Applications of Three-Dimensional Computer Generated Visualisations in Road Safety

Fabian Marsh[1] (Presenter); Nigel McDonald[1]
[1]TRL

Biography

Fabian Marsh is a Senior Consultant within the Investigations and Risk Management Group of the UK's Transport Research Laboratory (TRL).

Fabian has had specialised training in crash reconstruction, crash prevention and road safety audit and is experienced in roadway engineering design and traffic management. Fabian has undertaken all stages of road safety audit both in the UK and Australia and his safety work has included identification and treatment of individual crash cluster sites as well as carrying out route and network evaluations.

Fabian has been working in the UK specialising in crash reconstruction and using three dimensional computer simulation models to analyse crash scenarios.

Abstract

Road safety practitioners face increasing pressure and public scrutiny in demonstrating that new road safety initiatives will be cost effective and will deliver guaranteed results once implemented. Such initiatives can differ significantly in size and complexity ranging from new and improved safety schemes at individual sites to area wide strategies and legislation. Additionally, there is increasing pressure for highways authorities to ensure protection against liability and personal injury claims that may arise from new initiatives.

These factors exist in an environment where road safety countermeasures are becoming increasingly refined and where a greater complexity and interaction of contributory factors need to be considered. Compounding this, in many areas it has become more difficult to reliably collect information due to the specialist nature of detailed information required and the practicalities of collecting this information, resource constraints and privacy concerns.

This paper provides examples of situations where TRL has applied computer visualisation technology in the field of road safety in an effort to address these issues. The accompanying presentation will include additional examples of broader applications of visualisation technology in road safety.

1. INTRODUCTION

Computer visualisation provides a powerful tool in demonstrating how a new safety scheme is likely to look once it has been implemented, since it can be viewed from the perspective of any road user. Due to their realism, visualisations can be quite helpful in assisting managers to prioritise safety proposals and in gaining public consensus of a new scheme. Visualisations can also provide a cost effective and practical alternative to physical testing as part of road safety research.

The examples presented herein refer to both computer simulations and visualisations. For the purpose of this paper a *simulation* is a graphical representation in which vehicle and road user movements are calculated by computer software and are governed by the laws of physics. By contrast, in a *visualisation* these movements are determined by the software user.

Computer visualisations and simulations are already being used in personal injury claims against highways authorities. The authors of this paper anticipate their being significant benefits in using such technology at a much earlier stage in the road safety cycle.

2. DESIGN OF NEW AND IMPROVED ROAD SAFETY SCHEMES

The design of new and improved road safety schemes has traditionally been carried out and assessed using two-dimensional plans. Other parties such as safety engineers, highways authority committees, stakeholders and the public form their views and make decisions about proposed safety schemes largely from the information that is depicted on these plans. Obviously, a depiction in two dimensions will only provide a limited understanding of how a motorist might be expected to interact with a new road environment in the real world.

Three dimensional computer visualisations offer a more powerful way of illustrating how a new road safety scheme is likely to look once it is implemented, and how effective it is likely to be in achieving its safety objectives.

Safety scheme proposals also need to be shown to be cost effective. Computer visualisations can assist in prioritising safety schemes, particularly in situations where a manager may need to justify expenditure on sites which do not have a crash record (but still exhibit a safety problem) when there are plenty of high frequency crash locations waiting to be treated.

Because computer visualisations are so powerful in conveying information they can also be very useful in public consultation. New road safety measures are best implemented with the support of the people who are most likely to be affected by them. The design engineer and the road safety engineer will typically see the most desirable safety measures as those which best address trends that are shown in crash statistics. However, the perceptions of those directly affected by these measures do not always match the best intentions of the engineer. In fact, in some cases, the local people will have totally different views on what road user trends or problems should be addressed. It is therefore important to involve the local people in identifying safety problems and ways of dealing with them.

Visual aids can be a very effective tool in presenting road safety proposals to the public. Three-dimensional visualisations are particularly effective in developing public understanding of how the proposal will look once it has been implemented. Visualisations may also be used to show the public other similar safety schemes that have successfully been implemented elsewhere.

TRL has been involved in the design and assessment of various speed reducing initiatives being considered for a number of existing sites. These initiatives are being designed to restrict vehicle speeds in urban built-up areas to specified levels.

To achieve this objective, a variety of different scheme layouts have been developed using traffic management devices such as bollards, barriers and kerb extensions. The placement of each device was established initially by examining the swept path for a range of different design vehicles as they negotiated each proposed layout. A number of schemes were designed such that certain vehicle types could not physically travel through the proposed layout. Other,

successful, vehicle paths were examined using computer simulation to determine the maximum speed that a vehicle could achieve as it travelled through the scheme.

The computer simulations were carried out using crash reconstruction software designed to calculate the acceleration levels experienced by a vehicle, and its occupants, under various maneouvring conditions. This software uses physical laws to determine the results of vehicle/road environment interactions in response to driver controls and roadway characteristics. Each simulation event can be depicted graphically, providing a visual portrayal of the underlying numerical computations.

The swept path analyses and computer simulations undertaken enabled the design team to identify situations in which refinement of the layouts was necessary. A number of the proposals were developed into three-dimensional computer visualisations which were then used to help in deciding upon the preferred final options and in gaining public acceptance.

The existing roadway environments used in each of the simulations and visualisations undertaken were generated from data captured by TRL's 3D laser scanning system. Laser scanning data typically comprises hundreds of thousands of individual point measurements, often referred to as a point cloud, each having its own three-dimensional coordinates. TRL regularly deploys 3D laser scanning technology to assist in rapid data collection and surveying of incident scenes, where volatile information requires swift and accurate recording.

3. ASSESSMENT OF NEW AND IMPROVED ROAD SAFETY SCHEMES

The aim of a road safety audit is to ensure that any new or improved road safety scheme is going to operate as safely as practicable once it has been implemented. One of the primary focuses of a road safety audit is in designing out safety problems during the early stages of scheme development to minimise the likelihood of future problems.

A safety audit is more than just a check to make sure all the relevant design guidelines are met. It needs to consider the safety of all road users and make sure that all elements work together. When assessing a proposed safety scheme safety engineers have to consider that many of these elements need to comply with their own set of design standards and that some of these standards will have competing requirements, particularly in terms of road space.

Computer visualisations can enable the safety engineer to gain a better appreciation of how a motorist might be expected to interact with a new safety scheme and all of its inherent elements. This can be particularly beneficial in the design and safety audit of complex road environments. Visualisations may also provide a useful tool in resolving any differences of opinion that may arise between a designer's proposal and the safety engineer's comments.

Computer visualisations can also help to ensure that potential hazards are not overlooked during the safety audit process. This might, for example, happen when a certain element within a new safety scheme conforms to relevant design standards but does not present an obvious threat to road users. Such a situation could arise on a straight rural road with a line of power poles alongside the carriageway. If there is suddenly a curve in the road, but the power poles continue straight into the distance, a driver may form the impression that the road continues straight and fail to appreciate that, in fact, there is a bend coming up, particularly under adverse weather and lighting conditions. In this situation a visualisation would assist the safety engineer in determining how a driver might respond in such a situation and whether recommendations such as providing additional delineation are likely to provide adequate safety.

TRL was recently involved in a Road Safety Improvement Study that was carried out on a 55 km section of road in South East Asia. The scope of the study was to assess the existing road environment, monitor driver behaviour and make recommendations aimed at optimising safety for all road users. The assessment methodology involved an applied use of the existing road safety audit process to identify potential safety risks inherent in the existing roadway environment. A range of relatively low cost conceptual design improvements were then developed to address these risks.

TRL's 3D laser scanning system was used to capture detailed information about the existing road environment. The conceptual designs were initially drafted and overlaid onto two-dimensional plans generated from the scan data. Each of the conceptual improvement measures was then subjected to a design stage safety audit.

The point cloud produced by the scanning system was also used to generate a three-dimensional model of the existing road environment which was ultimately used to produce a visualisation, enabling the environment to be viewed in real time from a driver's perspective. Once the preferred design layouts had been selected and safety audited they were incorporated into the visualisation.

Part of the new safety scheme comprised delineation of the centre line on one of the approaches to a bridge. The visualisation highlighted a potential problem with significant safety implications; the new layout effectively directed vehicles approaching the bridge towards the side of the carriageway, directly in line with the end of the bridge abutment. This issue was not identified during the design stage or the safety audit stage as the layout conformed to the adopted design standards and there did not appear to be a problem. It was not until the entire road environment, including proposed improvement measures, was incorporated into a visualisation and 'driven through' that the problem was identified and then rectified (Figure 1).

Figure 1 Application of computer visualisation to Road Safety Audit

4. ROAD SAFETY RESEARCH

Research and Development of new road safety initiatives forms an important part of safety work and should be integral to any strategic road safety programme. Road safety research aims to improve knowledge about factors contributing to road crashes and the potential effectiveness of different countermeasures. The knowledge gained from road safety research often leads to the development of new and more effective safety measures.

An example of such research is the extensive work that has been carried out by TRL over the years in relation to the design of speed reducing humps. Much of this research has historically involved physical testing, requiring each hump type being considered to be constructed and tested under test track conditions. One of the greatest limitations associated with physical testing is the cost involved. Computer software programs are becoming increasingly sophisticated and, in some situations, they may present a more cost-effective alternative.

TRL is currently involved in a study in which computer simulation is being used to assess the effects of road hump design on vehicles and drivers. The primary aims of the project are to provide the research needed to further investigate the likelihood that road humps cause increased wear to vehicle components and distress or injury to vehicle occupants, and to suggest how these problems, if they exist, can be ameliorated.

The project involves developing a range of validated vehicle simulation models aimed at providing repeatable acceleration profiles that are consistent with measured data from real world tests. The simulated acceleration profiles will then form the basis for biomechanical modelling of the human response when subjected to travel over each different hump type.

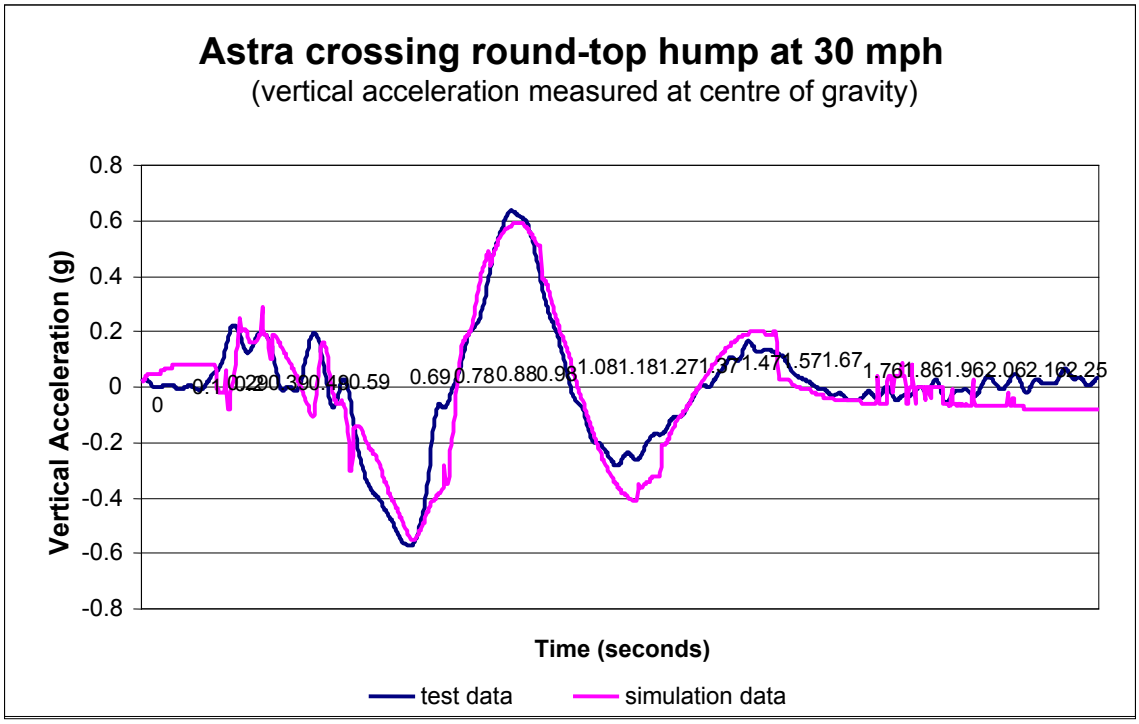

Figure 2 Comparison of simulation and physical test results for the vertical acceleration levels experienced at the centre of gravity of a Vauxhall Astra travelling over a round top hump

Preliminary results indicate that it is possible to obtain a good level of consistency between the simulated results and the physical test results (Figure 2). It is envisaged that these simulation models will provide a basis for the “virtual testing” of future hump designs. This project has also highlighted that there is significant potential in using computer simulation to assess other types of proposed road safety measures.

TRL frequently uses simulation technology in the study of individual crashes to determine the likely contributory factors. The knowledge gained from studying "real world" crashes provides valuable information in developing specifically targeted countermeasures, be they related to road user behaviour, vehicle design, or road environment design. Computer simulations also provide a cost effective and practical means of examining human response to crashes.

TRL's state-of-the-art driving simulator is used to investigate road safety, driver impairment and intelligent transport systems, enabling tests to be carried out which may otherwise be impractical, illegal or too costly in the "real world". A number of research projects have been undertaken to examine the effects of various factors on driver behaviour including:

- fatigue and energy drinks,
- alcohol, cannabis and other drugs, and
- mobile phones (both hand operated and hands free).

TRL have more recently incorporated a number of computer visualisations, developed for individual crash investigations, into the driving simulator. This shows significant potential in being able to test specific countermeasures in a "real" driving environment.

5. CLOSING REMARKS

Computer visualisation technology offers significant opportunities and benefits in the field of road safety. The benefits are particularly evident in situations where a road safety engineer is trying to demonstrate to an audience how a new safety scheme will look, or when an crash reconstructionist is trying to demonstrate the factors that are likely to have contributed to an individual crash. The examples provided in this paper illustrate situations where TRL has found computer visualisation and simulation particularly useful in addressing a range of issues often encountered in the field of road safety.

Nigel McDonald
Principal Consultant
TRL Limited
nmcdonald@trl.co.uk

Fabian Marsh
Senior Consultant
TRL Limited
fmarsh@trl.co.uk