S.T.A.R.S. – a risk-based road safety tool for urban planners

Chris Jurewicz
ARRB Group Ltd, Australia
email: chris.jurewicz@arrb.com.au

Abstract

The focus on road transport safety is often drowned out during the land use planning process by other competing concerns. It is left to the road authorities to manage road safety problems arising post-implementation through re-engineering works such as black spot interventions – after the casualties occur.

This paper presents Austroads Strategic Tool for Assessment of Road Safety (S.T.A.R.S) – its development by ARRB and its practical applications. The tool provides a quick star rating of expected road safety performance of proposed land development options, transport planning initiatives and infill developments. It is designed for use by urban planners and land developers at different stages of the planning process up to the detailed design stage.

The underlying method of safety assessment is a risk assessment-based test for application of road safety conscious planning principles developed over the past 40 years. Many of these principles now form the core of the Safe System approach to road transport. Multiple alternatives may be assessed to determine the safest long term option for implementation. The methodology recognises the benefits arising from application of sustainable transport planning principles resulting in a shift to non-car based modes of transport.

Keywords

Transport planning, road safety, sustainable transport, risk assessment

Introduction

The land development planning process requires planning professionals to consider a number of interdependent multidisciplinary inputs such as environmental impact, community infrastructure, employment opportunities, residential amenity and transport planning. The focus on road transport safety is often drowned out by other competing concerns. Also, it may be difficult for planning professionals to identify technical road safety concerns at planning stage. On the other hand, early consideration of road safety issues during the planning process provides an opportunity to address any concerns in the most cost-effective way – before the developments are built.

Currently there are no decision support tools for urban planners to gauge the road safety impacts of different planning options from a strategic perspective. It is difficult to quantify and minimise the negative road safety consequences of planning decisions. It is often left to the road authorities to manage road safety problems later through re-engineering works such as black spot interventions after the casualties occur.

This Austroads funded project aimed to scope and develop a planning-level tool for estimation of the road safety level, or change in road safety, of proposed land development options, transport planning initiatives and of the existing land use (e.g. for ‘brownfield’ or infill developments). The underlying method of assessment behind the tool is the test for application of road safety conscious planning principles developed over the past 40 years.

S.T.A.R.S (Strategic Tool for Assessment of Road Safety) was created as a prototype tool. A future tool or tools may be developed from this prototype and tailored to individual jurisdictions’ local planning guidelines and adapted to the applicable planning terminology. A more detailed account of this project is presented in Turner et al. (1).
Literature overview

The question ‘how can we create safer road networks?’ has occupied road safety researchers and policy makers for decades. Development of tools and methodologies to objectively assess or quantify the level of road safety at the planning level (macro) has been a subject of substantial research. An overview of published literature on this subject was carried out to inform this project and was included as part of Turner et al (1). The review found a number of largely computational tools (Road Safety Impact Assessment, Sustainably-Safe Indicator, RAP models, NetRisk, SafeNET 2). Such tools depend on engineering inputs (qualitative, highly deterministic, mathematical). While well structured and credible, such tools do not explicitly cover planning issues. Also, they generally require training and expert understanding of the methodology behind them.

A planning-level guide was developed in Victoria (2). It was a checklist of the key planning issues relating to road safety in the context of planned developments. While it provided no computational framework, it was accessible to a broad range of users familiar with infrastructure issues, including both planners and engineers.

The analysis of existing tools and methodologies informed the choice of the direction for the new tool. Given that one of the objectives for the new tool was the ease of use, it was decided to combine the qualitative approach of the Victorian guide (2) with the simplified computational approach of risk assessment of tools such as RAP models or NetRisk. This led to the development of a detailed methodology for quantifying the road safety level based on analysis of planning decisions.

The broader urban and transport planning principles resulting in improved road safety have been well established and documented. In this respect, the project relied on the best practice documented in two overview works by Brindle (3) and Fotheringham et al. (4).

Prototype tool development

After completion of the literature overview, the facts regarding tools and methodologies were presented to an ARRB panel of senior experts for discussion and guidance. The panel included: a town planner, a transport planner, a network performance manager, a traffic and transport engineer.

The expert panel reached consensus that the evaluation of road safety for any proposed development scenario should be based on the observance of road safety conscious principles described by Brindle (3) and Fotheringham et al. (4). The panel further agreed that the tool should be based on the elements of different existing methodologies to provide the framework which was transparent to the user and did not require in-depth knowledge of road safety engineering. Understanding of town planning and development issues was necessary and expected among the target user group.

The expert panel chose to use the risk assessment methodology, but to apply it to the town and transport planning issues. This approach meant the majority of risk factors had to be developed by expert consensus due to lack of existing research on the road safety impact of individual planning issues/strategies (e.g. there is no known crash reduction factor for combining a commercial activity centre with a public transport hub, as opposed to having them separated). Some risk factors from previous research undertaken under this project, the Road Safety Risk Manager (RSRM) software and NetRisk were applicable and were utilised.

The next task involved implementation of the conceptual framework and development of a prototype tool. Microsoft Excel was used as the development vehicle.

Five generic planning stage templates were designed to cater for different situations encountered during the planning process. Generic planning stage names were used to keep the tool free from administrative terminology used in any one jurisdiction. Thus the five stages are as follows (alternative terminology provided):

Level 1 – big picture: regional planning, structure plan
Level 2 – masterplan: outline development plan, local structure plan, precinct plan
Level 3 – neighbourhood: subdivision plan, neighbourhood, estate, development application
Level 4 – corridor: arterial transport corridor plan, new arterial, road duplication, road upgrade
Level 5 – commercial development: commercial or infill development, shopping centre.

A tool introduction, user instructions and extensive references are also provided. Each template form contains checklist questions targeting the typical issues and decisions made at that particular planning stage, which influence the road safety performance after the development is completed. Each checklist question was assigned a Risk Weight factor being a product of:

- likelihood factor – the relative risk of a casualty crash occurring due to the issue
- exposure factor – the relative change in the number of road users exposed to the risk
- severity factor – the likely increase in the severity of a crash, should it occur.

Table 1 shows a small selection of these factors to illustrate the method. The likelihood, exposure and severity factors were determined by the members of the expert panel; in some cases they were drawn directly from literature and in others from practical experience of crash data analysis. In the prototype tool, the factors are hidden from view to avoid confusion and tampering. The figures in parentheses represent the literature references provided as an Excel tag within the tool (not referenced in this paper).

Table 1: The mechanism for weighting each planning issue (fragment)

<table>
<thead>
<tr>
<th>Road safety planning aspects to be assessed</th>
<th>Likelihood</th>
<th>Exposure</th>
<th>Severity</th>
<th>Risk Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Is kerbside parking prevented, restricted or suitably designed so that arterial road safety and efficiency are not compromised? [3] [5] [20] [23] [24]</td>
<td>1.1</td>
<td>1.1</td>
<td>1.4</td>
<td>1.7</td>
</tr>
<tr>
<td>• Is side-road and frontage property access prevented or suitably controlled so that safety and efficiency of arterial operations are not compromised? [3]</td>
<td>2.5</td>
<td>1.1</td>
<td>1.5</td>
<td>4.1</td>
</tr>
<tr>
<td>• Are bus stops to be located to maximise safety of passengers and other road users? [3] [20]</td>
<td>1.1</td>
<td>1</td>
<td>1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The user is prompted to answer each checklist question either yes or no. If the answer to a checklist question is a no, this triggers an additional risk score quantified by the Risk Weight (RW). The NA answer may be given if the issue is not applicable to the planning option being considered. All triggered Risk Weights on the checklist are added and the following formula is used to calculate the total risk score for the given planning option:

\[ \text{Risk score} = \frac{100\% \times \sum (\text{RW}_{\text{triggered}})}{\sum \text{RW}_{\text{all}} - \sum \text{RW}_{\text{answered NA}}} \]  
(1)

Thus the relative safety of the development is expressed as:

\[ \text{Safety score} = 100\% - \text{Risk score} \]  
(2)

To make the scoring system easier to communicate a star system was devised. The stars are assigned as shown in Table 2.

Table 2: Star rating system

<table>
<thead>
<tr>
<th>Safety score</th>
<th>Stars</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20%</td>
<td>★★</td>
</tr>
<tr>
<td>20%-50%</td>
<td>★★</td>
</tr>
<tr>
<td>50%-75%</td>
<td>★★★</td>
</tr>
<tr>
<td>75%-90%</td>
<td>★★★★</td>
</tr>
<tr>
<td>90%-100%</td>
<td>★★★★★</td>
</tr>
</tbody>
</table>
The number of assigned stars provides an easily recognisable marker of safety performance. The more stars assigned to an option, the higher the level of the expected road transport safety. Many other assessment systems use this method, e.g. ANCAP for rating of vehicle safety.

At its completion, the prototype was retained in Excel format pending dissemination, user evaluation, further discussions and possible development into a fully fledged professional tool in the future.

**Using the tool**

The prototype tool is intended for safety evaluation of alternative planning and development options. It can also be used for stand-alone assessments. While the prototype is intended primarily for assessment of future developments, it may be also applied to existing areas. This may be of use in 'brownfield' or infill developments, where the existing infrastructure can be compared with that proposed in the future.

To use the tool the user should:
- select the development stage which best matches the case
- follow the questions, provide the answers: Y, N or NA
- obtain and note the star rating
- repeat for other options
- compare star ratings between options.

At the prototype stage the saving and retrieval of projects is done by copying a completed form (an entire Excel tag) to a new Excel sheet and saving it as a separate spreadsheet file. Figure 1 shows an example of a completed form for one of the development stages.

Some limitations of the tool should be considered:
- Star rating compares similar options at a point in time.
- Star ratings will change as development plans evolve over time, become refined and move towards design and implementation.
- A good score at one level does not equal a good score at the next.

An example of the application of the tool may be evaluation of the safety changes associated with a proposed shopping centre expansion. The expansion includes additional floor area, car park redevelopment, additional internal roads, and on-site public transport facilities. The existing (Figure 1) and proposed scenarios can be evaluated using the Level 5 form and the scores compared. Targeted amendments may be then negotiated with the developer to ensure the total road safety score for the proposal exceeds that of the existing scenario.
### Level 5 - commercial development

**Definition**
Commercial, infill development, shopping centre, confined commercial precinct.

**Road safety objectives**
1. To provide safe site access from arterial/collector road network.
2. To plan parking/loading areas for safety.
3. To provide safe environment for cyclists and pedestrians.
4. Assuring overall road safety.

**Decision makers**
- Environmental planners
- Traffic engineers
- Transport planners
- Developers
- Urban designers
- Architects
- Public transport strategists, planners and operators
- Strategic planners
- Local businesses and residents

### Location

<table>
<thead>
<tr>
<th>Road safety planning issues to be assessed</th>
<th>Risk Weight</th>
<th>Answers</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Provide safe site access from arterial/collector road network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Are intersections/access points on arterial or collector roads suitably located, controlled and designed to cater for the planning horizon traffic volumes? (2) (3) (4) (14) (20) (21) (27) (30) (31)</td>
<td>5.1</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Are suitable design provisions made for safe truck and bus movements in/out and within the development (e.g. no excessive grade, turning radii)? (2) (3) (4) (15) (14) (20) (27)</td>
<td>1.1</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Do intersections provide clear sight lines across corners and across roundabouts (e.g. clear of features, buildings, trees and landscaping)? (2) (3) (4) (14) (20) (27)</td>
<td>1.4</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Is side-road and frontage property access to arterial roads suitably controlled so that safety and efficiency of operations are not compromised? (3)</td>
<td>4.1</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Are cross intersections avoided in favour of T intersections? (20) (26)</td>
<td>1.4</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Are access points removed sufficiently far from other intersections to reduce risk of conflict? (25) (26)</td>
<td>1.7</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Is kerbside parking prevented, restricted or suitably designed so that arterial road safety and efficiency are not compromised? (3) (5) (20) (23) (24)</td>
<td>1.7</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Is the development integrated with the public transport system? (26)</td>
<td>1.3</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>2 Plan parking/loading areas for safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is there sufficient off-street parking to avoid overspill parking and congestion on adjacent roads? (3) (6) (19) (26)</td>
<td>1.1</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- If development is of local character, is parking limited and restricted to reduce car trips?</td>
<td>1.5</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Does the layout of off-street parking and internal roads ensure clear right-of-way priority to minimise intersection crashes? (1) (2) (4) (5) (13) (16) (20) (21)</td>
<td>2.5</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Does the layout of circulation roads and loading docks ensure safe separation of vehicular and pedestrian movements? (1) (5) (6) (9)</td>
<td>5.7</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td>- Is landscaping designed to ensure clear sightlines for all road users?</td>
<td>1.4</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Are traffic speeds minimised on internal roads by engineering measures (e.g. speed humps)?</td>
<td>4.2</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>3 Provide safe environment for cyclists and pedestrians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Are safe and direct paths to the development provided for pedestrians and cyclists, separated from other vehicles? (1) (5) (6) (7) (8) (20)</td>
<td>1.2</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Has high level of priority been given to pedestrians and cyclists within the development? (6) (7) (8) (20)</td>
<td>1.3</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Are DDA requirements to be met throughout the site (ramps, continuity of accessible path, pathfinding)? (20) (29)</td>
<td>1.1</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td>- Is lighting to be provided? (20)</td>
<td>1.5</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>4 Assuring overall road safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Has the crash history in the area been analysed and have existing problems been addressed by the plan? (17)</td>
<td>1.3</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>- Has a Road Safety Audit been carried out? (11)</td>
<td>1.2</td>
<td>y</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1:** Example from the S.T.A.R.S. tool prototype
Future development

The prototype can be developed further into a stand-alone or web-based product for use by member organisations or the development industry. As a next step it requires trialling and assessment by jurisdictional safety and planning staff.

The tool has not been released for general use at the prototype stage. In its current form the prototype could easily be corrupted and/or transferred to third parties. It may be, however, considered by a group of jurisdiction road safety and planning staff for trialling and further development.

The tool can be obtained for trialling and evaluation from ARRB by request.

References