# Informal Crash-Reporting System

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## ABSTRACT

*The Land Transport Safety Authority is a body formed by the New Zealand government, having the mandate to maintain New Zealand's state highway infrastructure. One important source of information that helps the Land Transport Safety Authority to make decisions is crash data - recording motor vehicle crashes, location, road condition and so forth. At the current time it is recognised that there is chronic under-reporting of crashes to the New Zealand Police.*

*In an attempt to address this problem, the Land Transport Safety Authority investigated the possibility of getting information from non-legislative sources. Tow truck operators have been targeted as a likely source of crash data, given that they will likely attend a crash scene.*

*A prototype solution was implemented by way of web-based forms for the tow truck operators to complete. The Information Engineering and Prototyping methodology has been followed, allowing the results achieved to be reproduced in the future. A major benefit of this system is that the underlying database is extensible, allows multiple concurrent users, and can be used to generate statistics - all elements required by the Land Transport Safety Authority in their project brief. The chosen data structure supports the development of data warehouses in the future, given the ability to draw information from disparate sources and present results (reports) in a pre-prepared or ad-hoc manner.*

*Future technological developments are discussed, including the ability to incorporate GPS~information and information gathering through the use of hand-held devices.*

**Keywords and phrases:**

Internet. data gathering, Land Transport Safety Authority, location, data warehouse, hand-held device, data model

## 1 INTRODUCTION

The Land Transport Safety Authority (LTSA) has responsibility to maintain New Zealand's crash database. In order to do this effectively, and allow TransFund (the government body responsible for the apportionment of road funding) to apportion road maintenance funding fairly, records about the existing roading infrastructure must be kept.

One important issue is that of motor vehicle crashes. Currently data is gathered from Police records (which are comprehensive for crashes recorded). However anecdotal evidence suggests as many as 50% of injury related and 70% non-injury related crashes go unreported. Because of the perceived under-reporting, a substantial baseline of information is not available (Doesberg and Byfield 2000).

Tow truck operators often attend crashes that should be, but are not, reported to the New Zealand Police (as required under New Zealand legislation).

The LTSA use crash data for several purposes, including (but not limited to) the allocation of resources for road maintenance, road upgrade (shape correction work), allocation of police activities (active or passive inhibition of driver activities), and other regional road funding issues (LTSA 2000a).

The Otago/Southland region of the LTSA has a paper based informal crash-reporting system. Tow truck operators fill in a line on a paper form as they attend a crash. The pages are faxed or posted in when the tow truck operator has the time, or when the page is complete.

This incurs time delays contributing to incomplete or inaccurate data, particularly when the tow truck operator completes the form at a much later date (say at the end of the week when completing other paperwork). Data can lack integrity when there are (often very) vague descriptions of the crash locations. For example, a general description like "on the Te Anau highway" is quite normal for a road that is 98km in length. The LTSA need to know crash locations with greater accuracy than the current data provides.

This paper-based system causes problems for LTSA staff, mostly because a large amount of time required to input the data from these sheets. Because of the vague locations it is very difficult for the LTSA to use crash site information in a meaningful way (for example, to identify problem road sections).

## 2 IE/P METHODOLOGY - FOR SPATIAL PROBLEMS

Information Engineering and Prototyping (IE/P) is a tried and tested methodology for software development (Kennedy 1991). This information is usually prepared as part of a **document, looking to what will happen in the future and providing a guide for developers.**

There are some adjustments from a standard IE/P process when considering spatial database projects, so for completeness the process described in the `Scope and Objectives' project document is reproduced in part:

### 2.1. Identify Problem

• Data is supplied on an informal basis by alternative (non-legislative) sources. At the current time this comprises tow truck operators, but could conceivably be extended to a greater number of sources, including (but not limited to) insurance companies, health care providers, the hospitality industry and transport operators.

• Currently this information is a paper form that can be sent to the LTSA office by facsimile or post. Basic crash data is listed and relevant notes may be included. The desire is for this to be computerised, saving time, effort, with the possibility of checking independent information sources (cross checking).

• It is difficult to accurately establish the location of the crash.

### 2.2. Identify Functions

The proposed system should accept new data, including:

• location,

• vehicle type,

• origin of travelers (for example, NZ tourist, Foreign Tourist. Local resident . •      direction of travel,

• road and weather conditions,

• approximate time of incident, and

• other relevant information.

This information should then be stored in such a manner that the LTSA can prepare statistical and map-based reports in a meaningful manner.

The system should be able to record other data supplied, which may include sound, video or still imagery as appropriate. A picture of a crash site may also be useful. Some information may help identify types of crashes for reporting purposes. For example, there may be high proportion of crashes on curves on a particular stretch of road, compared to similar roads elsewhere in the country. This should be stored in a manner that makes retrieval or reproduction a relatively straightforward operation.

## 2.3.    Define Outputs

Assuming the Internet is the most available medium for this project, a `thank you' message is an essential, and often overlooked, means of letting the user know that their input is valued and has been accepted.

At some future time, there could be a `report back' feature, letting the tow truck operator know the number of crashes they have attended in the past (say) four weeks. It may also be possible to make comparisons on a more temporal basis, like monthly comparisons, annual comparisons and so forth.

For the LTSA, 'ad-hoc' query combinations should be possible. One likely use would be to allow crash investigators to tie together correlated but disparate data. It is likely that interactive colour maps of crash locations could be generated with other features of interest included.

## 2.4.    Model Data Flows

Data is likely to flow in, not out. This is similar in behaviour to Data Warehouse design, and may form a basis for future development.

Data Warehouses are an advanced form of database that allow fast and complex queries. Special tools, known as On-Line Analysis and Processing (OLAP) tools, allow querying in multiple dimensions. Standard reports can be generated automatically, and OLAP tools have the ability to support ad-hoc information discovery. One major benefit of data warehouses is their ability to combine data from many sources, and present it as a cohesive whole.
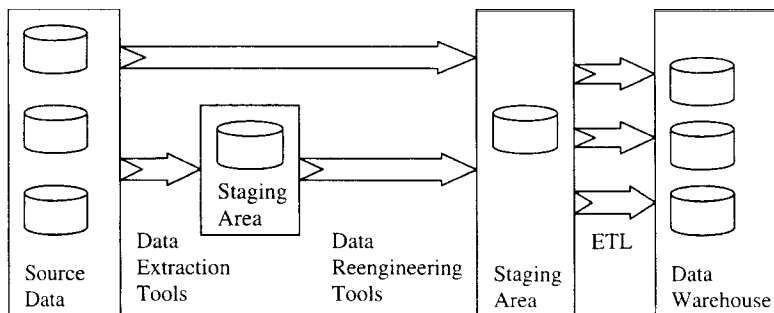


*Figure 1 - a typical EDW architecture (White 2000)*

Ultimately, the LTSA will look to a more advanced form of storage - the Enterprise Data Warehouse (EDW). The EDW can then be accessed by multiple data marts (small-scale data warehouses, usually for a specific purpose), possibly held by regional branches to satisfy local requirements.

Data cleaning should occur prior to entry (through the use of u 'staging' area or database), in order to capture and collate duplicate reports of a single incident. Staging may represent 24 hours or more, allowing data to stabilise, which in this particular instance is likely to be checking for duplicate reports of one crash for a particular vehicle or combining data from the various sources to get a more full understanding of the crash. Aggregation may occur at different levels, in the same way as data entered from disparate sources may have different granularities. Staging and transformation should take care of these issues (and can be addressed reasonably well provided there is sufficient meta-data available from which to draw valid conclusions). The complete architecture may look similar to that shown in Figure 1. This process is known as Extraction, Transformation and Loading (ETL), and is one which may take several forms depending on the source and nature of the original data. Once data is entered into the EDW, it should be removed from the staging area. Only when this is complete should the update process be termed complete (an atomic transaction).

## 2.5.    Perform Data Analysis and Generate Entity Relational Model

The existing model from the CAS system has been replicated as far as possible. There may be additions (although alterations should be limited) to allow for the flexible nature of the data being supplied. It is inadvisable for data duplication to occur between database systems, as this provides opportunity for synchronisation errors that will cause problems. Synchronisation errors occur when alterations are made in one place but not in other(s) where duplicate data is held.

The existing system, CAS, has been developed since 1995 with the aim of storing crash data in a format that allows LTSA staff to retrieve information about locations, crashes, crash types or other contributing factors (LTSA 2000b). Crash statistics can be generated. The underlying database was built using Oracle, and the

mapping components draw on data stored using MapInfo. The MapInfo data is in a complex form, to allow for inputs from both new and legacy databases.

When creating the data structure for the informal crash-reporting system, the decision was made to replicate the existing structure as necessary, while retaining a `slim' design. Figure 2 describes the final ERD.
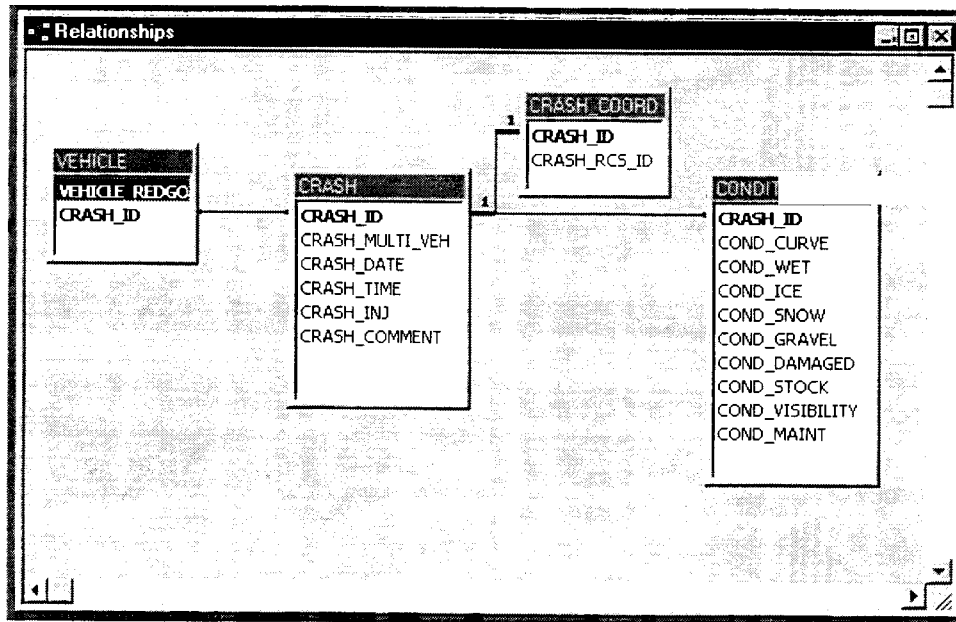


*Figure 2 - ERD from MS Access. Reflects the data types from CAS, grouped appropriately*

Data models must take into account future development, scalability, and purpose. In this instance, it is expected that LTSA staff will be conducting analysis on the sample data contained within the database to ensure it meets the needs of the LTSA.

## 3 POSSIBLE SOLUTIONS

We have attempted to identify some alternative systems and look at their advantages and disadvantages in relation to the prototype implementation.

### 3.1.    The `Paper Trail'

The first alternative is to consider a variation on the current system. To meet the main shortfall of the current system the inclusion of a suitably scaled map of the crash location would be needed. As rural tow truck operators can cover considerable distance several maps would need to be used to give the necessary scale. To include a map at all means the existing form would need to be modified so that there is one crash per page, possibly reduced to AS size. A pad of tear-off maps may be provided so they could be attached to the report. This would mean only one pad of crash reports for all tow truck operators and a series of tear-off maps for each operator by region.

GPS devices may be used to pinpoint the location of each crash removing the need for the maps as the co-ordinates could be entered on the form. GPS devices are not yet common equipment on tow trucks, but is a viable alternative in the future providing exact location coverage for the whole road network.

The choice of using stick-on maps may make faxing the report a problem so the cost of mailing needs to be considered. There are additional costs involved when printing forms and maps.

Most tow truck operators could handle this method as there is no `technology' involved. The time required filling out the form and map would not be longer than at present and the forms could stay attached to the pad until the operator decides to send them to the LTSA.

There are a number of problems with this type of system from the LTSA standpoint. Primarily, they will need to enter the information they receive into whatever computer-based system is used by the LTSA. This is likely to result in double handling, data entry of the location increases any location error from the original map marking, and additional costs involved in staff time. The informal nature of this data collection means it t would likely be vulnerable to budgetary cuts. Cost analysis may prove that the provision of CPS devices to tow truck operators

may be effective in reducing location error, but the main problem, in a paper based system, is the cost of data entry by LTSA.

### 3.2. WAP Technology and Hand-Held Devices

Wireless Application Protocol (WAP) technology is at the cutting edge of technology and as such it is hard to predict how it will be implemented. WML is used as a technique to get content from an HTML Web site, using WAR onto small-screen devices. However, you have to write a Web site to suit a four-line cell phone display and again for an eight-line display. There is significant effort required in writing web-sites in Wireless Mark-up Language (WML) for every device. Using a WAP incurs a fee for each connection, in the same way that Internet traffic is charged.

A Palm device with an attached GPS has advantages over its WAP cousin. The data is handled once only, crucial data such as date and time can be automatically generated and the `complete' crash record can be automatically uploaded when telephone transmission range is achieved, reducing operator requirements. The system can be changed at the server end minimising field upgrades and the future use of voice activated response is realistic. Future costs are unknown. but present indications are in the range of NZ$ 1,000 plus tax for a Palm/GPS combination. This will drop as applications come on line and communications protocols are developed. Transmission or service costs are also to be considered. Benefits of the Palm/GPS/Cell method include:

- restrict communications to less than a minute

- could be done while the tow truck operator was in the field

- would not require an internet connection by the LTSA - with related security advantages

- cost benefits to both the tow truck operator and LTSA tar less expensive than custom pad and mail options... )

- immediacy of results - the LTSA would have record     ,n a far more timely fashion than is currently the case

- relative accuracy, comparable with that provided by the NZ Police and

- the `gift' of a palm device and GPS provides tow truck operators a physical incentive to help.

### 3.3.     Web Alternatives for Image capture and Crash Location.

A web based interface has the greatest likelihood of succₑₛₛ at least in the short term) because the tools and expertise will already be in place. It is assumed that most tow truck operators are also associated with a garage capable of issuing Warrants of Fitness (WoF). The WoF process is already run through the Internet, so a new entry form for crash information is not likely to be a problem for tow truck operators. It can also be assumed that the necessary skills, hardware and software will be in place.

Following a discussion with Internet media experts, the following alternatives for web based crash location were proposed. Most discussion revolved around technology issues, but some have impact on usability.

QTVR: Quick Time Virtual Reality is an accepted means of navigation in a spatial sense. This relies on giving the user affordance, or means of navigation, that is simple and intuitive (Dix et al 1998).

The user is presented with an image (a map) then has a special mouse pointer. When the mouse button is held and the mouse moved, the `window' over the image `moves' in the desired direction and at a speed determined by the distance the mouse is moved. After initial training this is an effective means of navigation, provided the user has a suitable frame of reference (landmarks). However, this prevents the option of `zooming' in or out without additional functionality and user knowledge. The maps have to be stored locally, as map size would not be conducive to downloading 'on-the-fly'.

*MacroMedia Flash:* This can provide a `whizzy' interface - limited only by developer imagination. However, getting a result sent back across the Internet can take time, and calculation of location is difficult. The downloading of the entire map network can be overcome here by only having a `tile' downloaded at a time, downloading neighbouring tiles in the background. The novelty will quickly wear off, unnecessary complexity and speed may also become issues.

*CD-Mapping:* This can get around many of the downsides experienced by other means, as the entire map can be available, and the interface can be installed on the disk - only requiring connection to the Internet for the purpose of data transfer. However, licensing issues, software and map updates and lack of user computer

literacy may become sticking points. The LTSA is not in a position to offer help facilities, and it is likely that users not understanding computer complexity would abuse help support for the tool by expecting help for other software.

*Client Tools:* There was a suggestion that web-interface client/server tools be used. However, licensing costs and system complexity prevent this from being a viable alternative.

*Web Images:* After considering the passing of GIF tiles (quick and relatively seamless), based on the maps available, the following suggestion has been decided as most appropriate:

Initial GIF layer defining regular `regions'. User chooses the approximate centre point for the next layer. Higher scale layers are built 'on-the-fly' by a GIS tool at server side, and the GIF sent to the user. The user can then `click' on a point on the GIF, the point location returned to the server. This point is translated into a coordinate for the GIS, which zooms in to the next layer, generating a new GIF to be returned to the user. This is repeated until a suitable level of detail is reached.

At the lowest level, the user can then `drag' icons placing a vehicle type at the location it was found - the crash location.

This fulfils the major requirements as specified by LTSA for crash location information, and gives a measure of desired information (for example the type of vehicle involved in the crash and the actual location can be derived by looking at the image).

### 3.4.    Conclusion - Alternative Technologies

As long as the underlying data structure is sound then the implementation of any technology, whether old or new, becomes a technical implementation and cost issue. The major problems in this project's concepts are not technology but issues of finance, accuracy of user input, 'user-friendliness' user acceptance.

## 4 IMPLEMENTATION

A web-based prototype was constructed using a MS Access database to contain data submitted by users. The prototype tools were developed for scalability and reliability of use with multiple concurrent users. 24-hour availability is expected, though not essential.

A web-based interface has been chosen as the most appropriate means of data collection. This has the greatest reach, assuming that most tow truck operators are associated with a garage capable of issuing WoF. The WoF process is managed through a Web interface, so it was assumed most operators have the computer hardware, expertise, and Internet connection in place.

Web forms were created that the tow truck operator can complete (Figure 3). This allows the capture of such information as type of vehicle, crash location and so forth. The form also provides a map (Figure 4), which allows the tow truck operator to determine an approximate (within fifty metres) crash location. Once a location has been selected and other information has been supplied, the information is saved to a database.

Later, the LTSA can query the database and use existing database querying tools to extract relevant information. The database has been structured in such a way that it can be used in conjunction with data from the existing formal reporting system. These results can be combined for use in reports and presentations.

Members of the LTSA were presented with documentation and working prototypes created using Web pages linked to the MS Access database and an alternative using MapX (over MapInfo data). These alternatives provide the LTSA with a working prototype that can now be built in a more robust form by Internet professionals for testing `in the wild'. Although implementation is more expensive, the result will ultimately save resources through timesaving and stability. A business model for product development and rollout was prepared, allowing the LTSA better control over the final result.

**Crash Report Details**

The date of the Crash
eg. dd/mm/yyyy

The Time of day the Crash
Occured eg. 13:15

Vehicle Registration No:

Did the Police attend
the crash site?

Drivers Nationality,
(L)ocal, (K)iwi or
(I)nternational?

Drivers Gender M/F

Were multipule Vehicles
involved?

Were People Injured?

* Indicates a mandatory field

Please tick the additional conditions if they applied to this crash

ICE?

WET ROAD?

GRAVEL?

SNOW?

ROAMING STOCK?

DAMAGED SURFACE?

POOR VISIBILITY?

ROAD WORKS?

ON A CURVE?

Clear Fields

Submit

If there are any
additional comments
please place them here:

*Figure 3 - Web-based input form for tow truck operators.*

## 5 CONCLUSION

It is recognised that many crashes that should be reported to the Police are not reported. In an effort to capture these crashes, an informal reporting system has been implemented by the LTSA, Otago/Southland. This paper based system fails to give sufficiently accurate information to be of use to the LTSA for reporting purposes.

A working prototype computerised data gathering system for informal (non-legislative) reporting of crashes was built. This was a Web based system as it is assumed that most of the users (tow truck operators) have access to the Internet for issuing Warrants of Fitness.

The forms allow the entry of salient, generic information about crashes. The information can usually be obtained in the course of conversation without being overtly threatening or judgmental, and in general does not identify a driver specifically (avoiding legal issues). The forms allow the accurate mapping of crashes through the use of an on-line map that can be 'zoomed in' to a crash location and a location chosen. The data captured is stored in a database.

The resultant database is expected to provide sufficient information to be useful for reporting and decision making, complementing the existing CAS system. LTSA are expecting to receive more timely, accurate, and complete crash reports. These can be used to more fully report crashes by region and support the creation of reports. Road funding decisions will be made on a larger base of information influencing spending more to those areas affected by crashes that may not be captured currently. The costs of data gathering should be reduced, saving costs. Data accuracy will be improved through the use of a `standard' input method, better accuracy of crash location, and the provision of data in a more timely fashion.
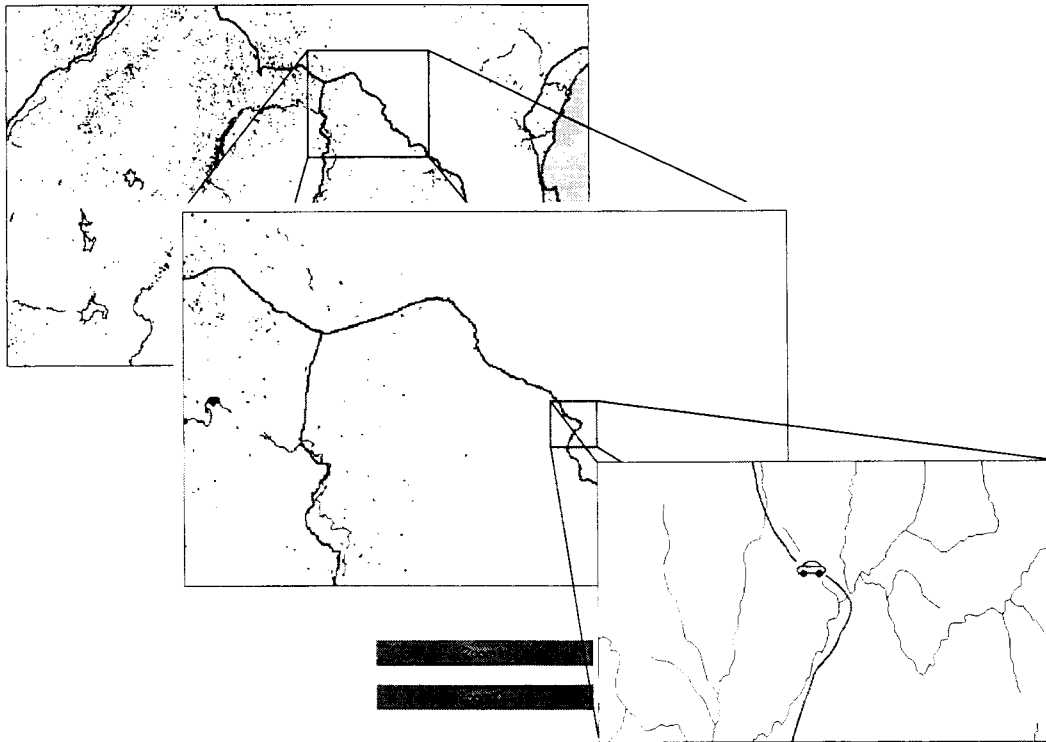
*Figure 4 - Map image layers. Zoom in, Zoom Out' and `Crash Location' (the car icon) functionality.*

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Note: Web addresses are correct as at 10 October 2000.

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