Automated Incident Recording System (AIRS) – Trial Study

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Biography
Damien Chee is currently acting in the Accident Investigation and Blackspot Program Manager position of the Road Safety Strategy Branch of the RTA where he is responsible for managing the State Blackspot Program. He has over 5 years in the field of road safety engineering having previously managed the Road Safety Audit and Crash Investigation Unit of RTA's Sydney Region.

Abstract
The development of engineering solutions to improve road safety at problematic sites has traditionally been dependant on a series of analytical and investigative techniques, where the analyst uses all data available to determine the solutions that will be effective. In this respect, the accuracy of the reporting and interpretation of the available data is of utmost importance to ensure that the solutions are effective.

In addition, the use of crash data to develop engineering solutions has been coupled with a considerable lag time between the crash events and the remedial action. This lag time is counter-productive as it allows more crashes to occur in the interim.

An audio-visual technology has been developed that enables footage of crash and near miss events to be captured on video. The collection of data in this manner has great potential to improve the accuracy of crash analysis and investigation as well as accelerate the process for remedial works to be carried out. The technology known as Automated Incident Recording System (AIRS) has been trialled by the Roads and Traffic Authority of NSW (RTA) at two locations in the Sydney metropolitan road network. This paper details the results of the trial and explores some future applications of AIRS in crash analysis and investigation, and countermeasure development. It is envisaged that AIRS will become an integral component of crash detection and reduction programs in the RTA.

1. INTRODUCTION

The RTA spends approximately $15 million each year on the Crash Reduction Program, which involves identification and improvement of crash problems across NSW. This includes Accident Investigation and Blackspot Treatments, Road Safety Audits and Remedial Works and Mass Action Treatments.

The current methodology used to identify countermeasures (improvement works) for crash locations is Accident Investigation and Prevention (AIP) Studies. This methodology requires the analyst to use all data available to draw reasonable conclusions. The use of crash data in AIP has several drawbacks including:

- The excessive time lag between the crash event and when the associated data becomes available for analysis often means the treatments are out-of-date. The lag also means that more crashes have been allowed to occur in the interim.
- The data does not paint a holistic picture of the processes that lead to the crash and as a consequence, crash causal factors are often speculated or assumed. Police reports rely on witness accounts which may be biased or incomplete.

♦ Only crashes reported to the Police are included in the crash dataset and there is no knowledge of unreported crashes, or near miss events (which may be of another crash type).
♦ Crash data is often inaccurate with errors due to reporting and data entry. There is also the possibility of misinterpretation by the analyst.
♦ Crash data provides little detail on behavioural factors involved.

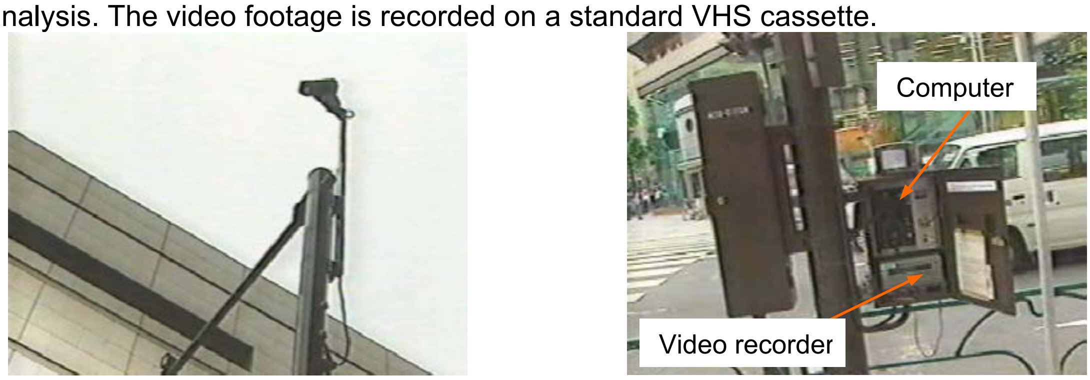
Many of these drawbacks can be eliminated if those responsible for developing countermeasures were witness to the crash events. However, in reality this would never be possible nor feasible. The next most ideal option is to have a recording system enabling the analyst to view the behaviour of traffic remotely. CCTV used in traffic monitoring could be used for this, but it would be extremely time consuming as hours would be spent viewing the video for the purpose of extracting crash events lasting mere seconds.

The Automated Incident Recording System (AIRS) described in this paper is the technology developed by the Mitsubishi Electric Corporation, that will greatly enhance crash analysis and investigation and eliminate many of the drawbacks as listed above. This paper will also give an account of a trial of the AIRS equipment conducted by the RTA as well as outline some future applications.

2. AUTOMATED INCIDENT RECORDING SYSTEM (AIRS)

Automated Incident Recording System (AIRS) is a hi-tech accident detection and recording system that works by detecting sounds associated with traffic crashes and near misses then recording the moving images on video for analysis. The RTA has conducted a pilot study into the implementation, data gathering and outcome evaluation of AIRS. Funding assistance was also provided by Austroads as an e-Transport demonstration project through ITS Australia.

The AIRS is programmed to detect sounds associated with traffic crashes and near misses. The system is comprised of a special camera (Figure 1a) and microphone connected to a computer (Figure 1b). The computer has a memory card that constantly receives images and sounds from the camera. A predefined series of sound frequencies which typify road crashes are set in the computer to enable the AIRS to detect occurrences of crashes or near misses (eg. noise from skidding braking tyres or glass breaking) triggered by the noise source. When the microphone detects these noises, the computer is triggered to record the moving images four seconds before and after the noise source on video, thereby capturing the entire event for analysis. The video footage is recorded on a standard VHS cassette.



(a) The camera unit is typically mounted at a height of 9m to maximise the “field of view”.

(b) The AIRS computer and video recorder are located near ground level for easy access.

Figure 1: Components of the AIRS system

As the placement of AIRS equipment requires a reasonably accurate understanding of crash locations, the system is best applied at intersections due to the greater concentration of crashes when compared with most midblock situations. At intersections, two camera units may be used to maximise the “field of view” and to capture all possible traffic movements and conflicts.

The potential benefits of AIRS include:

- Allowing earlier diagnosis of road safety problems at selected sites
- Enabling before and after analyses to be undertaken to evaluate the effectiveness of treatments
- Providing a means of acquiring live data on crashes (including unreported events) and near misses
- Providing a means of assessing the effectiveness of crash reporting mechanisms
- Providing a means of comparing the real causes of crashes with the reported or perceived causes
- Providing early warning to the Traffic Control Centres of potential traffic congestion due to crashes
- Enabling early dispatch of emergency vehicles
- Enabling road authorities, policy and emergency services to understand the nature of those accidents and near misses which go unreported.
- Improving the accuracy of crash mapping and hence the effectiveness of countermeasure treatments.
- With increased application, analysis of AIRS data can allow re-calibration of predicted crash reduction percentages due to type-specific and location-specific countermeasure treatments.

3. APPLICATIONS

3.1 Crash Analysis and Investigation

As indicated above, AIRS can be used across the road network where there is a perceived or identified road safety problem and where prompt diagnosis is required. Crash analysis using AIRS is more cost effective than conventional methods of accident investigation and prevention in the following ways:

- Less time is required for crash data collection as crash data feeds directly to the Road Authority
- Less time is required to develop a data sample size which can justify cost effective treatment

The earlier the crashes can be avoided, the greater the crash saving benefits.

3.2 Privacy

The RTA has discussed the issue of privacy with the NSW Privacy Council. A statement was issued confirming that the RTA conformed with the requirements of the *Privacy and Personal Information Protection Act 1998.* The cameras are not designed to output detailed images that enable licence plates or road users to be identified. For RTA applications of AIRS, the system is not intended to be a tool for enforcement issues or as evidence in legal disputes.

4. TRIAL PROJECT

Following a demonstration of AIRS provided by Mitsubishi Electric Australia, the RTA commissioned a trial study of the system with the following three sites being nominated:

Site 1: The traffic signal controlled intersection at Oxford Street and Crown Street, Darlinghurst

Site 2: The roundabout / giveway controlled intersection of Darling Drive and westbound off ramp from Pier Street, Pyrmont

Site 3: The STOP controlled T-intersection of the Pacific Highway and the Lakes Way ("Tuncurry Road"), Rainbow Flats, south of Taree (not covered in this paper)

The objectives of the study were to:

1. Test the effectiveness of AIRS in detecting crashes
2. Compile and collate data captured by AIRS at the three sites
3. Analyse the data to determine causes of crashes and near misses
4. Compare the recorded events with police records
5. Compare the recorded events with the historic record of reported crashes.

5. SITE 1 – TRAFFIC SIGNAL CONTROLLED INTERSECTION

AIRS was first installed at the signalised intersection of Oxford Street and Crown Street in Darlinghurst (Site 1) in early October 2002. The purpose of the trial was to evaluate the effectiveness of AIRS in detecting crashes and to identify any areas for improvement.

Two camera units placed at the south-eastern (Figure 2) and north-western corners of the intersection were used for this trial study. Each of these cameras was connected to the traffic signal controller box to obtain the traffic signal pattern at the time of recording. This was essential to determine if there were any traffic units in breach of the signals at the time of the crash thereby identifying whether any behavioural or road environment factors were prevalent with the recorded incidences.

Figure 2: An image taken from the camera on the south eastern side of the intersection. The braking associated with the yellow car and red car was the incident which triggered the recording.

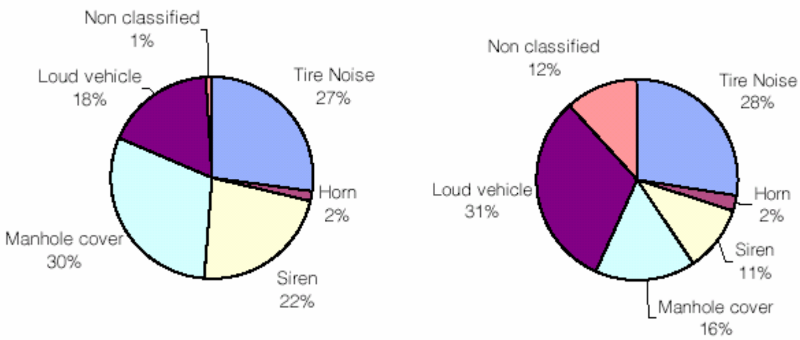
In the six-week initial trial period from 30 August to 18 October 2002, there were a total of 2,543 recordings captured by AIRS. An analysis of the footage revealed a high number of false alarms with 2,510 (99%) invalid recordings. The remaining 33 (1%) of recorded events were comprised of 32 near misses and one crash event. The noise sources responsible for the false alarms included:

- Frequent traversing of an uneven manhole cover (the major cause of false recordings)
- Tyre noises not related to a crash or near miss event
- Sirens of emergency vehicles (St. Vincents Hospital is near this intersection)

- High volume pedestrian noise and excessive construction noise from a nearby building site
- High volume noises from vehicles (eg. noisy exhaust systems)
- Vehicle horns
- Other non-classified noises

Following this analysis, it was clear that unless the system could undergo sufficient sound filtering adjustments, the application of AIRS as provided would not be suitable in locations with a high frequency and volume of noises that are non-symptomatic of crashes. Such "external" noises include pedestrian and construction noise, and emergency vehicle sirens. It should be noted that despite causing a high number of false alarms, noises such as horns and tyre screeching are often the precursors of crashes. The system showed a good level of sensitivity in detecting these noise sources.

In response to the high number of false alarms, methods of filtering out some of the unwanted noise sources were investigated. A software adjustment was made and the system was further tested at the Oxford Street/Crown Street intersection for a one-week period commencing 5 February, 2003, to evaluate the effectiveness of the adjustments. A total of 541 records was captured by the system during this one-week period. A "before and after" analysis of the valid vs. invalid recording showed an improvement in the effectiveness of the data capture as the number of valid recordings increased from 1.5% to 9%. Figure 3 shows a comparison between the before and after invalid recordings.



2,062 invalid recordings out of a Total of 2,095 in "Before" Situation

490 Invalid Recordings out of a Total of 541 in "After" Situation

Figure 3: The most effective way to determine the extent of improvement as a result of the software changes was to compare the invalid recordings before and after the software changes. (NB. The before situation was adjusted to remove temporary construction activity)

The pie charts indicate a reduction (hence an improvement) in the number of recordings triggered by sirens from 22% before to 11% after. There was also an improvement in the effectiveness of the equipment by reducing the number of incidences triggered by the uneven manhole cover from 30% to 16%.

Although sound filtering was effective in removing some of the unwanted noises, the system could not be configured to filter out tyre and horn noises as these are often associated with crashes and near misses. The improvement in the sound filtering software is an area for future improvement of AIRS.

5.1 Assessment of AIRS Results

A comparison of AIRS data with the RTA crash records for the period when AIRS was operational was required to ensure that all reported crashes were captured by AIRS. The crash data for the 93 day period (30 August and 22 November, 2002 and 5-13 February,

2003) was cross-referenced to RTA crash records to determine whether AIRS missed any of the crash events. There were no crashes reported to the Police that were not detected by AIRS. Prior to undertaking the analysis, it was possible to speculate some of the additional advantages of using AIRS such as:

- The improved accuracy of crash mapping and collision diagrams. This was made possible by comparing collision diagrams of historic data with the crash and near miss locations captured by AIRS footage.
- Gaining an appreciation on how many near misses occur per every crash event (near miss/crash ratio), and how many unreported crashes occur for every reported crash (unreported/reported crash ratio).

In the 93 days of data capture between 30 August and 22 November, 2002[1] and 5-13 February, 2003, there were a total of 74 near miss events and 2 crash events captured by AIRS.

An analysis of the crashes/ near misses recordings showed that:

- Majority of triggering noises were tyre noise (66%), followed by horn (20%) in the crashes/near misses
- 33 crashes/ near misses (43%) occurred on Thursdays and Fridays
- 45 crashes/ near misses (60%) occurred during daylight conditions.
- 12 recordings (16%) were made between 12.00pm and 2.00pm
- The key vehicles involved in the crashes/ near misses were 59 cars (78%) and seven taxis (9%)

The main Road User Movements (RUM) observed from the AIRS crashes/near misses recordings included:

- Pedestrian far side (RUM 2) – pedestrian proceeds from kerb or side of carriageway to cross the road and is hit by a vehicle from the left (one crash and 12 near misses observed)
- Rear end (RUM 30) – the front of the key vehicle collides with the rear of another vehicle travelling in the same direction (one crash and 14 near misses observed)
- Adjacent cross traffic (RUM 10) – accident involving two through vehicles approaching the intersection from two different approaches (seven near misses observed)

5.2 Comparison with historic crash data

The Collision Diagram shown in Figure 4a shows all crashes that occurred at the Oxford Street/Crown Street intersection during the period from 19 December, 1999 to 30 September, 2002. This represents the period after the Eastern Distributor was opened to traffic. As seen in the diagram, the predominant crash type involved pedestrians being impacted (RUM codes 0 and 2). Figure 4b shows a diagrammatic representation of the crashes and near misses that were captured by AIRS in the 93 days of data capture.

The most significant difference between the historic data and the AIRS data shown in Figures 4a and 4b is the amount of incident clustering. The historic data contained 24 crashes in the 1015 day period equating to 8.6 crashes/year. The AIRS data captured 74 near miss events in the 93 day period equating to 290 near miss events/year. The comparison showed that for every crash event in the historic data, there were more than 33 times more near miss events captured by AIRS.

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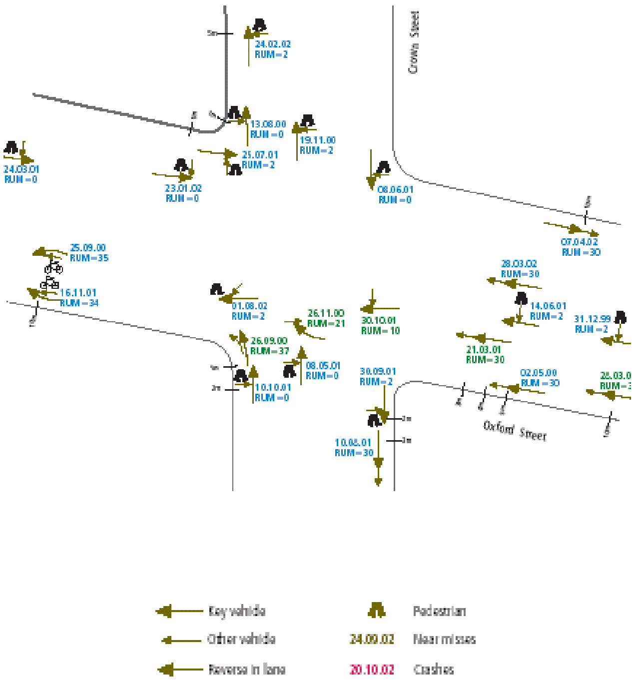
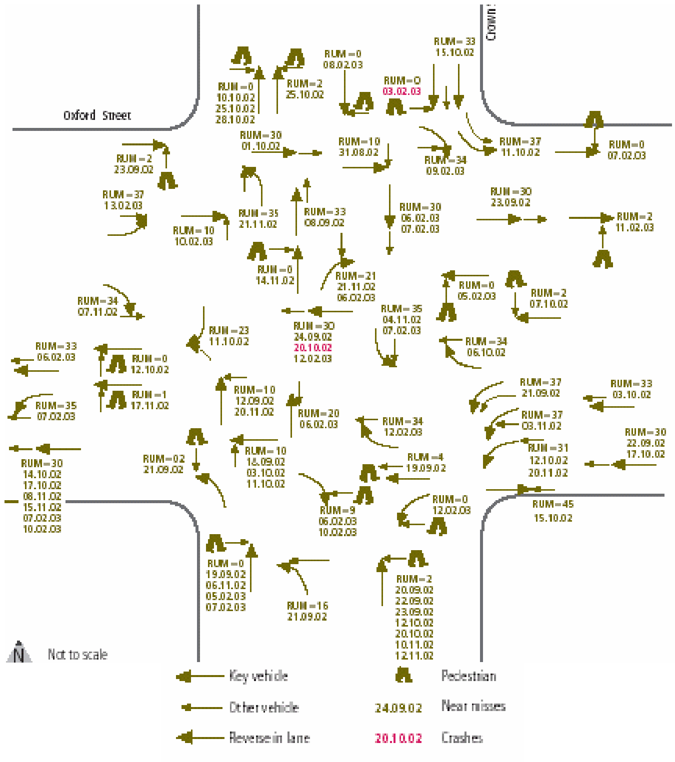
[1] This includes the initial six week period from 30 August to 18 October, 2002 described in the previous section.

The data captured by AIRS (Figure 4b) also showed pedestrian crashes as one of the predominant crash types. However, there were a number of discrepancies. In the historic data, the western and northern approaches of the intersection had the highest numbers of pedestrian crashes. The AIRS data showed that the number of pedestrian crashes on the southern approach greatly exceeded any other approach with a total of 12 near miss events being captured. The northern approach was the next highest with five pedestrian near miss and one pedestrian crash event.



(a) Collision Diagram for the intersection of Oxford Street and Crown Street, Darlinghurst for the period from 19 December, 1999 to 30 September, 2002 (Post Eastern Distributor opening)



(b) A diagrammatic representation of the near miss and crash events captured by AIRS in the 93 days of data capture between 30 August and 22 November, 2002 and 5-13 February, 2003

Figure 4: A comparison between the (a) Collision Diagram with historic crash data and (b) the near miss and crash events captured by AIRS

Another difference was the level of detail provided for each event captured by AIRS. With the historic data, the collision diagram is often flawed by three sources of error. The tabular crash data used to produce the collision diagram often contains errors due to reporting and data entry faults. In addition, the analyst producing the collision diagram must interpret the information provided, which is not always clear. As a result, the collision diagram is often considered to be the most “reasonable” interpretation of the data given the level of detail provided. Contrastingly, analysis of crash footage removes the reporting and data entry phases and allows the analyst to pinpoint the exact location of each event, identify the types of vehicles and which road user movements were involved. The level of detail in Figures 4a and 4b illustrates this point with Figure 4b containing more turning movements. Several of these crash types if reported the traditional way may have regarded the vehicles as “going straight” as the crash may have occurred at the departure end of the movement, where the vehicle trajectory straightens out. It is this level of detail that will greatly enhance road safety engineering work particularly where (reported) crash rates are low.

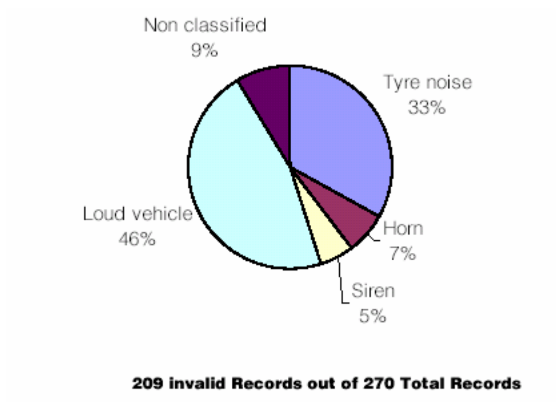
Due to the low number of crashes, no countermeasure treatments were proposed for the site. This component of the study was still of value as it resulted in improvements to the sound detection capabilities of AIRS.

6. SITE 2 - ROUNDABOUT/ GIVEWAY CONTROLLED INTERSECTION

Following the trial at the Oxford Street/Crown Street intersection, AIRS was installed at the roundabout/give way controlled intersection of Darling Drive and the off ramp from Pier Street, Pyrmont. The two cameras were placed as such:

- Camera 1: on the underside of the Pier Street overpass (See Figure 5a); and
- Camera 2: south west corner of the roundabout.

(a) An image from the camera mounted on the underside of the Pier Street overpass showing a single vehicle loss-of-control crash.



(b) A breakdown of the noise sources responsible for triggering invalid recordings

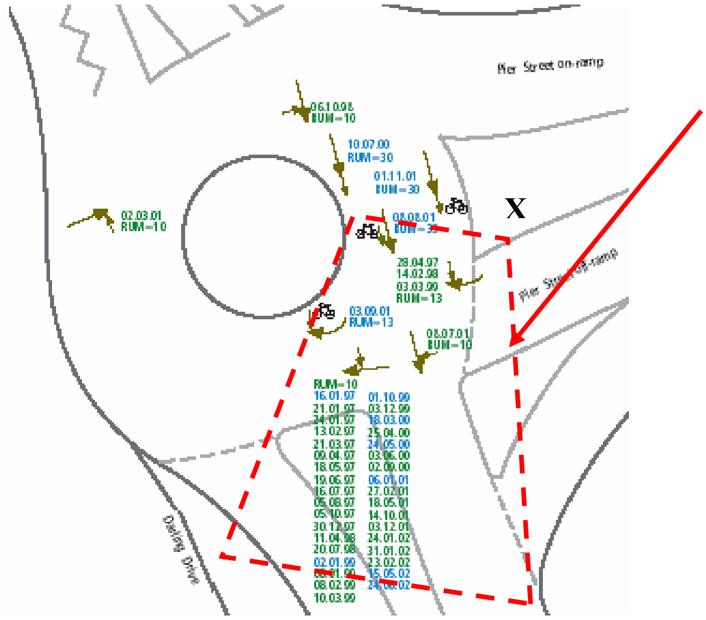
Figure 5: Video and data output from Site 2

In an eight-week period from 7 March 2003 to 3 May 2003, AIRS captured a total of 270 recordings. Of the 270 recordings, 61 (23%) were valid recordings including six crashes and 26 near miss events. In addition to the earlier sound filtering improvements, this improvement in the capture rate of valid recordings was due to the more ideal surrounding environment. Compared with site 1, this site has less pedestrian traffic, emergency vehicles and external noise sources that could trigger the system.

Of the 209 invalid recordings (“false alarms”), 33% were triggered by tyre noises, 46% were triggered by loud vehicles and 7% were triggered by horns (see Figure 5b). This is acceptable as these sounds are often symptomatic of crash or near miss events.

6.1 Comparison with Historic Crash Data

The Collision Diagram shown in Figure 6 shows all crashes that occurred at the intersection of Darling Drive and the on and off ramps from Pier Street in the 5.75 year period between 1 January 1997 to 30 September 2002. It should be noted that not all these crashes would have been detected by the AIRS units located as described above. It is important to acknowledge this so that a fair comparison can be made between this dataset and the AIRS data. As seen in the diagram, the predominant crash type involved westbound vehicles and southbound vehicles



NB. If AIRS had been in place, only the crashes in this area would have been captured by Camera X.

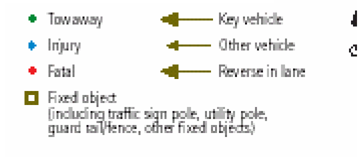
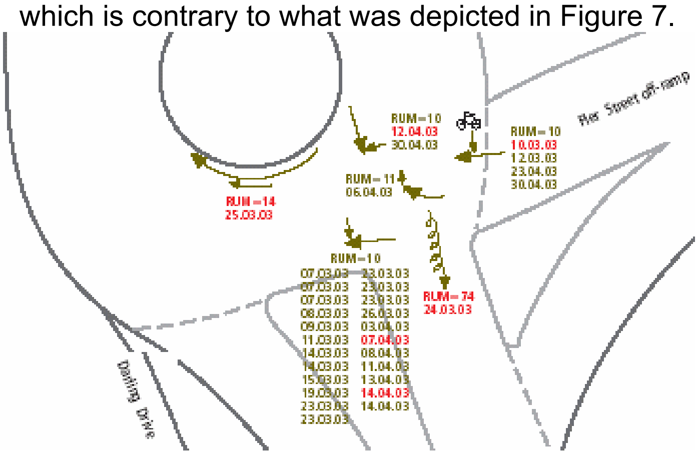


Figure 6: Collision Diagram for the intersection of Darling Drive and the Pier Street on/off ramps, Pyrmont for the period from 1 January 1997 to 30 September 2002.

Figure 7 shows the near miss and crash events captured by AIRS during the eight-week period from 7 March to 3 May, 2003. Of the 31 near miss and crash events, 23 (75%) occurred when a westbound vehicle on the off-ramp from Pier Street failed to slow down and give way at the roundabout resulting in a crash or near miss with southbound vehicles on the roundabout. The dominance of this incident type (which was consistent with the historic records) demonstrated the effectiveness of AIRS in capturing the crash footage. It also allowed some of the crashes depicted in Figure 7 to be questioned as summarised below:

- The 34 x RUM 10 crashes in Figure 7 were more likely to be closer to the hold line of the off-ramp
- The 4 x RUM 13 crashes in Figure 7 were most probably RUM 10 crashes
- The RUM 10 crash on 8 July 2001 was more likely to have the westbound vehicle at fault which is contrary to what was depicted in Figure 7.



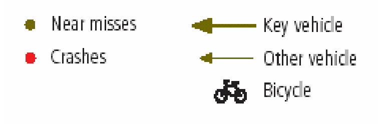


Figure 7: A diagrammatic representation of the near miss and crash events captured by AIRS between 7 March 2003 and 3 May 2003

6.2 Comparison with the RTA crash records for the same period

The crash data for the eight week period from 7 March to 3 May, 2003 was cross referenced with RTA crash records to determine whether AIRS missed any of the crash events. This analysis, carried out on 29 July, 2003, showed no crash records for the eight week period, which strongly indicates that the six crash events (highlighted in red in Figure 7) were not reported to the police. It should be noted that there is often a lag between the crash event and the time it is registered in the RTA database.

6.3 Countermeasure development

In response to the six crash and 26 near miss events, the RTA implemented a range of low cost countermeasure treatments through consultation with the City of Sydney Local Traffic Committee and Sydney Harbour Foreshore Authority. These have been summarised below as improvements in (i) advanced warning and guidance and (ii) sight distance and visibility.

Improvements to advanced warning and guidance are shown in Figures 8 and 9

(a) Before the sign adjustments (b) After the sign adjustments

Figure 8a and 8b: The diagram on the parking sign (westbound off-ramp to Darling Drive) was adjusted to more accurately depict the alignment of the roundabout. This was intended to reduce speed of approaching traffic. Advanced direction was also provided to Market City to enable removal of a cluster of guidance signage at the base of the ramp.

Figure 9a (top) and 9b (bottom): The following improvement works were carried out to improve guidance: (i) removal of the incorrectly placed Roundabout/Give way signs and replacement with high visibility advanced warning signs to the intersection, (ii) removal of a cluster of guidance signage at the base of the ramp to give more emphasis on the Roundabout/Give way sign and (iii) installation of a second Roundabout/Give way sign on the right side of the ramp.

Figure 10 shows improvements in sight distance and visibility through the roundabout.

Figure 10a (left) and 10b (right): The sight-obstructing vegetation shown in the photo on the left was removed to improve sight distance through the intersection. Work completed on 10 June 2003.

6.4 Monitoring Effectiveness of Countermeasures using AIRS

AIRS was re-instated at this site on 4 August, 2003 to enable footage to be obtained for the period after the installation of the countermeasure treatments shown in Figures 8-10. The camera will remain at this site for a period of four to six weeks to enable an adequate sample size for comparison with the "before" data[2].

The "before and after" analysis will enable the RTA to determine whether the countermeasure treatments were successful by comparing rates of crashes and near misses before and after the countermeasure treatments were installed.

In addition, the RTA will be able to assess the effectiveness of the crash reduction assumptions that were made prior to implementation of the countermeasure treatments.

7. FUTURE APPLICATIONS

There are many opportunities for future application of AIRS for both crash analysis and investigation and research purposes. The RTA envisages that the use of AIRS will become an integral component of annual crash reduction programs and a tool that will greatly enhance the quality and accuracy of traditional accident investigation and prevention techniques. While traditional crash reporting mechanisms result in a considerable delay in accessing processed crash data, the added advantage that AIRS offers is a reduced time lag between the crash event and crash data analysis. In these respects, the analysis and countermeasure treatments are more up-to-date with the prevalent crash trends.

AIRS can also be used for research purposes. With increased application of AIRS, there is potential to improve the accuracy of assumed percentage reductions in crashes due to specific countermeasures in specific road environment types. This will improve the accuracy of the economic evaluation that often precedes crash-reduction countermeasures treatments.

AIRS can also improve the area of crash mapping and collision diagrams for identification of crash clusters and development of countermeasures specific to the prevalent crash problems. This has been demonstrated above with Sites 1 and 2, where collision diagrams using historic data were compared with data obtained through AIRS. Mitsubishi Electric have

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[2] This paper was written shortly after AIRS was re-instated at Site 2 and as such the results of the "before and after" comparison could not be documented.

also developed a computer software that enables the analyst to "map" the crash event by the sequence of events before, during and after the crash. This has not been pursued as a part of this project as the benefits appear to be intended for forensic diagnosis of the crashes and associated legal issues.

In future, it may also be possible to have AIRS incidents linked to the RTA's Transport Management Centre. With early notification of crashes (particularly those that can potentially disrupt traffic flows through critical links across the network) AIRS could enable early dispatch of emergency crews and traffic management teams.

8. CONCLUSION

AIRS provides an opportunity for insight into the factors and causes that lead to crashes. From trial sites 1 and 2, AIRS has proven to be effective in providing information to determine the individual types and causes of crashes or near misses. With a high level of sensitivity in capturing both crashes and near misses, AIRS has demonstrated that it is accurate and complete in detecting crash and near miss events. Analysis of AIRS data enables a more holistic assessment of the crash problem, particularly in cases where there is a high proportion of unreported crashes. In this respect, it is also able to provide insight into the effectiveness of crash reporting mechanisms and compliance with reporting requirements as detailed in Australian Road Rule 287.

The reduced lag time between crash event and analysis, will allow countermeasures to be more quickly implemented thereby maximising the benefit achieved. AIRS can also be used to monitor and evaluate the effectiveness of any countermeasures implemented and also to continually calibrate crash reduction assumptions regarding each treatment type.

AIRS improves the accuracy of crash mapping following traditional crash data analysis techniques and hence will improve the effectiveness of countermeasures developed. With continued use, AIRS can also enable assumed crash reduction percentages to be reviewed and modified.

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AIRS, Crashcam, Accident Analysis and Investigation,