the United Kingdom based on the safety audit concepts originally developed for railroad networks during the Victorian Period. It was done as part of a Quality Assurance Scheme in a number of County Councils to facilitate a systematic check of highway projects prepared by the County Councils. This practice was formalised in the United Kingdom in 1990 with the publication of The Institution of Highways and Transportation on Guidelines for the Safety Audit of Highways. The guidelines were subsequently revised when the Department of Transport in United Kingdom made it mandatory for all major national trunk roads and motorways to be audited.

At the same time, a similar safety audit process was initiated in New Zealand when the newly formed Transit New Zealand was given the responsibility to conduct post-construction safety reviews of road projects. Initially, pilot reviews were conducted for state highway projects, but by 1993 a set of policies and procedures was already developed and implemented for all types of roads.

In Australia, road safety audits were first introduced in the State of New South Wales in 1990. The practice was quickly followed by other states and in 1994, the Australian Road Authority, AustRoads has published its own guidelines on auditing roads in Australia.

In the last decade, road safety audits have been adopted in similar fashion in other countries in Europe, North America, Africa and Asia.

2 Objectives and benefits of road safety audits

Road safety audits were introduced as an attempt to implement quality assurance in organisations involved in planning, design, construction and operation of road projects. Hence they are some form of quality control checks undertaken at specific points in time so as to ensure quality is maintained throughout the life
cycle of a road project. Specifically, road safety audits are aimed at achieving the following objectives:
1. To identify potential safety problems faced by all road users and others who may be affected by the road project;
2. To ensure adequate measures are considered to eliminate or minimise the potential safety problems.

Most road designs tend to favour the drivers rather than non-drivers. For example, the criteria for establishing curvatures in horizontal and vertical road profiles are solely based on the performance of drivers in maintaining adequate sight distances and speeds. Consequently, other road users may be inadvertently forgotten in the design process. A failure to provide adequate and appropriate facilities for vulnerable road users can often lead to unsafe conditions for these road users who may resort to taking unsafe actions. By considering all road users, particularly the vulnerable ones in the examination, road safety audits seek to cover whatever lapses in safety considerations in the design process.

There are identifiable benefits in conducting road safety audits. Evidently, the necessity of safety audits makes those who are responsible for road development and maintenance become more aware of the safety requirements in their projects and will indirectly help to promote a better road safety culture among road providers and operators. Potentially, safety audits should reduce the likelihood of crash occurrences as well as severity of crashes on the roads. Such reductions can mean significant economic benefits to the road users and operators as well as to society as a whole. When hazards are identified early and measures to eliminate them are taken promptly, there will be a reduced possibility of having to undertake expensive remedial works on the completed road system subsequently. Furthermore, by noting design deficiencies that are highlighted in a safety audit, designers can work to incorporate safety features into their future designs, bringing about improved designs and facilitating a more efficient way of updating design standards and procedures. The extensive documentation required in safety audits can also lead to better appreciation of the principles of road safety engineering among highway engineers and operators.

While there appears to be potential benefits in road safety audits, there are few quantitative assessments to confirm these benefits, despite the numerous safety audits that have been undertaken to date. It has been argued [18] that since road safety audits are unlikely to cost more than accident blackspot programs which have been shown to result in significant economic benefits, the benefit to cost ratio of safety audits should be high. Based on some early work done in New Zealand [9], the potential benefit to cost ratio of 20:1 seems to be attainable.

3 Types of road safety audits

As a formal process of assessing the crash potential and safety performance of a road project, the safety audit requires an independent and qualified team to be the
Such an examination is not considered to be a design check as it deals only with safety issues. However, as a complete safety check, the concerns of all road users, including motorcyclists, pedestrians and cyclists, must be taken into account.

Road safety audits can be undertaken throughout the entire life cycle of a road project from conception to operation. Various types of road safety audits have been defined in road safety audit manuals and these are conducted at the different stages of the life cycle in the road development, as follows:

1. **Feasibility stage.** In this case the review looks at the route options, layout options and treatment options. The audit allows an assessment of the relative safety performance of scheme options and identifies the specific safety needs of the various potential users based on the adjacent land use. It may also highlight the need to reprogram other nearby road or traffic projects to accommodate changes in traffic.

2. **Preliminary Design Stage.** At this stage, the issues such as intersection or interchange layout and the alignment details are addressed along with considerations on the design standard to be chosen.

3. **Detailed design stage.** Once the design details are available, the geometric design, traffic signing scheme, line marking plans and landscaping plans are examined in relation to the operational safety of the road.

4. **Post-Construction Stage.** A critical safety audit is undertaken just before the road is opened to the public; hence the audit done at this stage is also regarded as one at the Pre-Opening Stage. Site inspections are made under various conditions (e.g. day and night setting) and the safety impact is examined for all road users who will likely use the road. This audit ensures that hazards identified earlier have been rectified and are in place before traffic is allowed on the road. Other deficiencies not apparent on the drawings are easily identified at this stage.

5. **Existing Roads.** A safety audit can also be conducted on roads that are in operation. Safety aspects of the road network may have changed significantly since the road was first built. For example, the development of adjacent land and new roadside features such as new signage or commuter facilities may have a safety implication on the operation of the road.

6. **Temporary Road Works.** In a major road-upgrading program, there can be many elements in the road scheme that may be hazardous to the road users. A safety audit during this stage can significantly improve operational safety and ensure that the usually tight road construction schedule does not compromise on safety.

Audits may not be conducted at every stage of the road project. Indeed, there are differences in what are required in the various safety audit guidelines. The AustRoads guide [4] recommends only the first five categories. In New Zealand, the audit of existing roads is applicable only at a network level and while the audit of temporary road works may not appear in the audit guide [9], its practice has been encouraged [19]. The British manual [7] has only the first four categories because it considers the traditional accident investigation programs to
be equivalent to audits of existing roads. Nonetheless, there is a subtle difference – as a proactive approach, an audit of existing roads need not be called only when crashes have occurred. This may explain why many County Councils in UK have carried out audits on existing roads [20]. In Singapore, audits are not carried out at the feasibility stage because there is usually little time gap between the feasibility stage and the preliminary design stage.

4 The audit process

There are specific steps in the audit process that are spelt out in the various guides. AustRoads [4] details 7 steps from the point of selecting an audit team to taking follow-up actions after the audit. These steps are discussed below.

Selection of the audit team

The first logical step in the audit process is selecting the audit team. This may seem straightforward, but concerns raised at this step are those centred on the qualifications and composition of the audit team.

The need for a qualified team stems from the requirement that the road safety audit has to be a formal exercise. Consequently, members in the audit team are to have both the relevant educational qualifications and experience, typically, in traffic engineering, road safety engineering or accident investigation and prevention. In some instances an understanding of the local issues is seen to be an advantage although it may be argued that someone with a different cultural background may provide a more objective assessment on safety. For the audit to be carried out without bias, it is also necessary that the audit team should have no direct involvement in the design or execution of the road project. This independence is necessary to ensure that the project will be evaluated with “a fresh pair of eyes”. Furthermore, it is considered desirable for auditors to consider only safety issues and not be biased by design considerations known to the design team.

The composition of the audit team is also an important consideration though there appears to be no consensus on its requirements. Ideally, the team should comprise several individuals with diverse backgrounds and experience, who will complement each other in evaluating the safety performance. Based on audit exercises undertaken in training classes, it has been found that in general, audits are better conducted and more safety issues are raised by teams whose members are drawn from professionals with different training and experience in road design, construction, maintenance, traffic operation or traffic management. However, in practice, it may be difficult and costly to muster a large and varied team. Consequently, some authorities have allowed one-member audit teams to audit their smaller road projects.
Provision of Background information

Before the audit team takes on the job, the road designer or project manager will need to prepare the necessary background materials and supporting documents for the audit team.

The information to be gathered depends on the type of audit to be undertaken. The background to the road project may include information related to the intended function of the road section to be audited as well as information on the adjacent streets and intersections. The existing or projected vehicular flows and pedestrian flows and the kinds of vulnerable road users expected are also made known. Where applicable, the accident history of the site may also be needed.

In all cases, drawings of the road project such as the traffic plans, layout plans, horizontal and vertical profiles as well as typical road sections are essential. The audit team also needs other documents such as design specifications and constraints as well as reports of previous audits, at this stage. In audits of temporary road works, operational safety procedures for workers as well as emergency plans are also reviewed.

Commencement meeting

The formal meeting between the project team and the audit team marks the commencement of the audit proper. In this meeting, the project team briefs the audit team on the road project to be audited.

The idea of having one’s work to be audited is often uncomfortable and the commencement meeting can generate some tense moments of hostility. It is known that road designers have found it difficult to accept that their design skills are questioned by those who have little or no experience in road design [21]. Setting the right atmosphere in the commencement meeting and treating designers with respect for their professional work can gain invaluable support from the designers, which can lead to higher quality in the reviews [22]. Emphasizing the complementary roles in promoting safety can also bring about greater mutual benefits in professional developments.

Safety Analysis

The purpose in a safety analysis is to identify the crash potential of the road project. To do this, the audit team needs to examine the drawings as well as carry out site inspections under various conditions. All audits, irrespective of the stage of the road project, should include a site visit so that ground conditions can be properly understood [23].

Whether on the drawing or at the site, the auditors have to undertake a systematic appraisal of the risk potential. Few road safety audit guidelines provide a rigorous methodology on how this is to be done. One of the more structured approaches is that adopted by Singapore Land Transport Authority (LTA), which followed the concept based on military risk assessment [24].
Applied to road safety audits, risk assessment is the decision making process that seeks to evaluate and control the likelihood of occurrence and the severity of a crash. The process involves identifying the potential hazards, evaluating the extent of the risks involved and establishing further controls and precautions needed to mitigate the risks.

The steps in the risk assessment methodology are as follows:

1. **Risk identification:** Specific hazards are identified and described. A road hazard is defined as any unsafe condition on the roadway that can generate an incident that will inflict potential injury or harm to any road user. Risk is a measure of the potential for such a dangerous incident being realised. Hence, the concept of risk is a combination of two elements: the likelihood of a crash and the severity of the crash. In reporting the hazard it is important to indicate both the location and nature of the hazard, i.e., how the unsafe condition may result in an undesirable unsafe outcome. The description should include not only the type of vehicles and road users that will be involved but also the manner the crash will likely occur. Since different road users are involved, there may be several hazards at a single location.

2. **Impact assessment:** For each of the hazard identified, its severity is next determined according to some ordinal scale. The level of crash severity is influenced by the nature of the crash and the vulnerability of the road users involved. Table 1 shows the four categories of severity adopted by LTA [25] together with the corresponding definitions and examples. Since severity may be reduced by possible evasive actions of the road users and the kind of safety protective devices used, the choice of the severity level can be subjective and dependent on the judgement of auditors.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Examples</th>
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<tbody>
<tr>
<td>High</td>
<td>Multiple fatalities and/or serious injuries</td>
<td>Head-on crash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High-speed crash</td>
</tr>
<tr>
<td>Medium</td>
<td>Single fatality or severe injury with possible other minor injuries</td>
<td>Pedestrian or cyclist struck by car</td>
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<td></td>
<td></td>
<td>Side-swipe crash</td>
</tr>
<tr>
<td>Low</td>
<td>Minor injuries or property damage only</td>
<td>Low speed crash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclist fall</td>
</tr>
<tr>
<td>Negligible</td>
<td>Property damage only</td>
<td>Car reverses into post</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Car crashes into guard rail</td>
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</tbody>
</table>

3. **Probability estimation:** Following impact assessment, the expected frequency of occurrence in the hazardous event is determined by estimating the likelihood of occurrence. This estimate also requires good professional judgement from the auditor. Four categories of accident frequency are proposed in the LTA guidelines [25], ranging from frequent to improbable. These are defined and illustrated in Table 2.
4. Risk Rating: The category of risk for each hazard is evaluated by mapping the impact and probability values against the risk matrix as shown in Table 3. The risk rating establishes whether the risk of any potential hazard is acceptable or not.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Frequent</td>
<td>More than 10 times a year</td>
</tr>
<tr>
<td>Occasional</td>
<td>From 1 and 10 times a year</td>
</tr>
<tr>
<td>Remote</td>
<td>Once in 10 years to once a year</td>
</tr>
<tr>
<td>Improbable</td>
<td>Less than once every 10 years</td>
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<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Accident Severity Category</th>
</tr>
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<tbody>
<tr>
<td>Frequent</td>
<td>B</td>
</tr>
<tr>
<td>Occasional</td>
<td>C</td>
</tr>
<tr>
<td>Remote</td>
<td>D</td>
</tr>
<tr>
<td>Improbable</td>
<td>D</td>
</tr>
</tbody>
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A: Intolerable – Risk shall be reduced by whatever means possible
B: Undesirable – Risk shall be accepted only if cost of risk reduction is disproportional to gain
C: Tolerable – Risk shall be accepted if cost of improvement is high
D: Acceptable – Risk is minimal

5. Risk management: Once the risk rating is known, the appropriate courses of action needed to manage or mitigate the risk can next be worked out. Where the risk rating is exceptionally high, it is imperative that such risks should be reduced by whatever means possible. On the other hand, the risk level may be so low that nothing needs to be done to reduce it further. In most cases, risk ratings fall into the region where the risk needs to be managed. In such cases, the decision to mitigate the risk is based on a comparison between the expected benefit in a risk reduction measure and the likely cost incurred. In general, risks should be reduced as much as practically possible and economically feasible.

To assist the review team in the tasks of risk assessment, checklists or prompts are often used. A set of the customised checklists is usually included in the most guidelines on road safety audits. These typically show the sort of issues and problems that can potentially arise at the relevant stages of the road project. The main advantage of using such checklists is that this formalised checking procedure can help ensure that potential problems will not be overlooked. Checklists may also be helpful for the designers to review their work before it is subjected to a formal audit by the audit team.

Safety report
As a formal process, the safety audit will require a report to be produced. The report details the findings related to road safety deficiencies identified and makes
the necessary recommendations for mitigating these identified hazards. The report usually contains a background description of the road project with a map or location plan. As plans and designs are modified constantly, it is important to know which sets of drawings have been audited. Thus, the report will usually include a list of the plans, drawings and documents and their versions that have been examined.

The main part of the report is devoted to hazard description. For each hazard identified in the audit, the location of the hazard and how it may develop is presented together with the nature of the potential crash and the result of the risk assessment. The risk rating and the recommended remedial measures to eliminate the risk are also included. To facilitate ease of reference, these are usually organised and presented in a tabular form. This is supplemented by a set of appropriate photographs showing the hazards and the surrounding road conditions. The list of the hazards and their ratings, together with the recommendations are summarised in a form at the end of the report. This summarised list is intended for the project team to document their response to the audit findings.

Completion meeting
Following the submission of the safety audit report, it is usual for the audit team to orally present the findings to the project team. This is done at the final meeting. With the help of visual aids and photographs to describe the hazards and road conditions, this presentation of audit findings can sometimes be more effective than the written report in bringing across the safety concerns observed by the audit team. While the project team needs to examine all the recommendations in order to make an appropriate response, it is not normal for the project team to respond to any of the recommendations during the meeting itself.

Response report
The indirect consequence of having a formal safety audit is that there needs to be a response from the project designer or builder to the recommendations raised in the audit report. In responding to each of the safety deficiencies identified, the designer or project manager may choose to accept or reject the existence of such a potential hazard. Where there is concurrence on the existence of the hazard, the project team may choose to agree or disagree on the risk rating. Finally, the project team may decide to adopt the recommended remedial actions or suggest an alternative or even to reject the recommendation and take no action. Whenever the design team or project team differ from the assessment of the audit team, it is normal to document the reasons for the differing opinions.

The safety audit submission and the response report are usually presented to the next level of management overseeing the project. In smaller projects, the reports may end up with the immediate superiors of the designers or builders but in larger projects, it is not uncommon for a high-level safety review committee to examine the safety and response reports.
5 Liability concerns

One of the main stumbling blocks to having more extensive use of road safety audits is the concern over professional liability. The manner in which liability implications are viewed may depend on the cultural setting of the country and practice of governance. In Australia, anyone alleging professional negligence must prove that the party charged with the duty of care has failed to act with reasonable diligence. Thus in calling for road safety audits, the authorities or road providers can show themselves to have acted with due diligence and hence become less subjected to litigation. In New Zealand, where the national insurance program does not permit lawsuit for personal injury, the liability issue in road safety audit does not arise.

Safety auditors have always expressed concerns over liabilities should there be mishaps arising from safety deficiencies that have not been identified in the audit. Some have argued that the role of auditors is different from that of accident investigators. In a safety audit, the intention is to identify safety problems so that safety deficiencies can be fully considered [18]. On the other hand, accident investigation seeks to apportion blame or award compensation. Hence, following this argument, the liability of reviewers should not be an issue.

There are still serious debates over the legal implications arising from the conduct of road safety audits, particularly in the United States where government decisions are subject to intense legal scrutiny. One concern is whether a team, agency or authority would become liable to those crashes that occur following the rejection of a safety audit recommendation. Such fears may indeed discourage agencies from carrying out safety audits. However, as safety audits deal with potential hazards while accident analysis deal with manifested hazards, then assuming that potential hazards cannot be treated as evidence for lack of safety, it has been argued [18] that agencies are no more liable in conducting safety audits than in executing programs to identify hazardous locations.

6 Conclusion

For the road safety process to be successful there should be commitment to the audit process at all levels, from the management of an organisation to the various working levels of staff and contractors. Often the audit process is perceived to be a challenge to the competence and professional judgement of the designer or road builder. This can inhibit the sharing of vital information. On the other hand, the audit process may also be treated as an approval of the design. In this case, designers and contractors have known to adopt a more careless attitude, knowing that their failings will be picked up. For the process to work well, all the stakeholders must view the audit process as an important avenue to promote road
safety and to prevent the occurrence of crashes. It seems that much work is still required to encourage the various parties to agree on this common goal.

In the last decade, there has been significant progress in the development of safety audit practices around the world. Yet there remain numerous challenges ahead. As in many safety initiatives, there are as many sceptics as advocates. There are those who remain unconvinced that there is enough evidence of real safety benefits. It has also not been proven that the objective of creating a safer road environment and inculcating a safety culture among road professionals through safety audits has been achieved. Furthermore, there needs to be more research work to improve the assessment methodology. The manner of assessing risk as described in this paper, though more rigorous than what is reported in existing road safety audit manuals, is still far from perfect.

References

14. Lipinski, M. E. and Wilson, E.M., Road safety audits - a summary of current


