An Coimisiún Sábháilteachta Iarnróid
Railway Safety Commission

Special Topics Report –

Railway Bridges in Ireland & Bridge Strike Trends

Anthony Byrne

Principal Inspector

February 2009

Executive Summary

On average in excess of 180 railway bridges over roads are reported as being hit each year in the Republic of Ireland by oversized road vehicles and the trend shows that this figure is increasing. Similarly an increasing number of road bridges over the railway are being struck by road vehicles with the figure doubling in just 2 years to over 40 incidents in 2007, which is believed to be due to better reporting. As a consequence, train services are disrupted and infrastructure maintenance costs are increasing. This figure may appear small, however, if one considers that the railway network in Ireland extends to only 1277 route miles, the figure is somewhat worrying.

Rail transport passenger miles are also on the increase. Faster, more efficient train services are expected by the travelling public and rail operators are increasingly under pressure to ensure that train services are on time. In 2000 31.7 million passenger journeys were made while, in 2007, the figure had risen to 45.5 million passenger journeys (RSC, 2007), representing an increase of 43%.

In the Republic of Ireland, as of the 31st December 2007, there were 3094 railway bridges, with 1906 being under-bridges, i.e., roads under the railway and 1188 being over-bridges, i.e., roads over the railway. Specifically focusing on the under-bridges, 414 are referred to as being height or headroom restricted. This means the clearance from the road level to the underside of bridge deck is limited to 5.03m / 16’ 6” or less in height and it is these that are the most problematic. At such interfaces the railway is vulnerable in terms of risk to safe railway operations. Following an under-bridge strike the tracks alignment can become mis-aligned and cause a train to derail. Similarly, following an over-bridge strike, debris can fall onto the track below and should a train hit this, it could potentially cause a train to derail. In the writer’s opinion, the risk is greater at bridges over the railway, as there are more vehicles that can strike a parapet then there are can hit a headroom restricted bridge. Besides, there are far more vulnerable bridges over the railway then there are under it. A bridge’s deck and abutments are in general strong elements that can withstand an impact. A parapet, on the other hand, may often be the weakest part of a bridge, being of limited width, height and mass. While the risk to the railway is constant the likelihood is exacerbated if there are no additional safety measures installed such as safety barriers on the approaches to and over the bridge over the railway.

Chapter 4 provides detailed statistical analysis of both bridge classes, identifying the most vulnerable bridges, in terms of location, road class, material type etc. However, the principal statistics in terms of roads under the railway (under-bridges) are that the Portaloise bridges, UBC145 and UBC146, remain the most problematic. It should be noted that infra-red detection installed on the approaches to these bridges and a town centre diversionary route may see strikes fall over the medium term at these bridges. Analysis suggests the focus should be on the under-bridges that are located in and around Dublin

City Centre. In terms of over-bridge strikes, OBC196, Lisduff Country Boundary Bridge, located on a regional road between two relatively small towns, Templemore and Abbyleix remains the most problematic being hit 9 times, 8 since 2005 and 4 in 2007.

A number of bridge strike mitigation and prevention measures are discussed in Chapter 7 and these include traffic calming, improving advance warning signage on the approach to railway bridges, introducing deterrent measures such as collision protection beams, advance portal frames etc. A number of recommendations, a total of 27, are suggested and assigned to various stakeholder organisations. These include the Irish State railway company, Iarnród Éireann (IÉ) which is a subsidiary of Córas Iompair Éireann (CIÉ) - 17 recommendations, the Irish Road Haulage Association 1 recommendation, the Road Safety Authority – 2 recommendations and the Railway Safety Commission – 7 recommendations. The writer has specified priorities for all 27 recommendations and of these, no urgent recommendations have been identified, 7 are assigned as being a high priority meaning review and possible action should commence within 3 months. A further 16 have been assigned with a medium priority meaning review and possible action should commence within 6 months with the remaining 4 being assigned as low priority, commencing within 12 months. Table *i*, lists the high priority recommendations and the stakeholder company responsible for its implementation.

Number	**Area**
RSA2	Mandate drivers of goods and similar vehicles to know vehicle / load height
IÉ3	Liaise with Tipperary County Council re: OBC196 Lisduff
IÉ7	Have advance warning signage installed at all vulnerable under-bridges.
IE12	Install bridge signage where necessary
IRHA1	Promote use of height measuring devices and in cab displays
RSC2	Facilitate roundtable talks between stakeholders regarding the Portlaoise under-bridges.
RSC6	Promote use of height measuring devices and in cab displays

Table i: High priority recommendations

To conclude this summary, it may be useful to consider one question. If a railway undertaking demonstrated an indifference to track maintenance allowing a track to become distorted or mis-aligned and this subsequently caused a derailment, then this company would be ostracized. The media would, and rightly, high-light the significant malpractice and incompetence of the company concerned. The question then is; why the social and political indifference to the activities of road users who through their actions could cause the same result to occur?

Acknowledgements

I would like to thank my work colleagues for their help and support, more particularly Mr. Donal Casey for reviewing my work and offering me helpful and objective advice.

I would like to thank Ms. Fand Cooney, Mr. Brian Gray and Mr. Peter Cuffe and numerous other staff of Iarnród Éireann for their provision of data and photos. I would further like to thank Mr. Keith Ross of Network Rail for the GB bridge strike data, literature and photos. I also acknowledge Dublin City Council, the Central Statistics Office, the Road Safety Authority and the Vehicle Registration Unit of the Department of the Environment, Heritage and Local Government who responded kindly to my requests for information.

I would like to thank the Safety Unit of the European Railway Agency (ERA), for facilitating my presentation at the National Safety Authorities Meetings and subsequent dissemination of my questionnaire.

Unless otherwise stated, tables, graphs, illustrations and photographs within this dissertation have been produced by the author. The accident data was sourced from the records of the Railway Safety Commission and Iarnród Éireann.

The views expressed, and any mistakes, are the writer's own and do not necessarily represent the opinions or views of any organisation connected with the management and supervision of railway bridges in Ireland.

Table of Contents

List of Figures

List of Tables

List of Plates

List of Graphs

Glossary of Terms

Term	Meaning / Definition
CIÉ	Córas Iompair Éireann
DCC	Dublin City Council
DoT	Department of Transport (Ireland)
DfT	Department for Transport (UK)
EF	Equivalent Fatality
EN	Euro-norm
ERA	European Railway Agency
EU	European Union
ft	Foot / feet
GB	Great Britain (i.e., England, Scotland, Wales, Isle of Man & Channel Islands
GPS	Global Positioning System
HGV	Heavy Goods Vehicle
HMRI	Her Majesty's Railway Inspectorate, UK
HSE	Health & Safety Executive, UK
IÉ	Iarnród Éireann (subsidiary of CIÉ)
IRHA	Irish Road Haulage Association
kg	kilogram
km	kilometre
MS	Member State/s
NR	Network Rail
NRA	National Roads Authority
OB	Over-bridge or Overline bridge
RRSWG	Road Rail Safety Working Group
SIP	Safety Investment Programme
RSC	Railway Safety Commission (Ireland)
RSSB	Railway Safety Standards Board (Great Britain)
T21	Transport 21
UB	Under-bridge or Underline bridge
UK	United Kingdom of Great Britain & Northern Ireland
€	Euro, equivalent to GB £0.78389 and IRL £1.27

1 Introduction

It is widely accepted that systems often fail at their interfaces. The railway is a complex system comprised of numerous subsystems and interfaces. One such interface that is particularly problematic is the road-rail interface, in particular at level crossings and at bridges that pass over or under the railway.

Both the above mentioned asset areas are problematic because of the third party interface, i.e., the public, who are largely unaware of the potential risks associated with their actions or omissions. It is an appreciated fact that the railways principal third party risk is at level crossings and indeed the largest proportion of railway fatalities occurs at such locations. The area of level crossings has been researched by many, while the issue of bridge strikes has had a more limited review. This was a contributing factor in selecting bridge strikes as the writer's research subject.

This is further substantiated by the fact that in Ireland in 2007 there were 180 bridge strikes and this figure represents an increase of 68% over that in 2002. In fact the trend appears to be rising and this report will look in more detail at this and try to put forward reasons for this.

Most of the railway network in the Ireland is rural in nature, and the reliance on roads remains high. Given Ireland's prosperous economic climate over the past decade, construction has seen unprecedented growth, none more so than in the road sector. Under the 'National Development Plan/Community Support Framework 2000-2006' the Government invested in excess of €8 billion in the road infrastructure and pledged a further €13.3 billion over the period 2007-2013 (Dept. of Finance, 2007).

Invariably, with new road projects, new road-over-rail and road-under-rail bridges are necessary. In the period 2004-2007, 87 under-railway-line bridges were constructed and therefore the asset register is increasing. It is recognised that, in general, newly constructed under railway line bridges will be constructed with sufficient clearance, however, a risk remains in terms of oversize vehicles travelling under these bridges.

To put this into context, in 2004, the network had one road under-line bridge every 1.13 route kilometres. By the end of 2007 this figure had worsened to one road under-line bridge every 1.08 route kilometres. This figure may appear small, but represents an increase of 5% in the number of road-under-railway bridges in just 3 years. Research undertaken by the writer would suggest that Ireland has experienced more accidents as a consequence of bridge strikes per route km than most other EU member states and this is explored further in chapter 5.

Bridge strikes are not responsible for significant numbers of fatalities in the rail industry; however, they have the potential to cause catastrophic accidents that could easily result in multiple fatalities. Fortunately, more often than not, a bridge strike leads only to train delays and passenger fury.

However, these delays can prove costly in terms of public performance measure (PPM) and, indeed, financially as, in the UK at least, compensation payments are made under schedule 8 of the contract between the infrastructure owner and train operating companies (TOCs). Fortunately there is only a single owner/operator in Ireland and, hence, no penalty payments are necessary. To comply with the European Safety Directive 2004/49/EC, of course, there is a functional split between maintainer and operator. It might be argued that given this fact there is no incentive to improve. This would not be the case as no operator wants to expose their staff or the people they carry to unnecessary risk.

1.1 Overview of Special Topics Report

In Chapter 2, the writer outlines the background to the Irish railway network providing details of network size, infrastructure and an overview of services provided on the network. The term bridge strike is defined and the classification of bridges is explained to develop the reader’s understanding of the topic. Some over arching statistics are revealed.

In Chapter 3, the writer introduces the reader to the various stakeholders involved in the area of bridges strikes. He provides a short synopsis of each of the stakeholders’ activities and how they are related. He provides an overview of the working group established with the remit to promote safety at road rail interfaces and outlines some of the work undertaken by the group to date.

In Chapter 4, the writer explores the nature of bridge strikes and explains the characteristics of the various type of bridge. He considers the incident rate and risk by presenting the data and analysis of the data set. He looks at the risk profiles for the various type of bridge. Also revealed are the statistics relating to the geography of the incidents. He then presents some case studies of serious accidents that have occurred in Ireland at both under and over railway line bridges.

In Chapter 5, the writer presents the experience of the risk of bridge strikes in other European countries and beyond. He then presents, in more detail, the state of affairs in GB and compares all the situations with the case in Ireland.

In Chapter 6, the writer discusses the legal implications surrounding bridge strikes and with whom responsibility lies. He explains the classification of road traffic signage, making particular reference to signage associated with under-bridges. He outlines the measures that are being put in place to improve goods vehicle driver knowledge and competence.

In Chapter 7, the writer discusses bridge strike prevention techniques in current use and identifies new technologies that may be utilised in bridge strike avoidance. The role of human factors in design is also discussed.

Finally in Chapter 8, the writer draws his conclusions from the study, listing the recommendations made throughout the report. Where possible SMART principles are applied to the recommendations, i.e., they are made Specific, Measurable, Achievable, Realistic & Time bound.

1.2 Methodology

The starting point for the study is the late 1970s. Historic and more recent events are examined, considering varying risk related attributes, such as location, road geometry, signage, speed, etc. In addition, historical and current risk status of bridge strikes in Ireland are examined to ascertain changes in the level of risk and the key factors are explored that may have driven these changes. Incident statistical data are presented to show where risk is concentrated and to indicate patterns and trends.

The topic of bridge strikes is not one which springs to mind as a significant cause of incident or indeed fatality. However, it is a risk that, if certain circumstances prevail, can result in multiple fatalities. It is an area of increasing occurrence here in Ireland and, given this has been the case in recent years, the writer believes it to be a worthwhile area of research.

The aim of this project was to conduct research into railway bridge strikes. The research sought to understand the bridge strike trends that appear to have developed over the years and to suggest possible safety measures that could be employed to eliminate or reduce these incidents from occurring. Research was undertaken to fulfil the following objectives:

1. To review and examine historic bridge strikes in Ireland
2. To analyse incident statistics and identify bridge strike trends
3. To gain an understanding of bridge strikes in other countries
4. To gain an appreciation of the view from road hauliers
5. To identify technologies and methods for assisting in bridge strike prevention, detection and management

The writer first performed a review of literature pertaining to the research area. Literature on the subject of bridge strikes is scarce and the writer found it particularly difficult to trace documents relating to this topic. However, a limited number of related publications have been sourced, reviewed and discussed, where appropriate.

A qualitative approach was chosen to understand the attitudes and experiences other countries have with bridge strikes. Qualitative research, broadly defined, means "any type of research that produces findings not arrived at by means of statistical procedures or other means of qualification" (Strauss & Corbin, 1997).

This qualitative research consisted of a questionnaire sent to all EU Member States (MSs) that have representatives attending National Safety Authority meetings at the European Railway Agency (ERA). Furthermore this research consisted of telephone interviews with a number of Irish based road hauliers.

1.2.1 Validity

Validity is concerned with the accuracy of the data gathered and ensuring it matches reality. In this regard the questionnaire sent to the MSs comprised, in the main, a series of closed questions asking for the participant to provide definitive answers, e.g., ‘Do you collect statistics on under-bridge strikes?’. There were also a number of open questions but where a factual answer was necessary, e.g., ‘How are low bridges identified?’. A response rate of 73% was achieved which was deemed to be sufficient to undertake a cross comparison and analysis.

For the road haulage survey, telephone interviews were conducted with 10 companies. Again a series of open and closed questions where asked again looking for factual answers. In addition a small number of questions asked for the respondent’s opinion, e.g., ‘What do you believe Irish Rail should be doing with regard to low bridges?’ While it is acknowledged the sample size is small, a 100% response was achieved and the writer deemed this sufficient to gain an appreciation of the Irish road haulage industry and in particular their views relating to low bridges and under-bridge strikes.

1.2.2 Recommendations

Throughout the text recommendation areas are identified and explained, and then tabulated in chapter 8. As previously stated, recommendations are whenever possible made SMART and other key information added. The format in which recommendations are given is shown below in Table 1.

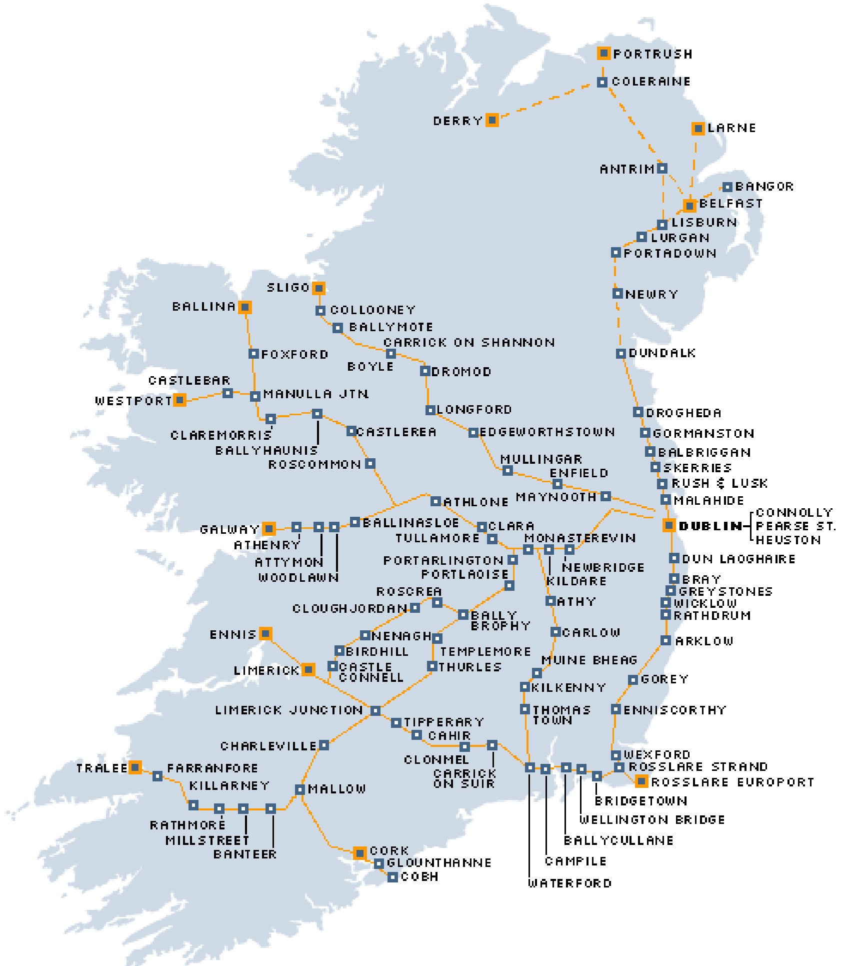
Number	**Title area** Explanation of what the recommendation is.
RSC1	**Priority** Urgent – action needed immediately to avoid unacceptable risk High – action needed to control a safety risk (commence within 3 month) Medium – action needed to control a safety risk (commence within 6 months) Low – action suggested to support longer term improvement in safety management (within 12 months)
Timescale	Suggested duration of project or of project delivery
Cost	Estimate of cost of delivering the recommendation, if applicable. NA is used to denote no expected cost other than within normal internal resource levels.

Table 1: Recommendation Format

Each recommendation has a number prefixed by an appropriate abbreviation, indicating the stakeholder to whom the recommendation is assigned. For example, RSC1 – Railway Safety Commission recommendation number 1, IÉ1 – Iarnród Éireann recommendation number 1, etc.

2 Background

The railway network in the Ireland is largely rural in nature, with essentially seven routes radiating from the capital's two main railway terminals, namely Dublin Connolly Station and Dublin Heuston Station. The network covers approximately 1919 route kilometres of lines in use, and is predominantly formed of continuous welded rail (CWR) on concrete sleepers. There are three types of signalling system in current use, based on track circuits using solid state interlocking (SSI), axle counters and to a lesser extent, semaphore signals with the absolute block method of working.



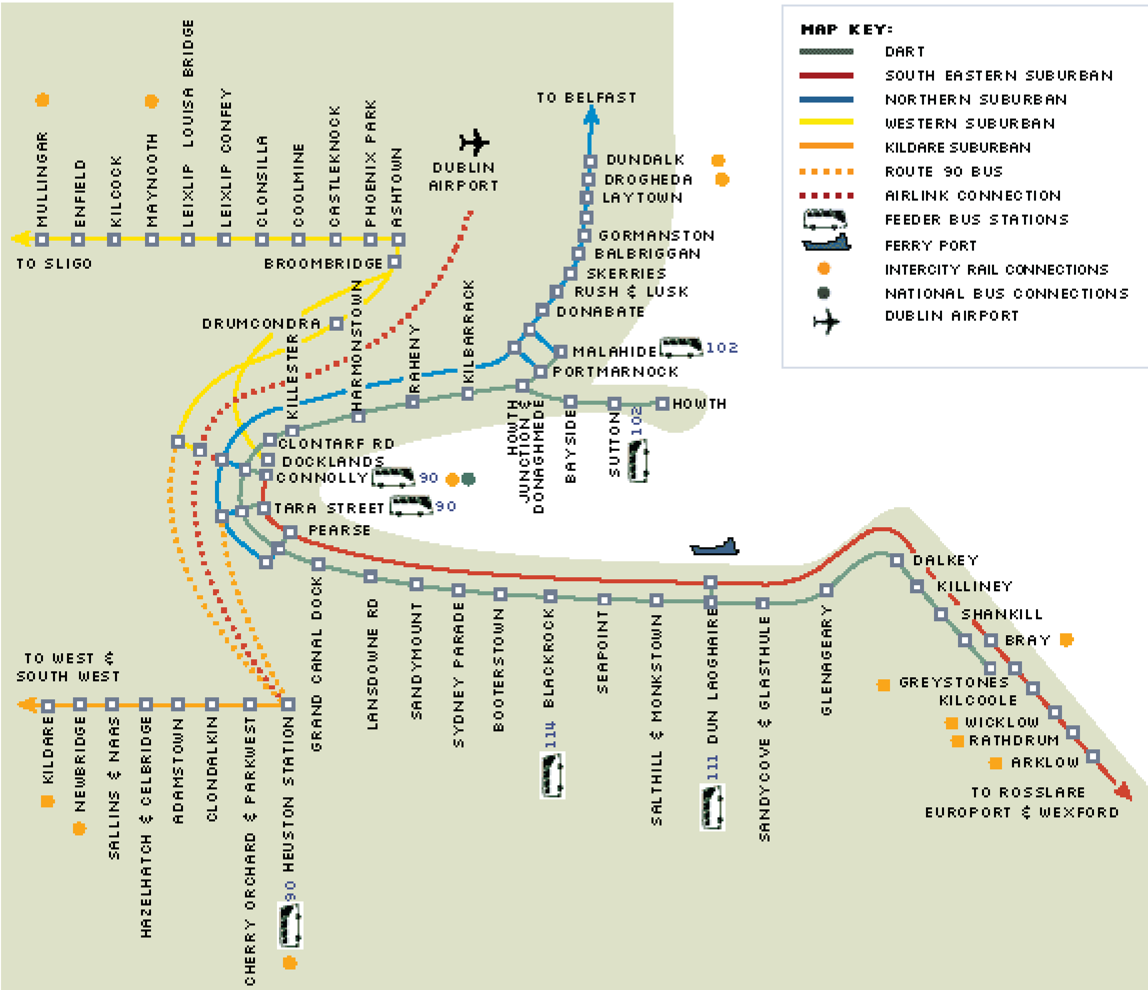
(Courtsey Irish Rail)

Figure 1: Ireland's Rail Network

The Dublin to Cork and the Dublin to Belfast routes are the principal intercity routes and are double track railways. Services on these lines run to a clock-face timetable operating hourly on the Dublin to Cork route and two hourly (approximately) on the Dublin to Belfast route.

The remainder of intercity services essentially operate to provincial cities and towns at varying frequencies on single lines with strategically located passing loops.

Dublin also has a commuter service comprised of what is essentially a Metro, albeit sharing tracks and train paths with main line services, and a diesel multiple unit (DMU) commuter rolling stock.



(Courtsey Irish Rail)

Figure 2: Dublin Suburban Route Map

As of the 31st December 2007 there were some 3094 railway bridges, in Ireland and, in 2007, there were 179 bridge strikes.

2.1 Definitions

There are many types of bridge in use today. Bridges may be simple culverts, footbridges, flyovers or viaducts and they may be constructed in many different ways. In the Irish context, railway bridges tend to be relatively simple in construction, essentially being one of two types, either a simply supported span or an arch bridge, although there are a few exceptions.

In a material sense, the vast majority of new railway bridges are constructed from concrete, usually by means of precast beams placed on reinforced concrete abutments or bankseats resting on reinforced earth structures. Figure 3 illustrates the principal components of a bridge.

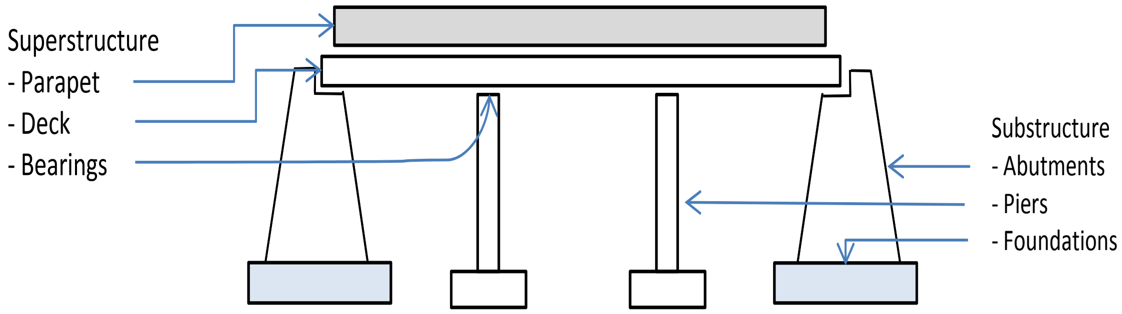


Figure 3: Bridge Terminology

Other materials from which railway bridges are made include steel and wrought iron, although the latter tend to be historical bridges built at the same time as the railway. Bridge material is discussed in greater detail later in this chapter.
Clearly, there are many different types of railway bridges, however, all must be designed to support a number of loads that include:

Load type	**Explanation**
Dead load	the structure itself
Superimposed dead load	static but moveable loads such as the ballast, sleepers, rails
Live loads	temporary loads such as the passage of vehicles over the bridge, collision loads

Table 2: Bridge Load Types

In terms of bridge strikes, they are collision loads and are a live load in that they occur at an instance in time. Clearly, the risk to the railway of bridge strikes depends upon a number of factors that include the available clearance, the location, the road geometry etc. These factors are explored in greater detail in subsequent chapters, but in particular in chapter 4. However, a significant aspect of a bridge's vulnerability is the material in which it is constructed and this is discussed below. (See section 2.3 Bridge Materials)

In terms of bridge strikes there are, in essence, only two classes of railway bridge referred to in the industry, they are the 'over-bridge' and 'under-bridge'. Upon initial reflection the above terms can be confusing. This confusion may be resolved quite simply by inserting the word "line" at the hyphen. Therefore over-bridge becomes over-line bridge and under-bridge becomes under-line bridge, where 'line' refers to the railway line. Plate 1 illustrates the classes.

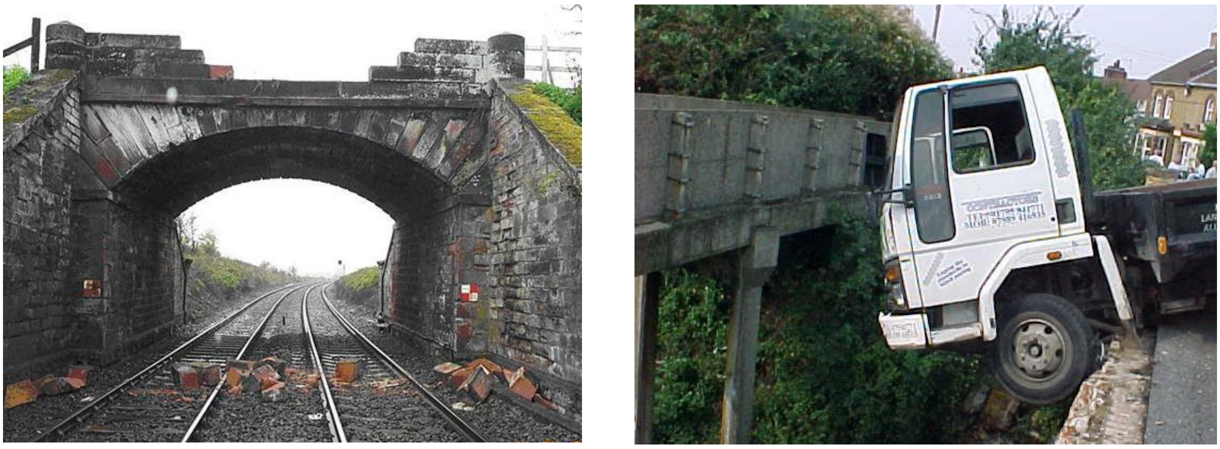
Plate 1: Over-bridge (Left) & Under-bridge (Right)

It should be noted that, in a number of countries, the converse is the case, such as in Australia. Indeed road authorities always use their road as the datum. It is therefore important to have a clear understanding of the terms used.

As previously stated, as of the 31st December 2007 there were 3094 railway bridges in the Ireland, with 1906 being under-bridges and 1188 being over-bridges. Specifically focusing on the under-bridges, 414 are referred to as being height or headroom restricted, that is the clearance from the road level to the underside of bridge deck being limited to 5.03m / 16’ 6” or less in height.

2.2 What is a Bridge Strike?

Now that the terms over-bridge and under-bridge have been explained, it is prudent to explain what exactly is meant by the term bridge strike or bridge bash, as it is often called. If one first considers an over-bridge. An over-bridge strike is where a road vehicle strikes the parapet or roadside containment of a bridge over the railway (plate 2).



(Courtesy Network Rail)

Plate 2: Examples of an over-bridge strike

The above photos clearly illustrate the potential risk to the railway and, indeed, road users following an over-bridge strike. In many cases parapets are weakened or, as is illustrated, result in debris falling on the track which could cause a train to derail.

If we now consider an under-bridge strike, this is where a road vehicle strikes the underside of a railway bridge (plate 3).

(Courtesy Iarnród Éireann (left) Network Rail (right))

Plate 3: Examples of under-bridge strikes

In terms of bridge strikes, in Ireland, historically the vast majority of potentially hazardous or serious events occurred at under-bridges. However, in recent years a noticeable increase has occurred in the numbers of over-bridges being struck. Most recent figures are for 2007, during which year, there were 40 over-bridge strikes. (See Chapter 4 for further details)

2.2.1 Bridge Strike Classification

Iarnród Éireann has a severity classification system which classifies the severity of an under- bridge strike as follows;

Serious	- The track has become distorted;
	- The bridge has shifted;
	- Girders have broken.
Potentially Serious	- The girders have been damaged;
	- Arch rings are damaged;
	- There are severe marks on the concrete.
Not Serious	- Signs are damaged;
	- There are scrapes to the underside of the bridge deck;
	- Masonry has loosened;
	- There is buffer beam (collision protection beam) damage.

IÉ have developed and provide classroom based training on bridges and bridge strikes to their Patrol Gangers as it is recognised that they are often the first permanent way staff to attend a bridge strike. Clearly, it is important that these staff can identify the seriousness of the bridge strike and take the appropriate action, i.e., is it necessary to block the line and stop train movements. As part of the training, a number of case studies are presented and the trainees are asked to classify the severity of the bridge strike in each case.

Clearly, it would seem prudent to have as many people trained as possible. However, it is recognised that this is not always practical. It would seem sensible though that IÉ formalise their training and provide some form of competence assessment to the task of classifying bridge strikes.

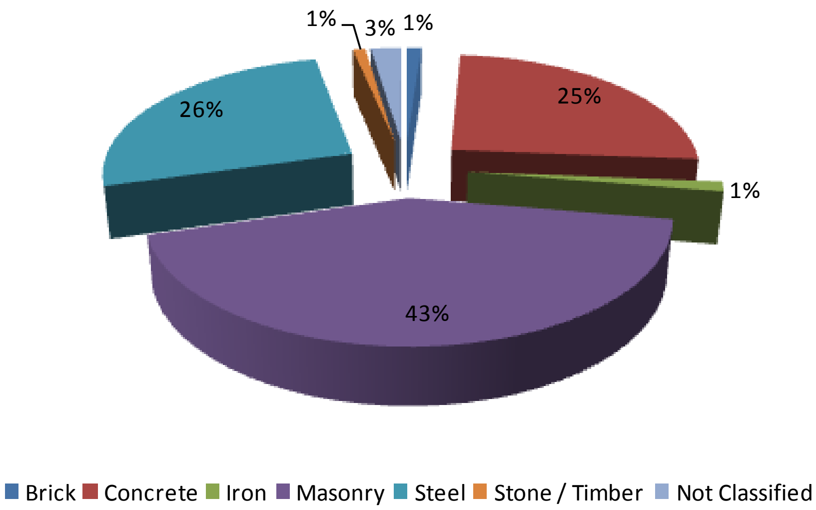
IÉ1	**Classroom Based Training.** IÉ should undertake a review of their bridge strike training for Permanent Way and Operational Staff with a view to making it a competence based course rather than a simple attendance based course.
Priority	Medium
Timescale	6 Months
Cost	NA

In an interview with the Network Rail Bridge Strike Champion it was stated and backed up by a document, that a similar severity classification system is employed. It is recognised, however, that NR's classification provides more detail, enabling the individual on site to classify the severity of the bridge strike more accurately.

IÉ have no formal classification system for over-bridge strikes, however, at the time of writing, an internal standard is being written and it is hoped that this will be issued and briefed by the end of 2008.

2.3 Bridge Materials

In the Irish context, and considering under-bridges in the first instance, the breakdown of bridge by material is shown in graph 1 and the photos below (plate 4) are examples of under-bridges in the country.

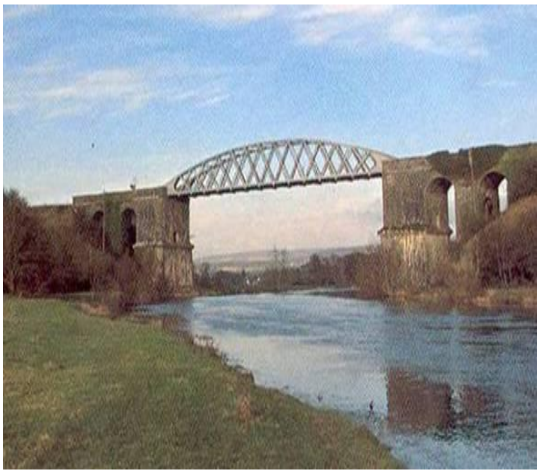


Graph 1: % breakdown of under-bridges by material

Steel bridge

Concrete

Masonry Arch



Wrought Iron *(Courtsey Irish Rail)*

Plate 4: Railway Under-bridge types

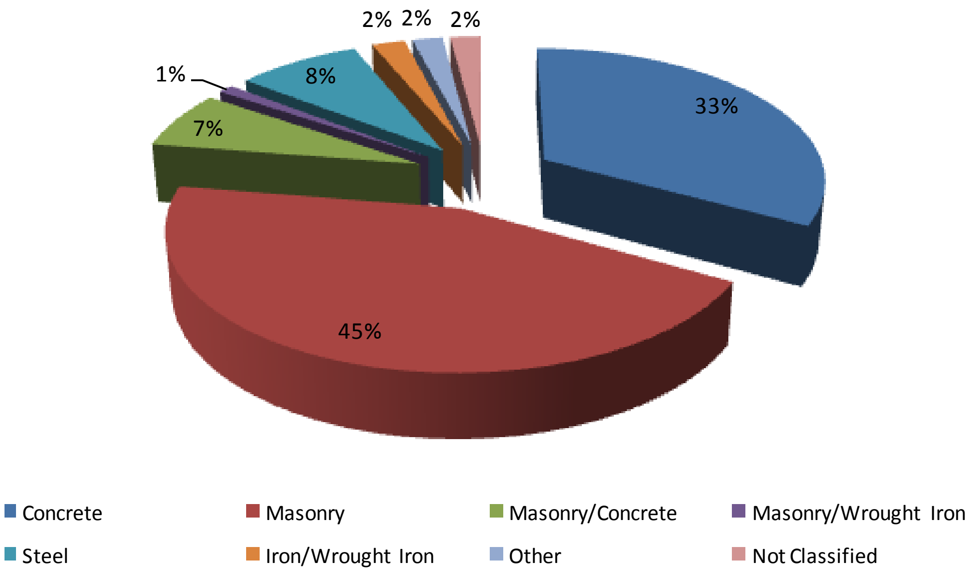
It can be seen from graph 1, 43%, almost a half, of the under-bridges are of masonry construction, followed by steel with 26% and concrete with 25%. Experience indicates that concrete bridges are less susceptible to serious bridge strikes and indeed pose more of a risk to road drivers than those travelling by rail, as loads can be knocked from the back of road vehicles.

Bridge strikes to concrete under-bridges tend to result in only superficial damage to the underside of the bridge as illustrated by the photos in plate 5 and rarely pose a risk to the railway. Nonetheless, following a bridge strike the bridge must be inspected immediately following notification and the railway line deemed fit for traffic, based on the assessment.

The greater risk to the railway is at the masonry and steel under-bridges where track distortion can occur and debris can fall on the track and/or on the road below. Chapter 4 looks in detail at the historical bridge strike data to identify if this is actually the case.

Plate 5: Superficial damage to concrete under-bridges

If we now focus on the over-bridge, it can be seen from graph 2 that there are a number of material types and combinations of materials.



Graph 2: % breakdown of over-bridges by material

As shown on the above graph 45%, again almost half, of the over-bridges are of masonry construction, followed by concrete with 33%, (which includes pre-stressed and or reinforced concrete) and steel with 8%. In the case of over-bridges the important aspect in terms of railway safety, apart from road speed and geometry, is the parapet material. Experience would suggest that concrete parapets are less susceptible to serious bridge strikes as they are sufficiently strong to withstand and deflect a vehicle impact.

It is the masonry over-bridge that would appear to pose the greatest risk as following an impact, debris can become dislodged and fall onto the track below and potentially derail a train. Instances of this type of bridge strike are shown in the photos below in Plate 6.

Plate 6: Examples of Masonry over-bridge damage

The damage to the parapet on the right is obvious while the damage to the parapet on the left is not so obvious. Upon closer inspection the second coping stone is loose following an impact with a digger and clearly poses a risk to the railway below. However minor, following a bridge strike, rail traffic is suspended, the bridge inspected and only if deemed safe is the railway line re-opened.
As stated previously, chapter 4 looks in detail at the historical bridge strike data to identify amongst other things if there are any trends of where bridge strikes are occurring.

2.4 Measurement of Under-Bridge Clearance.

Measuring the clearance available under a bridge is not as simple as one might imagine and is not simply a measurement from the road surface to the underside of the bridge deck. It is a little bit more complicated. Headroom restricted bridges across public roads are those that provide less than 16’6” clearance. Signage illustrating the dimensional clearance is as per the Traffic Signs Manual (1996) and shown in feet and inches and metres. See chapter 6 for further details.
The quoted headroom clearance on a standard flat beam bridge and an even road surface is simply the measurement from the road surface to the lowest point on the underside of the bridge deck, e.g., to the rivet heads on a wrought iron bridge. However, if there is vertical curvature on the road or the road is uneven then the measurement is taken from a 40ft chord simulating a road vehicle of this length to the lowest part of the bridge, e.g., the rivet heads on a wrought iron bridge. In this way road levels, cambers, dips, humps are all taken into account.

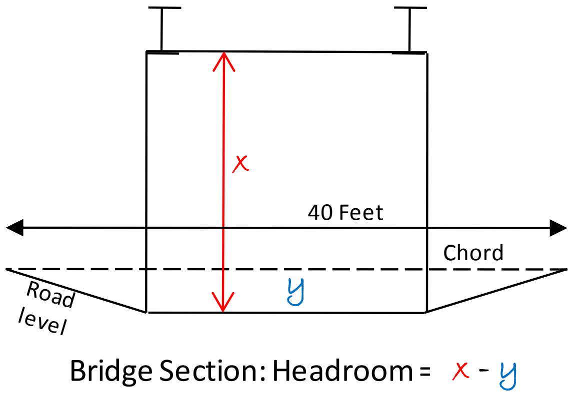
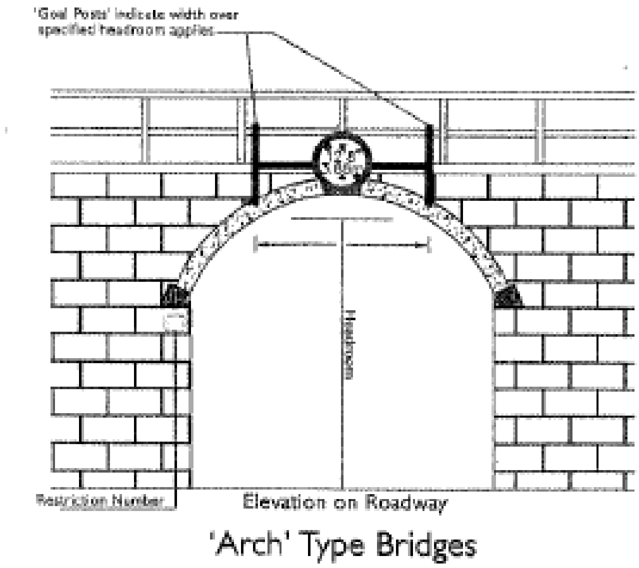


Figure 4: Iarnród Éireann method of calculating headroom

The same principle applies to arch bridges. Measurements are taken to the lowest point on the underside of the deck under which a road vehicle may pass. In such cases the signposted height is only available over a certain width of the arch and this width is indicated by what is referred to as 'goalposts'. See chapter 6 for further details.



(Courtsey Irish Rail)

Figure 5: Headroom clearance for an arch bridge

3 The Stakeholders

Bridge strikes in general occur due to an act or omission of a road based party, either consciously or unconsciously. In order to consider all aspects relating to the circumstances surrounding the bridge strike, it is ideally necessary to obtain the views of all the relevant parties. There are many stakeholders involved in managing road-rail interfaces, however, the two main stakeholders are, the railway undertaking and the road authority. Unfortunately it is often not this straightforward as there are many other agencies involved. These include; the road safety authority, the rail regulator, the Gardaí, the Department of Transport, road user groups etc. In the remainder of this chapter the writer provides a brief synopsis of each of the stakeholders and also the current working relationship between them.

3.1 The Train Operating Company (TOC) / Infrastructure Manager

The Railway Safety Act 2005 established the Railway Safety Commission (RSC) and, with that, a formal rail regulation process. Article 2 of the Act defines ‘railway undertakings’ and lists the Irish State railway company, Iarnród Éireann (IÉ) which is a subsidiary of Córas Iompair Éireann (CIÉ), the semi-State national transport company.

Unlike railway operations in many European Union (EU) countries, in Ireland IÉ are responsible for both train service operation and infrastructure maintenance. There are some 4768 (IÉ, 2007) employees within IÉ, with operations and engineering staff making up the majority of this figure.

Under the Chief Civil Engineer, there are two Divisional Engineers who manage the maintenance of the railway network and are responsible for the inspection and maintenance of 1188 over-bridges and 1906 under-bridges (figures correct as of 31/12/2007).

There is also a sizeable safety department responsible for, amongst other things, audit and monitoring, investigation, managing and controlling internal standards and maintaining accident statistical records.

3.2 The Irish Road Haulage Association (IRHA)

The IRHA was founded in 1973 as a non-profit organisation with the purpose of representing and promoting the interests of Ireland’s licenced road haulage industry at a national and international level. The IRHA’s remit is to promote excellence, professionalism and safety in the operation of road transport businesses. It is the national representative body of the licenced road haulage industry in Ireland and its members operate under Road Haulage Operator Licences issued by the Department of Transport.

A Road Haulage Operator's Licence is required where goods are carried for hire or reward in a vehicle or combination of vehicles which is in excess of 3.5 (metric) tonnes. These licences are valid for 5 years, after which a licence must be reapplied for. On average, over 1000 licences are applied for and issued each year, while in 2007 there were a total of 5187 road haulage operators licensed to operate in the country. This may appear a small number, however, a single licence covers an unlimited number of vehicles, for example, one of the largest operators in the country currently has 435 vehicles on the licence. Clearly, the number of goods vehicles on the country's roads is large and this is discussed further in chapter 4.

3.3 The Regulatory Framework

3.3.1 The Railway Safety Commission

The Railway Safety Commission (RSC) was established under the Railway Safety Act 2005, with the remit to:

- Foster and encourage railway safety;
- Enforce this act;
- Investigate and report on railway incidents.

The Act also set the requirement for railway undertakings to produce and submit to the RSC for acceptance a safety case outlining the company's safety management system. The Act must be enforced and in this regard the RSC is obliged to monitor and oversee the management of risk in terms of railway safety. Clearly, there is increased risk where the railway interfaces with the public, e.g., at railway under and over-bridges. Hence, the RSC is particularly interested in what the railway undertaking is doing to manage the risk at such vulnerable locations. The RSC achieves this in part by routine inspections of bridges but also by chairing a working group, known as the Road Rail Safety Working Group (RRSWG), which brings together all the relevant stakeholders to discuss, review and promote safety at these interfaces.

3.3.2 Road Rail Safety Working Group

The working group, originally known as the Level Crossing Working Group (LCWG) was established by the Minister for Transport & Power in 1964. The first meeting took place on the 20th February 1964 and, at that time, the working group comprised members from the Department of Transport & Power, Department of Local Government and Córas Iompair Éireann (CIE). It was established with the purpose of considering questions relating to the provision at level crossings of automatic controls with and without half-barriers, instead of manually operated gates.

At a meeting held on 5th September 1967, Mr. L. Collins of CIE is minuted stating that;

> *"The group was a very useful forum for discussion suggested that the groups terms of reference be expanded to deal with all situations where there were road and rail interfaces, such as at under-bridges and over-bridges."*

The working group agreed and since then the LCWG has discussed all matters affecting the road-rail interface. The working group has met regularly over the years. In 2007 the LCWG renamed itself to the Road Rail Safety Working Group (RRSWG) as there was an increasing focus on matters other than level crossings and it was felt that the re-naming more suited the actual remit of the working group.

The RRSWG advises on technical and procedural matters and the group meets quarterly at the RSC's offices in Dublin. The working group contains representative from a number of organisations, including members from the Railway Safety Commission, Department of Transport, Road Safety Authority, National Roads Authority, Iarnród Éireann, Veolia Transport (a light rail operator), An Garda Siochana (police service), City & County Managers Association and the Irish Road Haulage Association.

In the context of bridge strikes, IÉ present statistical data and any issues arising. The forum proves particularly useful in discussing planned initiatives as all party perspectives are aired with a view to improving and prioritising safety investment where it will be most beneficial.

3.4 The Department of Transport and the Local Authorities

Clearly, the Department of Transport (DoT), the government department responsible for the procurement and development of new transport infrastructure projects has an important role to play in the context of safety investment. The DoT has a railway safety division who are responsible for managing and drafting any new legislation pertaining to railways, light railways and metros. While the departmental representatives are civil servants and not railway professionals they can add weight to arguments put forward for funding safety initiatives.

The local authorities are represented at the RRSWG by a member of the City & County Managers Association (CCMA) and there participation is crucial to the success in implementing safety measures on the roads under their stewardship.

3.5 The National Roads Authority & Road Safety Authority

The National Roads Authority (NRA) was formally established as an independent statutory body under the Roads Act, 1993, with effect from 1 January, 1994.

The Authority's primary function, under this Act, is 'to secure the provision of a safe and efficient network of national roads'. In order to achieve this, it has overall responsibility for planning and supervision of construction and maintenance works on national roads. National roads are the most important routes that include motorways and, in general, have an ‘N’ prefix followed by a number 1-33 & 50 for national primary roads and 34 upwards for national secondary roads. By way of comparison they are equivalent to ‘M’ and ‘A’ roads in the UK.

Road safety in Ireland has a poor record in comparison to many European countries, according to the EU DG Tren (Director General of Transport & Energy) report of 2007. In this report Ireland is ranked in 12th place, out of 25, for fatalities by population while Ireland is ranked 26th and worst for people under the age of 25 dying on the nation’s roads. In 2007, noted as being one of the best years in terms of the number of road deaths, some 338 people lost their lives on Irish roads. By comparison, Great Britain, with a population 15 times that of Ireland, had to accept 2946 deaths in the same year.

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Persons Killed	415	411	376	335	374	396	368	338

(Source: Garda Website11th June 2008)

Table 3: Road deaths in Ireland

This brief analysis of road based statistics shows the cultural problem that exists in Ireland and may be a contributing factor to the rate at which railway bridges are struck by road vehicles. Given the relatively high numbers of fatalities in Ireland, the Road Safety Authority (RSA) was recently established as the body tasked with improving safety on our roads, in order to reduce death and injury resulting from road collisions. The legal basis for the RSA is set out in the Road Safety Authority Act 2006. The RSA formally came into existence on 1st September 2006.

The RSA’s objective is to bring Ireland's road safety record into line with "best practice" countries throughout the world. The achievement of this objective will involve cooperation with many stakeholders working in the area of road safety, including the Gardai (police), education sector, health sector, local authorities, National Roads Authority, the media and, of course, the general public.

Whilst reviewing the ‘Rules of the Road’ (RSA, 2007), in particular focusing on railway bridges, an error was identified. The text explains that there are information signs that appear on bridges that give the code for the bridge and an emergency contact number to phone. However, the signage shown, in the figure below the text is that for advance warning signage and not that which has been explained. The RSA should ideally correct this for the next publication of the document.

RSA1	**Revise the Rules of the Road.** Page 77 of the Rules of the Road should be corrected in the next issue to include the actual information signage that is present on height restricted bridges. What is illustrated is advance information signage.
Priority	Low
Timescale	When next revising the publication
Cost	Minimal (travelling costs & subsistence)

3.6 An Garda Síochána

An Garda Síochána, Ireland's National Police Service, as any such body, comprises many divisions / units. The one pertaining to bridge strikes is the Garda National Traffic Bureau and its function is to formulate policy and oversee traffic policing throughout the state. Enforcement of these policies is then carried out by operational Traffic Corps Units based in each Garda Division. The primary responsibility of the Bureau is the proactive formulation of policy to reduce deaths and road accidents.

Key factors in policy formulation are prioritised enforcement and traffic management and, while enforcement is almost entirely a Garda function, traffic management is a shared responsibility between the police and other agencies, such as the local authorities and the NRA.

Given their attendance at the RRSWG, one would expect the police service to be familiar with the risk posed by bridge strikes. Unfortunately, the writer believes that many police have little appreciation of the risk of their acts of commission and omission. A case in point occurred recently (2005) during a visit by the United States of America’s President to Ireland. As part of the necessary security measures, numerous traffic diversions were put in place. Unfortunately, one of these diversionary routes directed vehicles under a headroom restricted railway bridge and, as luck would have it, an under-bridge was struck by a HGV. Luckily this only resulted in superficial damage, however, there were substantial delays to train services as a result.

RSC1	**Communicating with Garda Síochána (Police Service).** The RSC should be proactive and consider undertaking a road-show promoting the Commission, their role and function to the Garda Traffic Divisions, high-lighting examples of vulnerability at railway bridges.
Priority	Medium
Timescale	6-9 Months
Cost	Minimal

4 Relevant Statistics

4.1 Irish Infrastructure Statistics

The starting point for the study is the late 1970s for under-bridges and the early 1990s for over-bridges. Historic events are discussed to gain an understanding of the severity of potential incidents/accidents.

However, to put bridge strikes into context, we first need to appreciate a number of important factors, namely the size of Ireland's road and rail network. If we first consider the size and classification of Ireland's roads network, table 4 shows the breakdown of the total road network into classes, in kilometres.

Motorways	Main or National Roads	Secondary or Regional Roads	Other roads
247	5168	11645	79447

(Source: EU Energy & Transport in figures-Statistical Handbook 2007/2008)

Table 4: Length of the Irish road network

This equates to a total of 96507 km as of 2005 figures. In order to put this into context it is necessary to compare this figure with the total road network, land area and population in various countries in the EU. These together, listed with the length of the railway networks, are presented in table 5.

Country	Length of Road Network (km)	Length of Rail Network in use (km)	Population (million)	Km of railway in use /1000 inhabitants	Land Area (1000 km^2)	Km of railway in use /1000 km^2 of land area
Germany	231480	34221	82.315	0.42	357.0	95.6
United Kingdom	412933	19956	60.853	0.33	244.1	81.7
Italy	175430	16545	59.131	0.28	301.3	54.9
Portugal	78882	2844	10.599	0.27	91.9	30.9
Ireland	96507	1919	4.315	0.44	70.3	27.3
Lithuania	79497	1771	3.385	0.52	65.2	27.2

(Source: EU Energy & Transport in figures-Statistical Handbook 2007/2008)

Table 5: EU country comparison of road and rail networks, land area and population

The above tables are useful to picture the size of the road and rail networks in Ireland and put the following railway statistics in context. It can be seen that Ireland's rail network is comparatively small in comparison to the road network. In fact for every 1 track km there are, approximately, 50 road km, i.e., a ratio of 1:50. Compared to some of our neighbours, e.g., Lithuania 1:45, Portugal 1:27, UK 1:21, Italy 1:11 and Germany 1:7, the Irish ratio serves to illustrate our significant dependence on road based transport.

The inspection and maintenance of under and over-bridges on the Irish railway network is managed by two Divisional Engineers covering three geographical areas, under the direction of a Chief Civil Engineer.

As stated previously, there are 1188 over-bridges and 1906 under-bridges (figures correct as of 31/12/2007) and the geographical spread of the assets across the divisions is illustrated in graph 3.

Graph 3: Number of bridges by maintenance division

IÉ maintain a central bridges register and this database holds detailed information regarding the bridges. For example, under-bridge data maintained includes: a unique identification number; asset functional location; divisional responsibility; mileage; construction type; available headroom; whether the railway traversing over the bridge is an operational or non-operational line, i.e., whether passenger train services operate or no passenger train services operate) etc.

Regardless of whether they are operational or non-operational, divisional engineers are required by IÉ standards to inspect all the bridges every two years.

Staff	Dublin Division	Athlone Division	Limerick Division
Divisional Engineer	1	0.5	0.5
Asst. Divisional Engineer	3	2	1
Senior Engineer/Engineer	9	5	3
Technical Engineering Staff	3	0	0
Total	16	5.5	4.5

Table 6: Competent Divisional Engineering Bridge Inspection Staff

Clearly, the number of competent staff is biased towards the Dublin division. However, it should be noted that the staff have to adequately undertake not only bridge inspections but all structural inspections, such as retaining walls, embankments, cuttings, platforms, level crossings, etc. It is further recognised that the Dublin division has the greatest number of assets to inspect, which is why it has significantly more staff.

IÉ2	**Increase numbers of competent bridge inspection staff** IÉ should undertake a review of their resource needs in terms of bridge inspection staff to see if additional personnel may be trained to ease Assistant Divisional Engineer workload.
Priority	Medium
Timescale	6 Months
Cost	NA

4.2 Bridge Strikes

Bridge strikes in Ireland are on the increase and the IÉ risk model figure pertaining to these events suggests this is the case. The IÉ risk model, developed in 1998, is used as a tool to monitor and assist in managing risk, and to aid the identification of areas where safety investment can provide the greatest return.

The risk model measures risk in terms of fatalities and/or of the number of major and minor injuries. The model considers the risk of all activities and represents the risk in terms of equivalent fatality (EF). An EF is calculated as the sum of fatalities and injuries, where 10 serious injuries = 1 fatality and 200 minor injuries = 1 fatality.

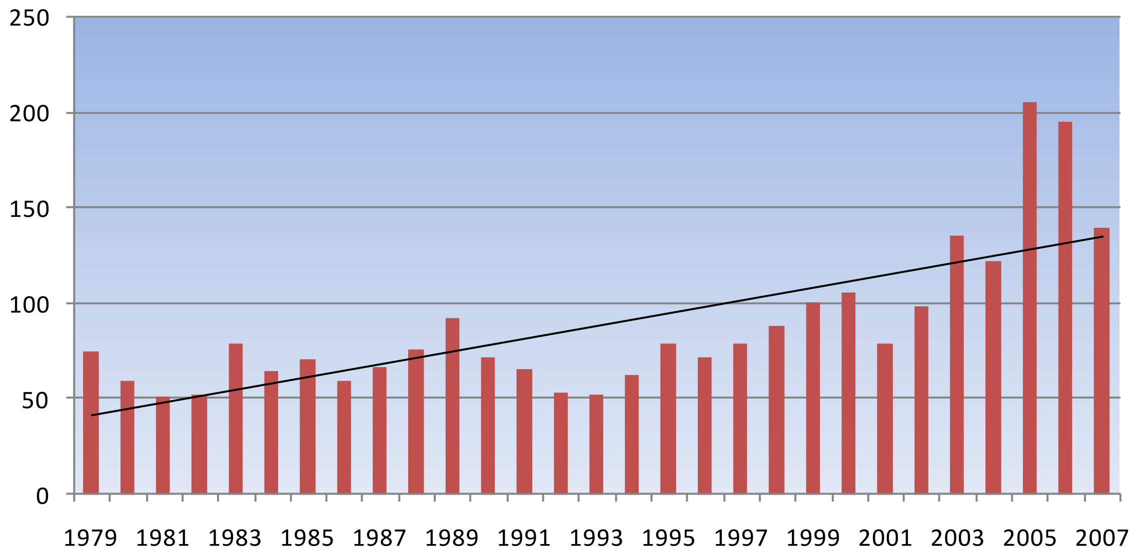
In 2003 the Iarnród Éireann risk model estimated the risk factor on the railway to be 17.5 EF from all accidents. In 2005, the risk model was run again and this figure had reduced to 11.3 EF. This was clearly good news as it appeared that safety was improving.

However, many argued that the improvement was largely based upon the fact that the data entered was more accurate. This hypothesis was further substantiated following an external audit of the system, conducted in 2006 (AD Little, 2006), which compared the risk rating of the Irish model with that of the UK's. The risk was not comparable, taking into account the sizes of the networks and operations. The most recent run of the risk model, in 2007, provided a figure of 9.0 EF which shows improvement in safety terms when benchmarked against the 2005 figure.

The overall equivalent fatality figure thus has fallen. However, if we consider only bridge strikes the risk has increased from 0.06 EF in 2005 to 0.1 EF in 2007 and the writer will now analyse the bridge strike statistics to try and identify where and why the increase is occurring.

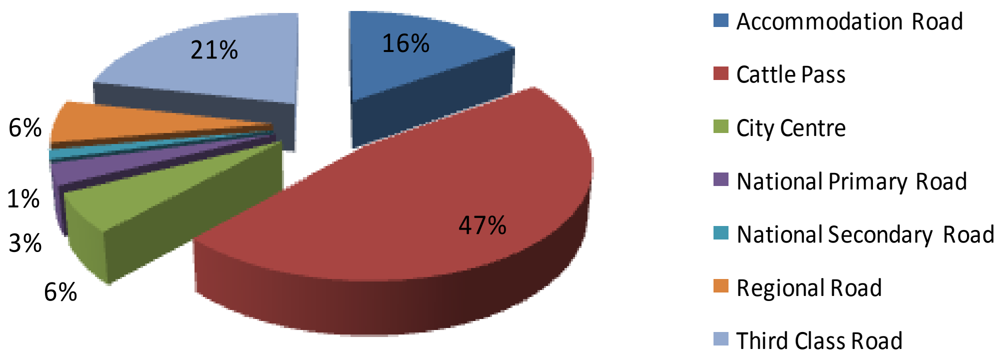
4.2.1 Under-bridge strikes

Statistics show that the greater number of bridge strikes occurs at under-bridges, and graph 1 illustrates the trend. Figures have steadily increased since 1995, peaking in 2005 with 206 under-bridge strikes. Following this, IÉ launched a substantial advertising campaign comprising a TV advert, targeted magazine adverts, radio interviews, press releases and a presentation to a road haulage conference. While 2006 showed no apparent fall in the figures, the 2007 figure had dropped to 139, representing a 32% reduction. It is believed that the campaign was the major reason for the sizeable drop in under-bridge strikes. Given that the campaign has essentially ceased, apart from the occasional TV advert, it will be interesting to see the 2008 figures.



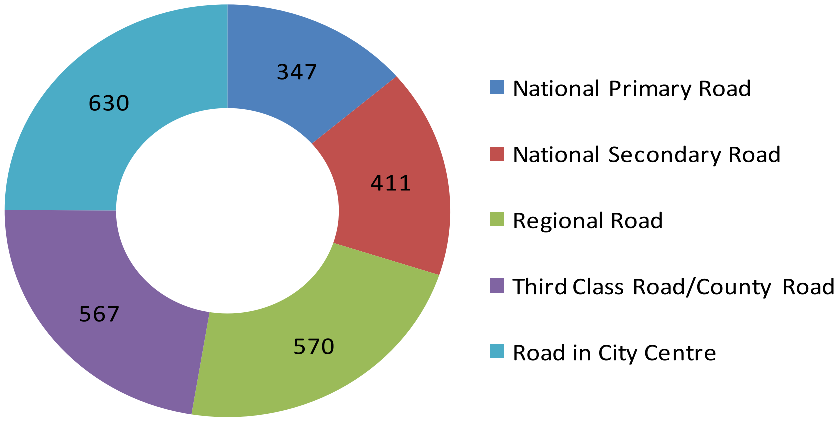
Graph 4: Number of under-bridge strikes by year, 1979-2007

The trend is indicative of risk but tells us little about where safety investment should be made, it simply tells us there is a potential problem with under-bridges.
Further analysis is necessary, and the following series of graphs illustrates the breakdown of what type of road the bridge is on, where these bridges are and identify the vulnerable bridges.



Graph 5: Breakdown of under-bridges by road type

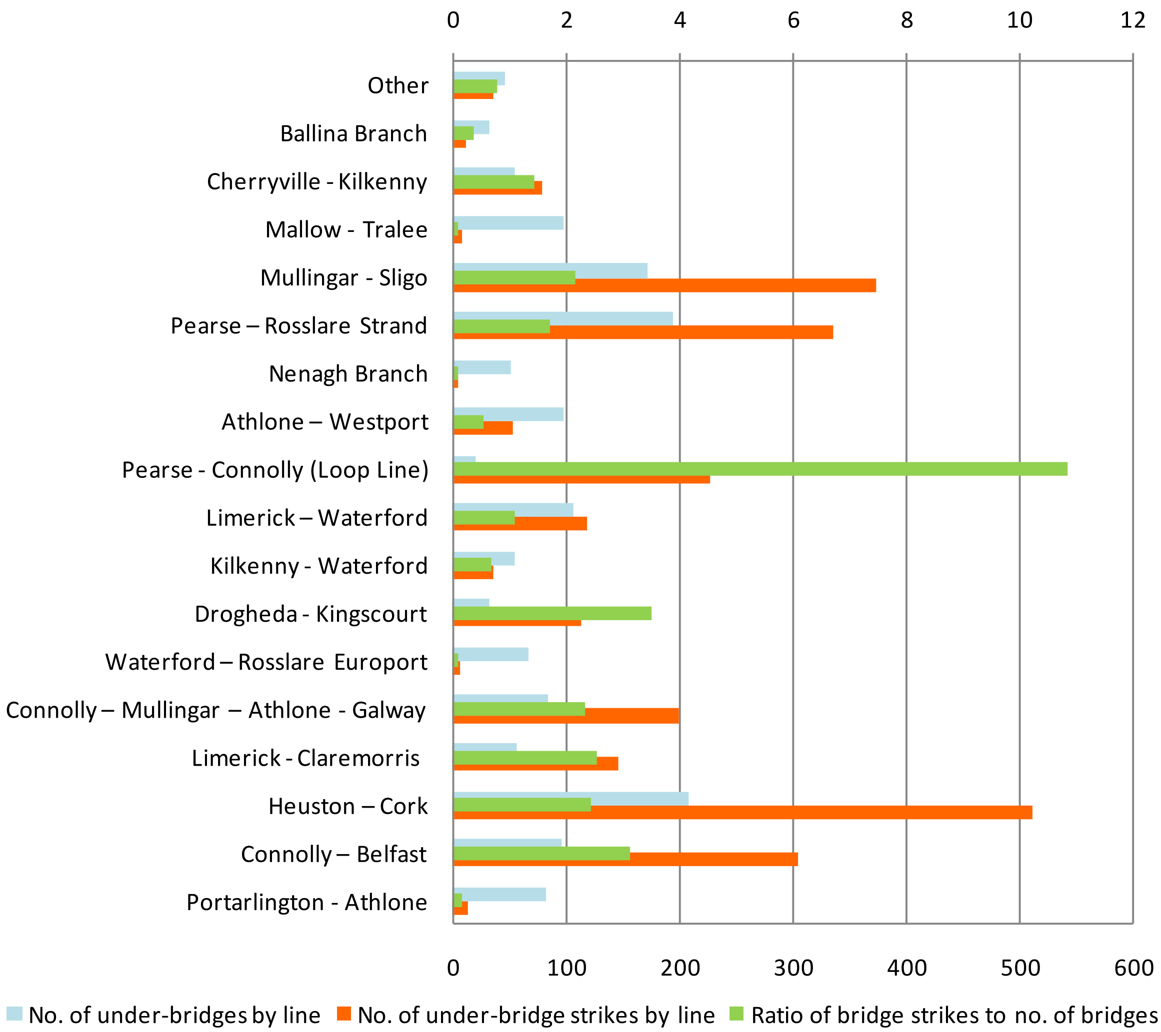
From the above (graph 5) it is clear that over half of the under-bridges are to facilitate the passage of either accommodation roads or cattle passes. Clearly, given the light usage of such under-bridges the risk is low at such interfaces. It is the remaining roads that pose the more significant risk in terms of bridge strikes. This is confirmed by an analysis of the actual bridge strike figures and graph 6 shows the breakdown of the class of road where under-bridge strikes are occurring.



Graph 6: Number of under-bridge strikes by road class

For the period 1979-2007 there is no recorded data for any bridge strike at a cattle pass and only 7 for accommodation road under-bridges. For this reason, the above were excluded from the graph. The figures do not categorically distinguish one class of road as being the main culprit in terms of bridge strikes. They do illustrate, however, that roads in city centres, regional and third class roads represent more problematic road interfaces.

It is now appreciated which road classes are the most likely to produce under-bridge strikes.



Graph 7: Number of under-bridges & under-bridge strikes by line, between 1979-2007

Graph 7 illustrates the geographical location, by rail route, of all under-bridge strikes from 1979 to the end of 2007 along with the number of under-bridges on these routes. In addition the graph shows the ratio of bridge strikes to the number of bridges on each route. It shows that there are 4 lines that have suffered most in terms of under-bridge strikes, all seeing in excess of 300 bridge strikes during the specified period. In order, these are;

1. Dublin Heuston to Cork Line (508 under-bridge strikes)
2. Mullingar to Sligo Line (375)
3. Dublin Pearse to Rosslare line (337)
4. Dublin Connolly to Belfast Line (305)

Previously, it was identified that the majority of bridge strikes occur on city centre roads closely followed by regional and third class roads. Three of the above lines emanate from Dublin City Centre, which would correlate with the earlier findings. Furthermore, it can be seen from graph 7 that the fifth most affected line is the Pearse – Connolly (loop line) which connects two Dublin City Centre rail termini.

If one considers the number of under-bridges by route, the Heuston to Cork line has the most under-bridges, with 208, followed by Pearse to Rosslare Strand, with 194, and Mullingar to Sligo with 173. The Connolly to Belfast line is 7th, out of 18, with 97 under-bridges. However, the most alarming conclusion is the fact that the Pearse to Connolly loop line which is only, approximately, 2km in length, with the second least number of under-bridges (21 under-bridges), is the 5th most affected line in terms of number of bridge strikes. If one considers the ratio of bridge strikes to the number of bridges per route the results present a different picture to the list above.

1. Dublin Pearse to Rosslare route, with a ratio of 10.9 bridge strikes per bridge
2. Drogheda to Kingscourt, ratio of 3.5
3. Dublin Connolly to Belfast Line, ratio of 3.1
4. Limerick to Claremorris, ratio of 2.6
5. Dublin Heuston to Cork Line, ratio of 2.5

Again, three of the above lines emanate from Dublin City Centre, which correlates with the earlier findings. Clearly, the Dublin City Centre bridges are some of the most problematic on the network. Inside the M50 orbital motorway, which essentially is a city boundary, there are 74 under-bridges. Given the fact that the 21 bridges on the loop line account for 9% of the total number of under-bridge strikes for the period 1979-2007, one can see the potential impact that these 74 under-bridges have in the overall picture.

Further analysis of the historical bridge strike statistics can identify the top 20 bridges involved in bridge strikes and these are listed below. It can be seen from the table that each of the top 20 bridges involved in bridge strikes has been hit a minimum of 32 times. Excluded from Table 7 is UBB3 on East Wall Road which was one of the most problematic under-bridges until its replacement in late 2001. Prior to its replacement it had been struck 88 times and would have been in 4th position in the ranking.

Serial Number	Restriction No.	Bridge Location	Date Last Struck	No. of Bridge Strikes	Ranking
UBC145	1	Portlaoise Town Centre	17/09/2007	195	**1**
UBC146	2	Portlaoise Town Centre	20/09/2007	132	**2**
UBLL44A	381	Dublin City Centre	05/10/2007	125	**3**
UBS455	183	Longford Town	01/11/2007	73	**4**
UBG55	215	Mullingar Town	05/11/2006	70	**5**
UBK350	55	Rural	26/11/2007	68	**6**
UBS514	191	Carrick on Shannon Town	05/11/2007	68	**7**
UBB1A	114	Dublin City Centre	14/12/2005	62	**8**
UBS449	181	Longford Town	23/10/2007	60	**9**
UBR53	101*	Dublin City Centre	11/09/2007	50	**10**
UBL7	29	Limerick City Suburbs	01/04/2004	48	**11**
UBLL38	375	Dublin City Centre	17/04/2007	46	**12**
UBS592	210	Rural	04/11/2006	43	**13**
UBR60	107	Dublin City Centre	06/10/2007	42	**14**
UBR280	57	Gorey Town	01/10/2007	39	**15**
UBR54	102*	Dublin City Centre	20/09/2007	39	**=15**
UBC401	301	Cork City	03/10/2007	39	**=15**
UBS587	205	Rural	30/08/2004	39	**=15**
UBS610	187	Sligo Town Centre	08/05/2006	32	**19**
UBR61	108	Dublin City Centre	07/03/2007	32	**20**

Table 7: Top 20 hit under-bridges, 1979-2007

* Indicates an arch bridge

It is also important to note that, in March 2007, infra-red detection equipment was installed on the approaches to both Portlaoise under-bridges, i.e., UBC145, and UBC146, that is the top two bridges involved in bridge strikes. Furthermore, in September 2007, a diversionary route was opened that, if followed, bypasses both bridges. Ironically, even after both these measures were in place, UBC146 was hit a further three times in 2007 while UBC146 was struck once.

It is believed that this was due to a lack of promotion of the new road and the lack of understanding of what the infra-red detection signage actually meant. By way of information for the period 1st January 2008 to 31st July 2008, UBC145 has been hit 5 times, while UBC146 has been hit twice, suggesting the problem remains. However, this does compare favourably with the same six month period in 2007 when UB145 and 146 were hit 11 and 13 times respectively.

It would appear that the bridge strike rates are falling, however, it remains too early to draw any conclusions as to the success of the measures put in place at Portlaoise as there have been road closures and other positive mitigating factors that may conceal the real figures.

Plate 7: Portlaoise Under-bridges, UBC145 (left) and UBC146 (right)

IÉ continue to lobby Laois County Council to promote the diversionary route, unfortunately there appear to be a number of stakeholders involved, including the local authority and the NRA. Clearly, there is a need for round-table dialogue.

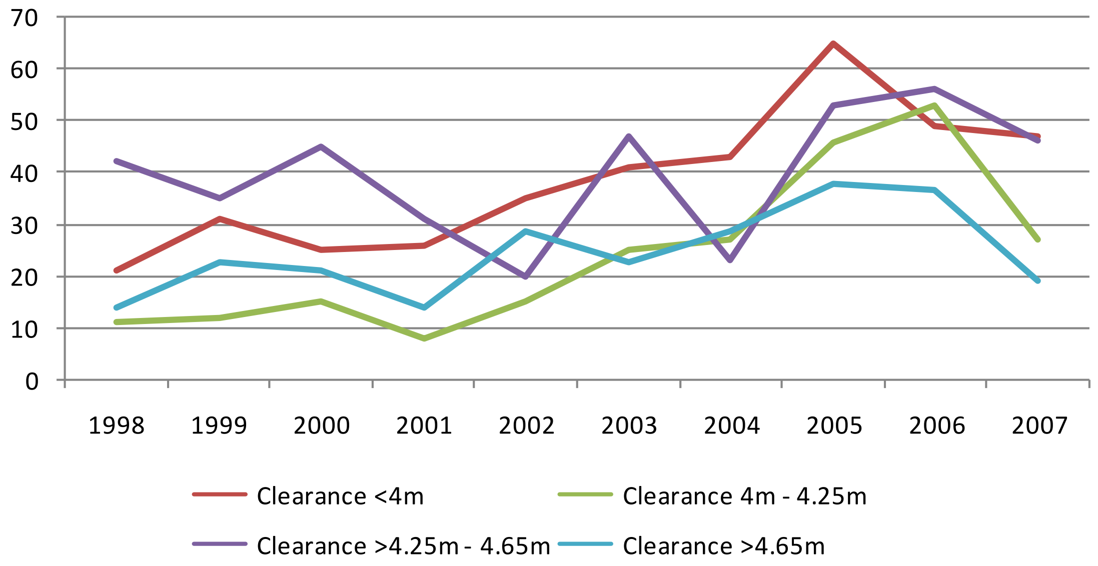
RSC2	**Facilitate roundtable talks between stakeholders regarding the Portlaoise under-bridges.** The RSC should consider writing to all relevant stakeholders and facilitate a meeting between them to expedite and resolve all issues pertaining to diversionary signage, road classification etc.
Priority	High
Timescale	3 Months
Cost	NA

If we consider the height of the top 20 hit under-bridges, as listed in table 7 above, the breakdown is as follows;

Bridge Clearance	No. of bridges
< 4.0 metres	9
4.0 - 4.25 metres	1
>4.25 – 4.65 metres	7
> 4.65 metres	3

Table 8: Top 20 hit under-bridges by height.

As one might expect, the vast majority of under-bridges that are frequently struck are lower than 4.65m in terms of clearance. Of these, 7 are located in Dublin City centre and two of these are masonry arch bridges. Focusing on heights in more detail the overall trend of bridge strikes by bridge height is illustrated in graph 8.



Graph 8: Number of bridge strikes by bridge height, 1998-2007

The trend, excluding the clear decrease in 2007, is rising in all height bands. Again excluding 2007, the bridges below 4.25m have seen the largest increase over the previous 10 year period, while the bridges within the >4.25-4.65m height band have fluctuated the most suggesting the events are random.

What is interesting to note is the fact that there is only 1 under-bridge in the 4.0-4.25m height band that appears in the top 20. However, it is UBC145 in Portlaoise, which is ranked number 1 in the bridge strike listing (table 7). The significant reduction in 2007 is most likely due to the additional safety measures installed in Portlaoise combined with the opening of the Dublin Port Tunnel. Additionally the strong advertising campaign by Iarnród Éireann has surely had a positive affect.

Analysis of bridge strike statistics over the coming years will prove if this is the case and is one which the writer looks forward to.

In terms of road class and bridge material, pertaining to the top 20 hit under-bridges, table 9 shows the breakdown.

Serial Number	**Bridge Location**	**Road Class**	**Bridge Type/Material**
UBC145	Portlaoise Town Centre	National Secondary Road	Steel
UBC146	Portlaoise Town Centre	Regional Road	Steel
UBLL44A	Dublin City Centre	Dublin City Centre	Steel Lattice Girder
UBS455	Longford Town	National Secondary Road	Steel Lattice Girder
UBG55	Mullingar Town	Third Class Road	Steel
UBK350	Rural	National Secondary Road	Steel Plate Girder
UBS514	Carrick on Shannon Town	Regional Road	Steel Plate Girder
UBB1A	Dublin City Centre	Dublin City Centre	Concrete
UBS449	Longford Town	Regional Road	Steel
UBR53	Dublin City Centre	Dublin City Centre	Masonry Arch
UBL7	Limerick City Suburbs	National Primary Road	Steel
UBLL38	Dublin City Centre	Dublin City Centre	Steel Lattice Girder
UBS592	Rural	National Primary Road	Steel Lattice Girder
UBR60	Dublin City Centre	Dublin City Centre	Concrete
UBR280	Gorey Town	National Primary Road	Iron Plate Grider
UBR54	Dublin City Centre	Dublin City Centre	Masonry Arch
UBC401	Cork City	Third Class Road	Steel Lattice Girder
UBS587	Rural	Third Class Road	Concrete
UBS610	Sligo Town Centre	Third Class Road	Steel
UBR61	Dublin City Centre	Dublin City Centre	Concrete

Table 9: Top 20 Hit under-bridges, 1979-2007, by road class & material

Given the above information the following conclusions can be made;

- Steel bridges have been struck the most, representing over 60% of the top 20 under-bridges hit.
- Only 2 masonry arch bridges figure in the top 20 and both are located in Dublin City Centre.
- Approximately 1/3 of the top 20 under-bridges are located in Dublin City Centre.
- National Primary, secondary and regional roads all appear 3 times in the top 20.
- The single iron plate girder bridge located in a provincial town is situated on a national primary road. This town now has a bypass, opened in late 2007.

The above conclusions indicate that there are safety issues relating to Dublin City centre under-bridges. It is therefore necessary to review the bridge strike data specifically in the Dublin area.

4.2.2 Dublin City Centre Under-bridges

The above conclusions would suggest there is an issue with under-bridges located in Dublin city centre and, hence, further analysis is necessary. It is nothing new to say that there are a number of vulnerable under-bridges in the city. In fact, 7 of the top 20 under-bridges struck in the period 1979-2007 are located in and around the city centre. Table 9 provides a more focused look at the Dublin under-bridges that appear in the top 20.

The total number of bridge strikes for these 7 city centre bridges is 396 for the period 1979-2007. This represents 15% of the countywide total for this period.

What is also a cause for concern is the fact that 6 of the 7 under-bridges suffered at least one strike in 2007 which would suggest the problem remains. The other bridge, UBB1A was last struck in December 2005. The bridge was raised back in 2000 and the 5+ goods vehicle axle ban only came into force in February 2007 which would suggest that there has been a traffic pattern change that is unexplainable to the writer's mind.

Serial Number	Restriction No.	Bridge Location	Date Last Struck	No. of Bridge Strikes	Ranking
UBLL44A	381	Dublin City Centre	05/10/2007	125	3
UBB1A	114	Dublin City Centre	14/12/2005	62	8
UBR53	101*	Dublin City Centre	11/09/2007	50	10
UBLL38	375	Dublin City Centre	17/04/2007	46	12
UBR60	107	Dublin City Centre	06/10/2007	42	14
UBR54	102*	Dublin City Centre	20/09/2007	39	16
UBR61	108	Dublin City Centre	07/03/2007	32	20
			Total	**396**	

Table 10: Dublin City Centre

Only 2 (indicated by the *) of the top 20 under-bridges hit by road vehicles are of masonry arch construction. This is surprising since there are 8 masonry arch bridges in Dublin City that are headroom restricted.

It would suggest that there are specific traffic routes that traverse under such railway bridges. Clearly, one significant generator of HGV traffic, or traffic that is likely to be involved in bridge strikes, is Dublin Port.

Traditionally goods vehicles travelling to the port have essentially had only three routes open to them, one from the north, along East Wall Road, one from the south along Seán Moore Road and via Pearse Street and one from the west, with vehicles travelling along the quays of the River Liffey.

As mentioned previously, UBB3 was a significantly hit under-bridge until its replacement in 2001. This was due to the fact that it was located on the route from the north. There was no realistic alternative route available. Routes from the south required traversing under at least two under-bridges, that could be either UBR53, 54, 60, 61, all of which appear in the top 20. Similarly, routes from the west would pass under at least 1 under-bridge. Unfortunately this bridge is also headroom restricted, UBLL44A on Customs House Quay (plate 8), and it is therefore no surprise to find this bridge also in the top 20.

Plate 8: UBLL44A, Customs House Quay, Dublin City Centre

At Dublin Port, trade throughput combining imports and exports amounted to 30.9 million tonnes in 2007, which was a 5.7% increase on 2006 figure. In line with trends in previous years the trade sectors experiencing the highest level of growth are the RoRo (Roll On-Roll Off) sector and the unitised Lo-Lo (Load On-Load Off) sector. Ro-Ro freight handled 733,141 units in 2007 representing an increase of 5.8% on 2006. Lo-Lo twenty-foot equivalent units rose to 743,937 units, an increase of 9.3%. The Port Authority believes this growth is not surprising given the increased demand for consumer goods which account for the vast majority of Lo-Lo and Ro-Ro trade. This includes the food, clothes and white goods that the growing Irish population consumes/needs on a daily basis.

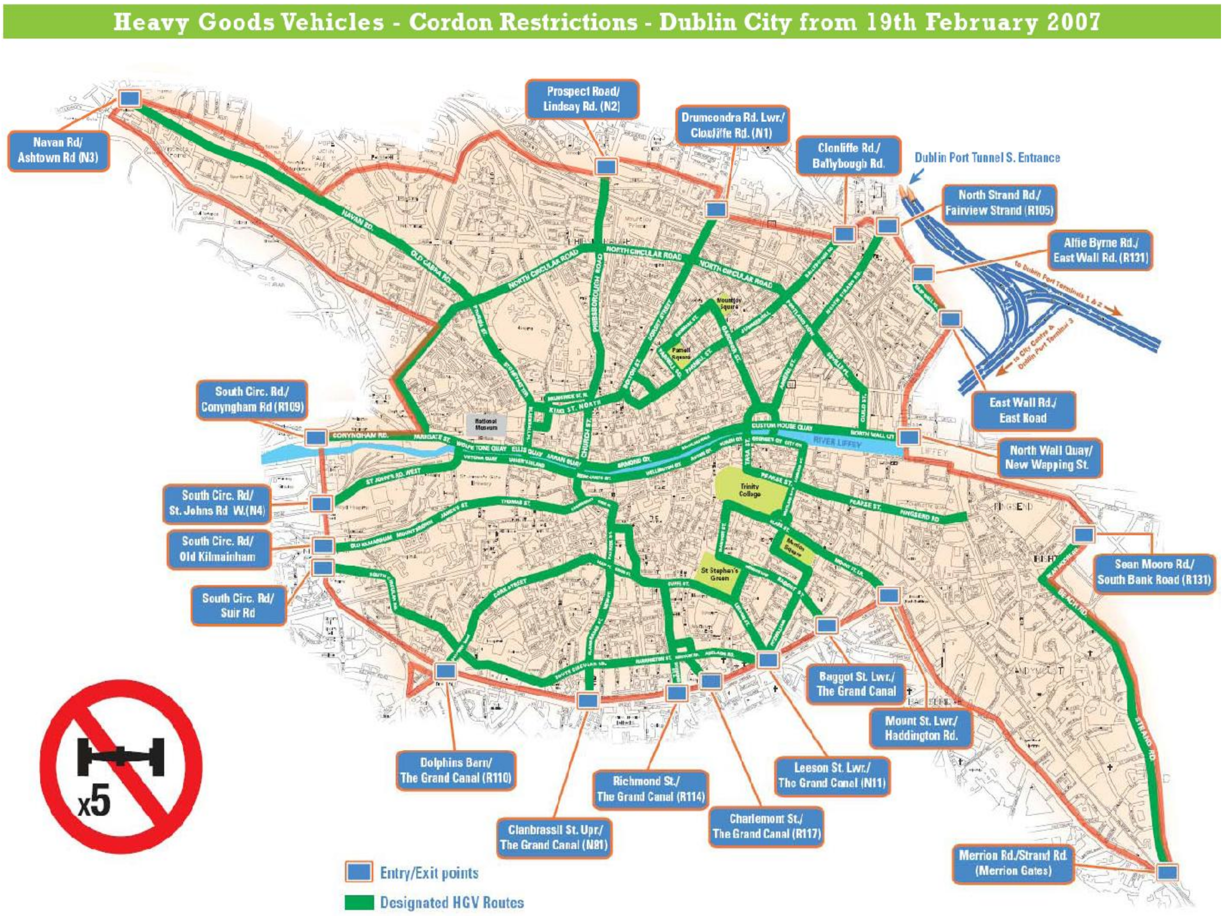
Clearly, given the year on year increase in Port generated traffic, essentially HGVs, Dublin City Council were under increased pressure to do something in terms of alleviating the congestion in the city centre. The council had predicted traffic growth would be significant and commenced research culminating in the publication of the Dublin Transport Initiative in 1993 where the Dublin Port Tunnel project was first mentioned as a possible solution. This project had the remit to remove HGVs from the city centre, thereby alleviating traffic congestion and improving road safety.

Construction of the 4.5km long twin bore Port Tunnel commenced in June 2001 and opened to traffic on December 20th 2006. It has a height clearance of 4.65m and is part of the M50 motorway, completing the northern part of the C-Ring around Dublin city. It is the dedicated route for Heavy Goods Vehicles between the Port, located in the heart of the city, and the greater road network via the Coolock Lane Interchange (M50).

It permits vehicles up to a height of 4.65m to pass through and figures for the first year of use suggest that in excess of 1600 HGVs use the tunnel daily. It should be emphasised that the tunnel was not constructed because of bridge strikes but rather as a measure to remove congestion from the city centre.

On Monday 19th February 2007, approximately 2 months after the port tunnel opening, DCC implemented a ban on 5+ axle trucks in Dublin city centre between 7am and 7pm each day. This almost immediately had an effect on the number of headroom restricted bridges being hit. Analysis of the bridge strike incidents shows that in the 6 months following the introduction of the 5+ axle ban Dublin City centre railway under-bridges were hit a total of 7 times. This compares favourably to the 6 months prior to the 5+ axle ban when there were 14 Dublin City Centre bridge strikes. This represents a 50% reduction in under-bridge strikes.

Unfortunately the ban only affects about two-thirds of goods vehicles which are currently accessing the port. Vehicles which are too tall for the Port Tunnel have to access the port outside the ban hours. This poses the same problem as before as the primary routes (See figure 6) to the port are via headroom restricted railway bridges. Similarly, trucks which are delivering goods to businesses in the city centre are given special permits and, again, depending on their height, pose a continued risk to the city centre railway bridges.



(Source: Dublin City Council Website)

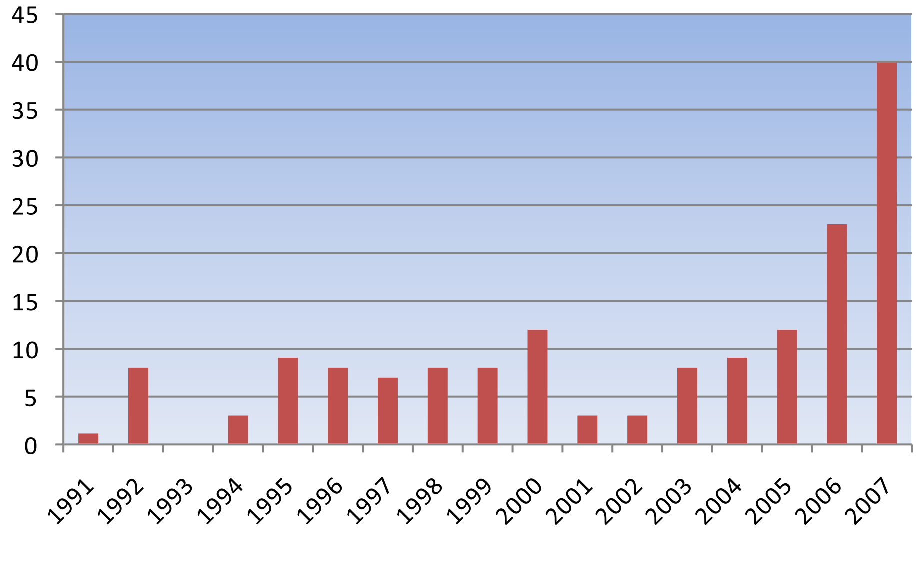
Figure 6: Dublin City Centre HGV cordon area

Regrettably, a permit only costs €5 per day for up to 5 drop-offs and DCC are issuing on average 149 permits a day or 54508 in the first year of issuing such permits. As stated earlier, the ban has had some positive impact. However, while permits are continually issued Dublin City Centre railway bridges and the rail travelling public remain at risk.

Gardaí enforce the ban or cordon using CCTV surveillance and those breaching it face fines of up to €1,500 and a prison sentence. Unfortunately, nobody thus far has been prosecuted due to some legislative issue that has only recently been resolved. In the first couple of months following the ban, users found inside the cordon were escorted from the city by Gardaí. A number of warnings were issued but, as previously stated, no one was prosecuted.

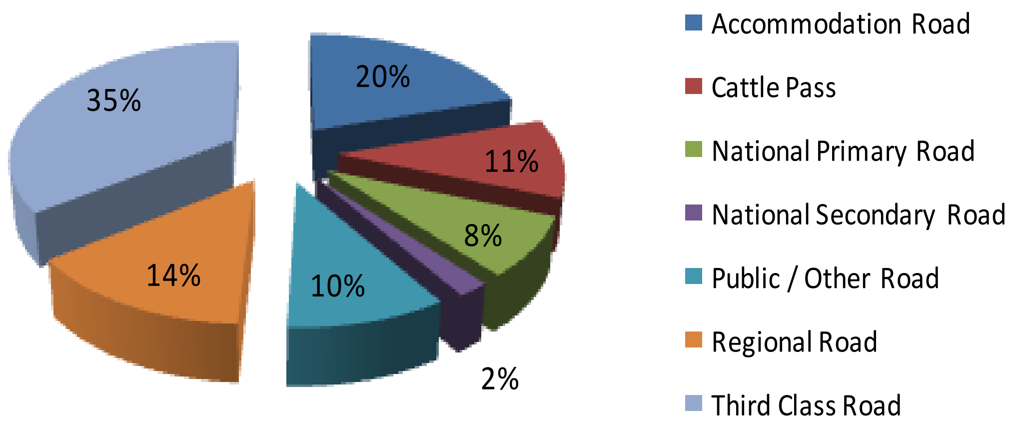
4.2.3 Over-bridge strikes

Strikes prior to 1991 were not actively recorded and, hence, were unavailable to undertake any further analysis. However, graph 9 illustrates the significant rise particularly since 2005 when there were just 8 over-bridge strikes reported, compared to 40 strikes in 2007. Approximately 1 year ago the programme of erecting bridge identification signage on over-bridges was concluded and perhaps this has led to better reporting of such incidents. Clearly, the focus has been on under-bridges in recent years as this is perhaps the reason for the sharp fall in this area. However, perhaps additional time and resource should be given to over-bridges and it will be interesting to see the figures for 2008.



Graph 9: Number of over-bridge strikes by year, 1991-2007

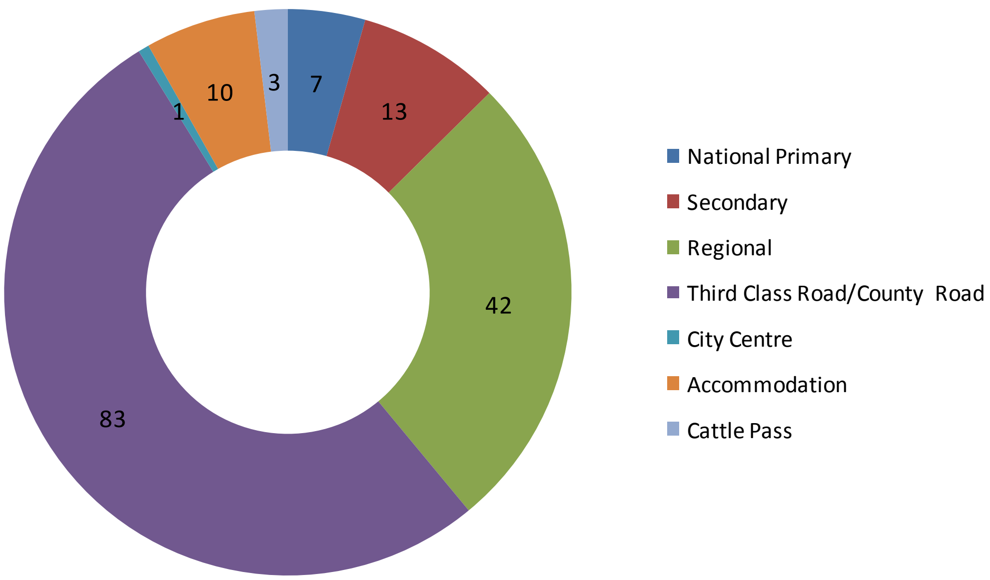
Further analysis is necessary and graph 10 illustrates the breakdown of what type of road the bridge is on. Therefore, in this regard it is important to try and identify where the greater risk lies.



Graph 10: Breakdown of over-bridges by road type

From the above it is clear that half of the over-bridges are on regional and third class roads, while the National roads only account for 10% of all road-over railway bridges. It is interesting to note that 1/5th of the total are located on accommodation roads or essentially private accesses and are not for public use.

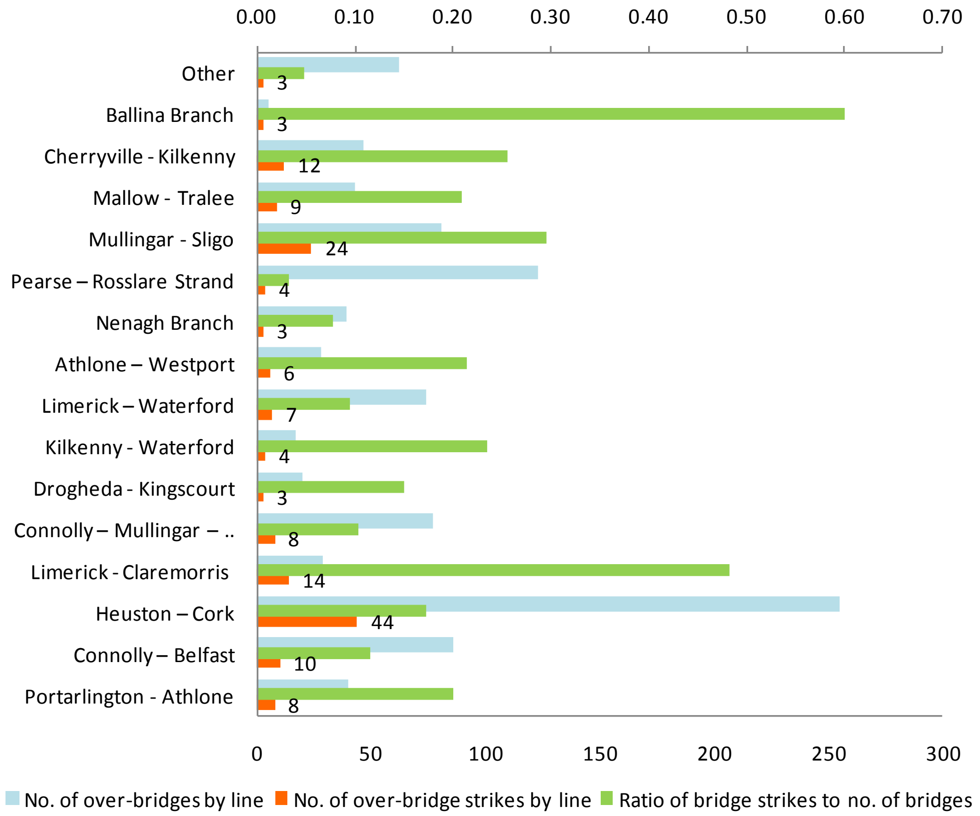
Given this breakdown, it is important to try and identify where the actual risk is, i.e., is one class of road more at risk than another. Between 1991 and 2007 there were a total 162 over-bridge strikes. Of these, 159 have the road category identified, and the breakdown of where these have occurred is now illustrated (graph 11).



Graph 11: Number of over-bridge strikes by road class, 1991-2007

It is clear from the analysis that just over 50% of all over-bridge strikes have occurred on a third class road, which is hardly surprising, given their likely width, surface condition and geometry.

As with under-bridges it is useful to identify where the over-bridge strike are occurring and graph 12 (below) illustrates the breakdown of over-bridge and over-bridge strikes by line. The graph shows there are essentially 2 lines that have suffered most in terms of over-bridge strikes. These are the Mullingar to Sligo Line and the Dublin Heuston to Cork Line.



Graph 12: Number of over-bridges & over-bridge strikes by line, between 1991-2007

Given this information it is worth focusing on the top 15 over-bridges for strikes for the period 1991-2007 to see if the above lines feature and what class of roads they are on.

Serial Number	Bridge Location	Date Last Struck	No. of Bridge Strikes	% of Total	Ranking
OBC196	Lisduff County Boundary Bridge	26/10/2007	**9**	5	1
OBS582	OBS582	11/11/2007	**7**	4	2
OBS608	Maugheraboy Road Sligo	31/05/2007	**5**	3	3
OBA33	Gaol Bridge Kilcruttin Tullamore	06/09/2007	**4**	2.25	4
OBE68	Knockanimana Bridge	10/11/2006	**4**	2.25	=4
OBT46	N72 at Rathmore	16/04/2003	**4**	2.25	=4
OBM747	OBM747	19/07/2007	**4**	2.25	=4
OBX888	Sraheen	09/08/2007	**3**	1.75	8
OBG103	Garrycastle	09/02/2007	**3**	1.75	=8
OBA75	Kilgarvin	03/02/2007	**3**	1.75	=8
OBS531	Roadstone Bridge	25/10/2006	**3**	1.75	=8
OB89	Kilcarrig Br	28/09/2000	**3**	1.75	=8
OB86	Kyle Bridge	27/03/1999	**3**	1.75	=8
OBE146	Mannin Bridge	24/09/1997	**3**	1.75	=8
OB81	Killaray Br	19/12/2007	**3**	1.75	=8

Table 11: Top 15 Hit over-bridges, 1991-2007

As previously stated, for the period 1991-2007 there were a total of 162 over-bridge strikes. However, what is interesting is the fact that almost 40% has occurred since 2006. It is appreciated that this substantial increase in the last two years is possibly due to better reporting of such incidents. However, it can be seen from table 11 that the top 15 over-bridges involved in bridge strikes have been hit a minimum of 3 times. The numbers are far lower than for under-bridges, however, this risk remains substantial. In particular OBC196 Lisduff, on the Cork line, has proved problematic over the years, suffering 4 road vehicle strikes in 2007 and three in 2008 (to 31st July 2008). Strikes at this bridge are most likely due to the road speed, 80km/h and the road geometry. It is located on a regional road, the 2nd largest category by road class, between two relatively small towns, Templemore and Abbyleix. The photos below illustrate the arrangement and the containment measures installed in recent years.

(Courtesy Iarnród Éireann)

Plate 9: OBC196 Lisduff County Boundary Bridge

Fortunately, the bridge is sufficiently robust, having a reinforced concrete parapet and safety barriers installed on the approaches to and departures from the over-bridge, which clearly reduces the risk to the railway. Nonetheless, additional traffic calming measures should be considered such as anti slip surfacing, rumble strips or chevron signage, indicating there is a severe bend in the road.

IÉ3	**Liaise with Tipperary County Council re: OBC196 Lisduff** IÉ should contact the local authority to arrange a joint inspection of the over-bridge to discuss possible further traffic calming measures.
Priority	High
Timescale	3 Months
Cost	Minimal, travel and expenses.

Similarly OBS582, also located on a regional road between two relatively small towns in the west of Ireland, Ballymote and Collooney, has been a concern over the years. As can be seen from the images below, the road geometry is a significant factor.

(Courtesy Iarnród Éireann)

Plate 10: OBS582, Drumfin, Co. Sligo

As can be seen from the above photo there is a severe bend in the road and the road speed of 80km/h does not adequately address the risk of the bend and proximity to the over-bridge. It is also apparent that the local authority are aware of the risk as, mounted on the telegraph pole in the distance, is a sign stating “Caution Slippery Surface”.

IÉ4	**Liaise with Sligo County Council re: OBS582 Drumfin** IÉ should contact the local authority to arrange a joint inspection of the over-bridge to discuss the possible installation of safety barriers on the approaches to and over the bridge, along with additional traffic calming measures, such as anti skid surfacing and signage.
Priority	Medium
Timescale	6 Months
Cost	Minimal, travel and expenses.

In terms of fatalities at over-bridges, the last one in 1999 occurred at Kyle Bridge (OBC86), on a regional road that crosses over the Dublin Heuston to Cork Line, in county Kildare which is in joint 8th place in the over-bridge strike ranking. (See chapter 4.3.3 for further details).

It is also important to note that the safety investment programme has provided funding to improve and upgrade many vulnerable interfaces. In terms of over-bridge strikes this has involved bridge strengthening and/or the installation of safety barriers on the approaches to and over the bridge. One example of such an installation is on the N72 at Rathmore (OBT46) which can be seen in the photo below (plate 11).

Plate 11: OBT46 on the N72, Rathmore, Co. Kerry

Again it is useful to identify where the incidents are occurring. Earlier analysis indicated that in excess of 50% of over-bridge strikes have occurred on Third Class roads and particularly roads over the Heuston - Cork and Mullingar – Sligo lines. Table 12 (below) confirms this is the case as the top 3 are located over these lines.
However it is the regional road that appears most prevalent, with 6 cases in the top 15 followed closely by third class road, with 5 cases.

Serial No.	Bridge Location	Road Class	Bridge Type/Material
OBC196	Lisduff County Boundary Bridge	Regional Road	Concrete
OBS582	Drumfin, Co. Sligo	Regional Road	Masonry Arch
OBS608	Maugheraboy Road Sligo	Third Class Road	Masonry Arch
OBA33	Gaol Bridge Kilcruttin Tullamore	National Secondary Road	Masonry Arch
OBE68	Knockanimana Bridge	Third Class Road	Masonry Arch
OBT46	N72 at Rathmore	National Secondary Road	Concrete
OBX888	Sraheen	Third Class Road	Masonry Arch
OBG103	Garrycastle	Regional Road	Masonry Arch
OBA75	Kilgarvin	National Secondary Road	Masonry with Concrete Parapets
OBS531	Roadstone Bridge	Third Class Road	Concrete
OBM747	OBM747	National Secondary Road	Masonry
OB89	Kilcarrig Br	Regional Road	Masonry Arch
OB86	Kyle Bridge	Regional Road	Masonry Arch
OBE146	Mannin Bridge	Third Class Road	Masonry Arch
OB91	Kilree Bridge	Regional Road	Masonry Arch

Table 12: Top 15 Hit over-bridges, 1991-2007, by road class & material

In terms of road class and bridge material, (table 12) and the data presented in table 11, pertaining to the top 15 hit over-bridges, the following conclusions can be made;

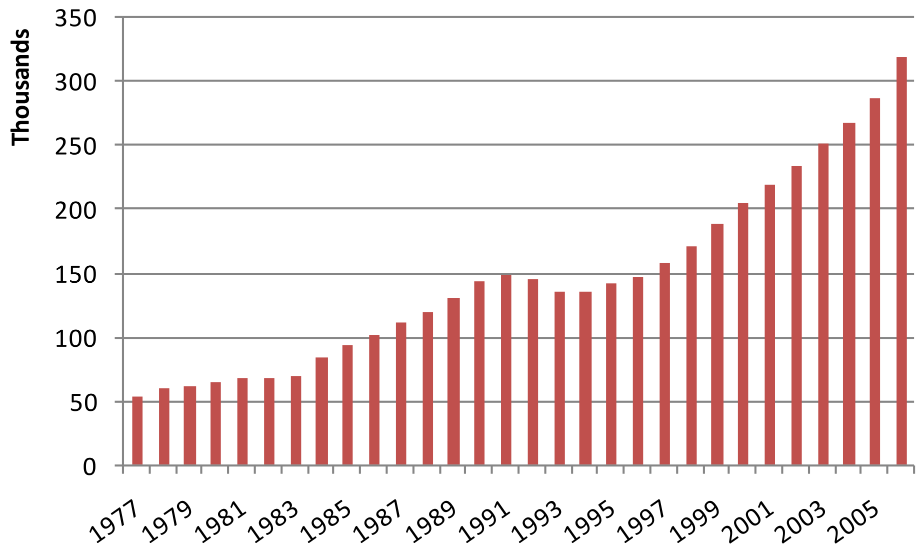
- Masonry bridges have been struck the most, representing over 70% of the top 15 over-bridges hit;
- All bridges hit were either on National Secondary, Regional or Third class roads. All of which are single lane carriageways with a road speed of 80kph or higher;
- The only fatality at an over-bridge happened on a Regional road;
- Of the 41 struck over-bridges in 2007, 6 were classified as being serious bridge strikes. Of these 6 serious bridge strikes 4 are also in the top 15 for the overall period 1991-2007;
- The four serious over-bridge strikes in 2007, that are also in the top 15, are all in the same geographic area (Mullingar –Athone-Sligo).

4.3 Goods Vehicles

Goods Vehicles are defined under the Motor Vehicle (Duties & Licences) Act 2008 as

> *"Vehicles (including tricycles weighing more than 500 kilograms unladen) constructed or adapted for use and used for the conveyance of goods or burden of any other description in the course of trade or business (including agriculture and the performance by a local or public authority of its functions) and vehicles constructed or adapted for use and used for the conveyance of a machine, workshop, contrivance or implement by or in which goods being conveyed by such vehicles are processed or manufactured while the vehicles are in motion:"*

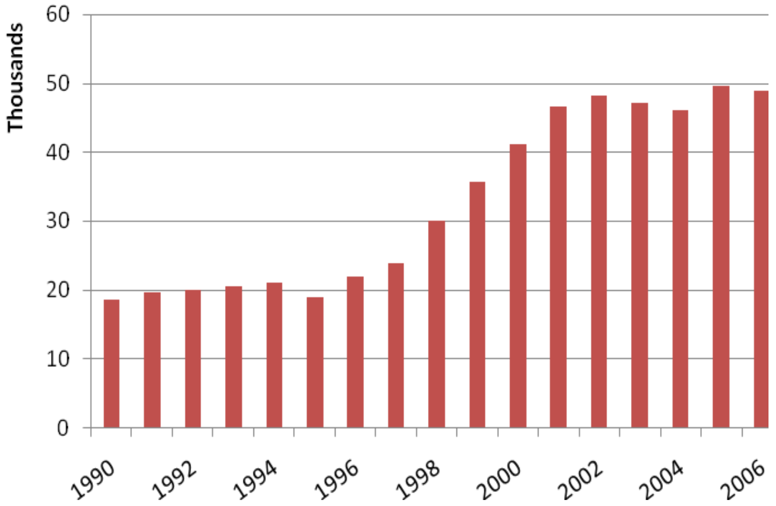
It is shown in graph 13 that the number of goods vehicles registered in the state has increased by a factor of five in 30 years. As the number of vehicles increase so to does the risk of vehicles being involved in bridge strikes.



(Source Data: Courtesy Central Statistics Office)

Graph 13: Number of goods vehicles licenced in the state by year, 1977-2006

Clearly, not all such vehicles have the potential to cause serious bridge strikes and, therefore, the writer has made a judgement that a more realistic number of vehicles would be better expressed by excluding all goods vehicles less than 5000kg as these would most likely be small vans lower than 2.5m in height.



(Source Data: Courtesy Central Statistics Office)

Graph 14: Number of Goods vehicles >5001kg registered in the state by year, 1990-2006

As can be seen in graph 14 there are approximately 50,000 goods vehicles over 5 tons in the country. Given our relatively small geographic size, an area of 70,280 sq. km, compared to, say, GB with 229,899 sq. km, this would appear to be a significant number. However, in order to confirm this it is necessary to benchmark our haulage figures for road and rail against some of our nearest neighbours.

Country	**National Haulage by road (thousand million tkm)**	**Haulage by rail (thousand million tkm)**
Austria	14.44	20.98
Belgium	19.62	8.57
France	182.75	40.92
Germany	251.38	107.01
Ireland	13.83	0.21
Italy	176	24.17
Lithuania	2.23	12.9
Norway	15.31	3.25
Portugal	17.54	2.43
United Kingdom	158.16	23.12

(Source: EU Energy & Transport in figures-Statistical Handbook 2007/2008)

Table 13: Comparison or haulage by road v rail sectors

Table 13 presents the data for 2006 for a number of EU and non-EU countries and illustrates the national differences in attitude to the carriage of goods by rail.

Focusing on Ireland, of all goods hauled in 2006 the haulage by rail accounts for only 1.5% and is one of the lowest in the EU. This demonstrates our reliance on road for the carriage of goods. It is recognised that Ireland is geographically small and is an island and, perhaps, these are substantiating reasons why the railway freight business in Ireland has decreased by 66% since 1990. The above statistics suggest that there is a reliance on road haulage as a means of transporting goods and as the population increases our reliance on imports and subsequent road haulage is likely to increase. Therefore given that road vehicles will remain it is necessary to focus on the mitigation of bridge strike events occurring.

4.3.1 Road Hauliers Survey

Given the above background information on goods vehicles and the bridge strike trends in recent years the writer consulted the Irish Road Haulage Association (IRHA) with the purpose of undertaking a small survey of some of its members. The writer developed a 20 question survey (See appendix *A*) and liaised with Iarnród Éireann to ensure all salient points would be covered. In July 2008 the writer conducted telephone interviews with 10 road haulage companies. The answers were cross referenced and the conclusions drawn from the survey are now summarised.

1. Many hauliers do not carry the IÉ Bridge Map in the driving cab. In fact many respondents were not aware of the document or that city maps were free to download from the Iarnród Éireann website.
2. Almost all of those persons interviewed stated that if any of their vehicles were involved in a bridge strike they would report the incident and provide their contact details. However, some thought there was no need to report a strike if their vehicle just scraped the bridge.
3. Only 1 of the respondents stated that the height of their vehicle was displayed on the dash board in the drivers cab. While a further 4 stated that the height of the vehicle or container was marked on the trailer. All stated that, to the best of their knowledge, there was no requirement to do this but felt it was good practice.
4. A number of those surveyed complained about the lack of advance signage. It was stated that having a warning sign 100m on the approach to a restricted height bridge was of little benefit as often there was nowhere to turn a HGV.
5. Most responded stating that following a bridge strike the majority of blame lies with the driver. However, nearly all stated that they felt the signage could be improved.

From the brief summary above a number of important recommendations may be presented and they are;

IÉ5	**IÉ should promote their Bridge Map and town maps** IÉ should consider advertising the fact that a bridge map is available free of charge and that city and town maps are also available on their website.
Priority	Medium
Timescale	6 Months ongoing
Cost	Sizeable, depending on media chosen.

In relation to the bridge map it was further suggested by a number of survey participants that the bridge map should go further than just the national primary and secondary roads. Many stated that they found the AA Truckers atlas used in GB to be an excellent source of route planning identifying height, weight and width restricted bridges on all classes of roads. This could be further supplemented by identifying the vulnerable over-bridges.

IÉ6	**IÉ should consider discussing all Ireland mapping with the AA.** IÉ should consider discussing with relevant cartographic companies, e.g., the AA the possibility of superimposing their headroom restricted bridges onto maps.
Priority	Low
Timescale	6 Months
Cost	Unknown at this time

Regarding signage almost all those interviewed stated that there is a need for advance signage and not simply the yellow diamond board. Many suggested that given the myriad of warning signage on Irish roads they are often not noticed. Three individuals suggested the use of solar powered signs to warn of a low bridge ahead. These could be similar to that found near schools that could flash the words “LOW BRIDGE”. Furthermore at night in poorly lit areas it would be a useful method of warning the hazard ahead.

IÉ7	**Have advance warning signage installed at all vulnerable under-bridges.** IÉ in collaboration with the RSC and RRSWG should liaise with road authorities to erect advance warning signage sufficiently away from headroom restricted bridges. Site specific meetings could be arranged whereby representatives from relevant parties attend.
Priority	High
Timescale	3 Months and ongoing
Cost	€20000. (Safety Investment Programme) To target most vulnerable bridges

Plate 12: Advance information signage used in GB

4.4 Case Studies

By way of background to the dissertation the writer reviewed the reports of the three most high profile bridge strike incidents that have occurred in recent times in Ireland as they serve to illustrate the potential risk to the railway following a bridge strike.

4.4.1 Longford under-bridge strike

One of the highest profile bridge strikes occurred in 1974 just outside Longford, a relatively small provincial town, approximately 76 miles from Dublin.

(Courtesy Iarnród Éireann)

Plate 13: Train derailed at Longford, 1974

The 07.45 hours ex Sligo to Dublin passenger train, with 24 passengers and 3 crew, derailed at about 09.00 hours as it approached Longford station. Around three hours earlier the single span steel girder bridge carrying the railway, with a signed clearance of 13’ 3” (4.03m) had been hit by an articulated vehicle. The bridge and track were found to be approximately 13” out of alignment and the Inspecting Officer at the time concluded that the derailment was due to this mis-alignment of the rails. Unfortunately, further investigation found the derailment could have been prevented had it not been for a breakdown in communication between the local signalman and permanent way inspector who, for whatever reason, inspected the wrong bridge.

Fortunately there were no major injuries largely due to there being no passengers in the two carriages that went down the embankment. Only the driver was removed to hospital for precautionary reasons. One other passenger received medical attention at Longford station but was fit enough to continue the journey (by bus) to Dublin.

This accident shows the potential of tracks being mis-aligned and subsequently causing a derailment (plate 13). It further illustrates the importance of communication that is clear and unambiguous.

In this case a member of IÉ staff made an assumption and then communicated a different message to another staff member resulting in the wrong bridge being inspected and the derailment occurring. Effective communication is vital when conveying emergency information as is further illustrated by the Transport Accident Investigation Commission, New Zealand’s (2005) investigation into a similar bridge strike in 2004. In this instance 2 under-bridges were inspected and the line cleared for the passage of trains, unfortunately neither of these was the correct bridge. Fortunately the damaged bridge was reported again by a member of the public leading to the correct bridge being inspected preventing an almost certain derailment.

4.4.2 Gorey, Co. Wexford under-bridge strike.

However the same luck was not present in an incident that occurred a year later at an under-bridge in County Wexford where a vehicle carrying construction plant completely dislodged two wrought iron girders, leaving the track unsupported, (Plate 14). Gorey, approximately 60 miles south of Dublin, is on the Dublin Rosslare mainline and is again a relatively small provincial town.

(Courtesy Iarnród Éireann)

Plate 14: The vehicle responsible for the bridge strike

The incident occurred around 09.30 am on New Years Eve 1975. An excavator on the back of a lorry struck Clogh Bridge, approximately 5km south of Gorey, dislodging its granite masonry and causing a track mis-alignment. Despite the efforts of the lorry driver and a passer by, they were unable to stop the 8.05am Rosslare Harbour-Dublin train that arrived on the scene shortly thereafter. The train hit the bridge at an estimated 60 mph resulting in 5 fatalities and 30 injured persons (Mac Aongusa, 2005). At that time this was the worst rail crash in CIÉ's history. The casualty figures could have been significantly higher had the first two carriages not been closed and empty.

This was the case because it had been intended only to open the two carriages for passengers joining the train further along the line. These leading vehicles and the baggage car were completely shattered when the train came upon the unsupported rails. Miraculously the driver survived, sustaining a back injury while the majority of the injured were located in the third carriage, with the five fatalities occurring to passenger travelling in the forth carriage. This carriage was penetrated by the coach behind it and it came to rest spanning the gap (plates 15 & 16).

(Courtesy Iarnród Éireann)

Plate 15: Clogh Bridge, Gorey, County Wexford, 31st December 1975

The impact had been severe with coach bodies completely smashed and wheel bogies and underframes badly twisted. Rescue efforts were hampered by inclement weather, however, many people were capable of walking free of the wreckage.

(Courtesy Iarnród Éireann)

Plate 16: The resting place of the forth carriage

4.4.3 Kyle over-bridge strike

A more recent incident was the Kyle over-bridge strike that occurred on 27 March 1999. Kyle over-bridge or OBC86 is located 1 mile south of Kildare Town, approximately 30 miles from Dublin. At the time when the incident occurred the road was a national primary road, the N7, between Dublin and Limerick. It has since been bypassed.

At approximately midday on Saturday 27 March, an articulated lorry, transporting a 40' container of timber, travelling southbound, crashed through the parapet and dropped onto the tracks below (see plate 17)

(Courtesy RSC)

Plate 17: Kyle over-bridge strike

There is a bend in the road at the location and eye witnesses stated that the lorry appeared to make no attempt to follow the road alignment, crashing through the parapet and completely fouling both tracks. Unfortunately the driver of the vehicle was fatally injured and died at the scene. However, the driver of 11.45 hours Heuston to Waterford train, having just departed Kildare station, noticed the obstruction ahead of him, in sufficient time so as to stop his train, potentially avoiding additional injuries and/or fatalities.

What was noted at the time was the fact that the track circuits showed the lines as ‘clear’ as the container and truck made contact with one rail only. It was fortunate that the next train in the section was stopping service and not an intercity service as the consequence could have been far serious.

The N7 was closed to road traffic for 2 weeks after the incident while a new strengthened parapet and safety barriers were installed. Following the incident the Chief Engineer undertook a major review of other such bridges, identifying vulnerable interfaces. A register was created of these locations and through the safety investment programme additional safety measures have been installed at a number of over-bridges.

This incident is similar to that which occurred at Great Heck, England, in February 2001 when a road vehicle deviated off the road fouling the railway line into which a train crashed. (HSE, 2002). Such events illustrate the potential risk at road-rail interfaces and the importance of sufficient roadside containment.

5 European View & Comparison.

In November 2007 the writer made a presentation to the 9th plenary meeting of the Network of National Safety Authorities, held at the European Railway Agency (ERA) in Lille, France. This gathering comprises representatives from EU Member States (MSs) and other external railway bodies, such as the International Union of Railways (UIC), etc.

The presentation was undertaken to illustrate the problem area of bridge strikes in Ireland and introduced a request for information through a short questionnaire. (See appendix *B* and *C* for a copy of the presentation and questionnaire). In December 2007, ERA emailed out this questionnaire at the request of the writer to all participating MSs, a total of 22 countries excluding Ireland and, in the timeline, a total of 16 responses where received from:

- Spain
- Portugal
- United Kingdom
- Netherlands
- France
- Czech Republic
- Slovenia
- Hungary
- Slovakia
- Belgium
- Lithuania
- Germany
- Latvia
- Sweden
- Finland
- Bulgaria

This represented a response rate of 73% which was deemed more than sufficient to undertake a cross comparison and to see whether bridge strikes were a phenomenon that was common to other railways.

In addition to the EU member state responses, completed questionnaires were received from Western Australia and East Japan Railway. The questionnaire consisted of 30 questions covering general information such as network size, location of respondent and then, more specifically, questions relating to under-bridges, over-bridges, statistics and finally law and enforcement pertaining to bridge strikes.

5.1 Questionnaire Analysis

The questionnaire was prefaced with a short explanation of the writer's understanding of a bridge strike, emphasizing the nomenclature used in Ireland and included two photos explaining the different classification of bridge. It further explained the basis and structure of the questionnaire and explained how the respondent should reply to each question. An overview of the responses to the salient questions follows, while the actual questionnaires with each Members State have been omitted for anonymity reasons.

Question 2 asked the simple question, "Do you collect statistics on under-bridge strikes?". Of the 18 questionnaires received (16 MS responses plus the two received from Australia and East Japan), 11 countries confirmed that they did collect bridge strike data and 7 did not. This was reassuring to find out that bridge strikes are not just an issue in Ireland. However, it was found that the vast majority of the 11 MSs only collected bridge strike data if it resulted in an accident that involved a train in motion. Clearly, this would suggest it is not a pre-cursor that ranks highly with many.

Question 3 probed a little further to ask whether or not the MS collected statistics for over-bridge strikes. There was an equal split of 9 who stated yes they did and 9 saying they did not. This led into question 4 which asked "Do you believe Bridge Strikes pose a safety risk?" and 14 said yes, 3 said no and there was 1 with a nil response. This, to an extent, conflicted with question 2 as only 11 collected statistical data, yet 14 felt there was a risk posed by bridge strikes.

Question 5 asked "Do you believe that one class of bridge strike poses more of a risk to the railway?, i.e., an under-bridge or over-bridge strike. Many MSs were undecided, while of those that replied "yes" the majority believed the greater risk was at over-bridges for various reasons that included; the frequency of them being hit was far higher, there was a greater risk of the railway being fouled by an errant road vehicle, there is little or no signage at over-bridges.

Question 6 asked "What risk mitigation measures/deterrents are used for under-bridge protection". A table was provided and the MS was asked to tick all those that were appropriate. Table 14 below lists the responses.

No.	Measure	No. of positive responses
1	Bash / collision protection beams	14
2	Infra-red beam and variable message displays.	2
3	Other automatic height detection systems	2
4	Hanging bells / chains	9
5	Regulatory road signage	14
6	Prosecution (Fixed penalty fines and/or penalty points)	8
7	Other (please list below)	2

Table 14: MS Response to bridge strike survey question 6

Other measures included safety barrier systems around bridge piers and abutments and lights in roads to indicate the safe width of vehicles.

Question 7 then asked "What risk mitigation measures/deterrents are used for over-bridge protection". The format was the same as the previous question. Table 15 below lists the responses.

No.	Measure	No. of positive responses
1	High containment parapets	9
2	Safety barriers on approaches to an over-bridge	9
3	Traffic calming, e.g. speed bumps, rumble strips	1
4	Road markings	6
5	Regulatory road signage inc. reduced speed limits	10
6	Prosecution (Fixed penalty fines and/or penalty points)	6
7	Other (please list below)	1

Table 15: MS Response to bridge strike survey question 7

Another measure introduced was accident blackspot signage at locations of known vulnerability, which is a measure worth considering.

IÉ8	**Liaise with local authorities and NRA regarding signage at OBs** IÉ should review their 'Vulnerable Interface at Bridge' register and liaise with road authorities to consider erecting 'accident blackspot' signage at these high risk locations.
Priority	Medium
Timescale	6 Months
Cost	€20k - For cost and erection of signage at top 10 risk OBs

Question 8 asked MSs to provide bridge strike data for the period 2000-2007 for both under-bridge and over-bridges. A relatively poor response was achieved to this question, with only 10 MSs providing data. It was clear from the figures provided (they were low) that the risk of bridge strikes is either far lower than that in Ireland or the fact that so many MSs simply do not collect the data unless, as was stated in question 1, bridge strike data is only collected if it results in an accident involving a train in motion. However, many MSs believed that many bridge strikes were not reported and, therefore, collecting data was more problematic because of this.

Question 9 asked, "Is warning signage present on the highway approach to restricted height bridges?" and of all the responses only 3 countries replied in the negative.

Questions 10-13 pertained to road vehicle heights and the responses proved most interesting. 15 MSs confirmed that road vehicles have a maximum height and that it is written into legislation. The findings were as follows;

- 1 Country has a maximum vehicle height > 4.6m
- 10 Countries have set the maximum vehicle height at 4m or less
- 14 Countries have set the maximum vehicle height at 4.5m or less

The above is particularly interesting since the maximum vehicle height in Ireland has been set at 4.65m considerably higher than a substantial number of our member state counterparts. This would suggest that perhaps a review of this legislation might be a worthwhile exercise.

As a compromise to reducing the vehicle height limit what could be introduced is a height limit on vehicles that enter cities and towns with known headroom restricted bridges such as Dublin, Portlaoise, Bray, Cork, Limerick, Galway, and Longford.

Another interesting response was that 15 MSs confirmed that road haulier operators are required to know the height of their vehicle, which is not the case in Ireland.

Question 14 asked how many under-bridges there were on the member state's network. This was asked in order to get a picture of whether Ireland has a disproportionate number of under bridges, compared to others. This would appear to be so as, out of the 15 responses, Ireland was placed sixth, with fewer under-bridges than the likes of the UK, Germany and the Czech Republic but with more than the likes of the Netherlands, Sweden or Finland. Cross referencing this information to that provided from responses to question 29 which asked the member states for the route km of their network, out of the 17 MSs who responded, including Ireland, only Lithuania and Slovenia had a smaller network. This emphasises the disproportionate number of under-bridges in Ireland and is perhaps a reason why we have such a high incidence of bridge strikes.

Questions 15 and 16 all related to height or headroom restricted under-bridges. 15 MSs confirmed that they had such bridges on their networks. However, only 6 could provide the number of low bridges and, of these 6, only Sweden has more headroom restricted bridges than Ireland. The writer would suggest that, given so many MSs believed bridge strikes posed a risk (see question 4), it would be useful for them/the Infrastructure Maintainers to create a register of their low bridges.

The next question asked for the height below which a bridge was classified as being height restricted. Table 16 (below) lists the responses, while the conclusions from this may be summarised as follows;

- 9 countries refer to a restricted bridge as being lower than 4.8m which is considerably lower than the 5.03m referred to in Ireland.

- Only 2 countries other than Ireland classify a low bridge as having a height greater than or equal to 5m.

Country	Restricted Clearance height (m)
UK	5.03
Ireland	5.03
Portugal	5.0
Czech Rep	4.8
Sweden	4.6
Germany	4.5
Hungary	4.5
Belgium	4.5
Finland	4.4
West Australia	4.3
Slovakia	4.2
Netherlands	4.1

Table 16: Country by country restricted clearance Height limits

Questions 17 asked how headroom restricted bridges are identified and 13 responded stating that signage is positioned either on the under-bridge or on the approach to it. It would appear that this is good practice and typical.

IÉ9	**Undertake periodic review of Bridge Register and site assessment of headroom restricted bridges.** IÉ should undertake a review of its bridges register to ensure all relevant details are held and are current. In this regard IÉ should undertake a site assessment of headroom restricted bridges to ensure signage that is required is in place.
Priority	Low
Timescale	6 Months
Cost	Minimal (if undertaken in-house)

Whilst undertaking this research the writer reviewed numerous IÉ databases and registers pertaining to bridges and bridge strikes. There were a few instances where some data was entered as being unknown. The registers should be managed by a central source and reviewed, updated and corrected as appropriate. Furthermore, during a number of site visits the writer identified cases where there was no signage present and where signage varied in its appearance.

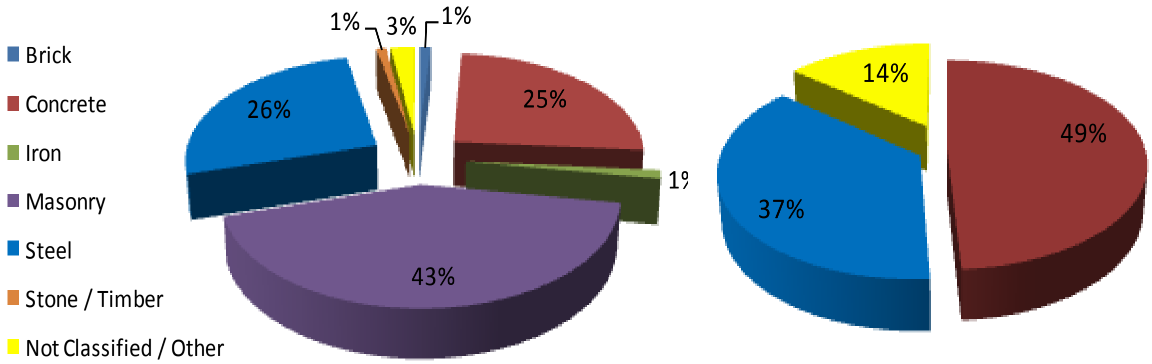
Question 18 asked whether maps were available that identified the location of height restricted bridges. Surprisingly, only two countries in addition to Ireland had maps illustrating the location of such bridges. A number of countries responded saying they were not aware of any, but clearly there may be.

Question 19 was perhaps a little too specific in that it asked 'what is the breakdown of under-bridges by type, as a percentage?'. A simple table was provided listing concrete, steel, masonry, iron and other as the main categories. Very few countries completed this question, however, those that did respond and their answers are shown in the table below. It illustrates the breakdown of the bridge types by country with all figures shown being a % of the total.

Country	Concrete	Steel	Masonry	Iron	Other
Bulgaria	73	12	15	-	-
Finland	94	5	-	-	1
Ireland	25	26	43	1	5
Latvia	65	33	-	-	3
Portugal	70	10	13	7	-
Slovakia	-	78	-	-	22
West Australia	40	60	-	-	-

Table 17: Breakdown of under-bridge type by material

The breakdown was generally quite different from that in Ireland as may be seen by the graphs below.



Graph 15: Under-bridge type by material in Ireland (left) & Averaged other countries (right)

As may be seen in graph 15, only a 1/4 of the under-bridges in Ireland are constructed from concrete. This is essentially half that of the averaged other countries who responded. Similarly there are significantly more bridges constructed from steel used in other countries than is the case in Ireland. Another noticeable difference is the fact that almost half of the under-bridges in Ireland are masonry which, in general, would provide less mass than a concrete bridge and be potentially more susceptible to damage following a bridge strike. This is certainly a contributing factor to the risk rating, as outlined in chapter 4.

Question 20 focused on arch bridges, asking how the clearance height of such a bridge was determined. The responses provided were vague and hence no conclusions could be drawn. However a detailed response was received from the UK and this is compared to the irish method in the next section.

Question 21 changed the focus to over-bridges, asking for the number of such bridges in their respective countries.

Country	Number of over-bridges	Length of Rail Network in use (km)*	No. of OBs per km
Netherlands	1800	2811	0.64
Ireland	1188	1919	0.62
Portugal	1131	2844	0.40
Belgium	1358	3544	0.38
United Kingdom	6600	19956	0.33
Finland	884	5732	0.15
Bulgaria	282	4154	0.07
Slovakia	221	3626	0.06
Lithuania	44	1771	0.02
Latvia	51	2270	0.02
Hungary	170	7950	0.02

**(Source: EU Energy & Transport in figures-Statistical Handbook 2007/2008)*

Table 18: EU comparison or road and rail networks

From the above table it can be seen that Ireland has the second highest number of over-bridges per km. Certainly this is a factor in the number of over-bridges struck by road vehicles, however, road geometry, road speed and driving competence or culture also play a significant part. As was illustrated in table 3, section 3.5, Ireland experiences in excess of 330 road deaths per annum which in a European context places us some way back in 12th place behind leaders the Netherlands, Sweden and the UK (European Commission, 2007).

Questions 22 and 23 asked simple questions pertaining to how bridge strikes are reported. The vast majority of countries had an emergency contact number to notify of a bridge strike. At least four countries used their standard emergency services number while the remainder use specific numbers. What was interesting was the fact that only two countries, other than Ireland, had this emergency number displayed on their bridges and perhaps MSs may which to consider this fact.

Questions 24 and 25 asked questions relating to the prosecution of drivers following a bridge strike. 9 countries stated that drivers were prosecuted, generally for costs, with 6 of the nine stating that penalty points were included but generally considered on a case by case basis.

To date there has only been 1 prosecution in Ireland for a bridge strike where a driver incurred a penalty point. In Ireland penalty points on licences can affect insurance premiums and should a driver reach 12 points with a 3 year period he/she is disqualified from driving for a period of at least 6 months. For road hauliers, where driving is their business, it is reasonable to assume that the risk of not only occurring a fine but also penalty points following a bridge strike would most likely have a positive effect on driving behaviour.

Question 26 asked whether or not countries felt that there was sufficient regulation of road hauliers to maintain safety standards. 9 believed there was, while the majority of the remainder were undecided.

Questions 27 and 28 asked whether there had been any train accidents following a bridge strike and whether or not fatalities resulted. 5 countries confirmed that they had suffered a train accident as a result of a bridge strike, with just two stating that fatalities had resulted.

The final two questions asked for network specific and operating details asking for route km and passenger and freight km figures.

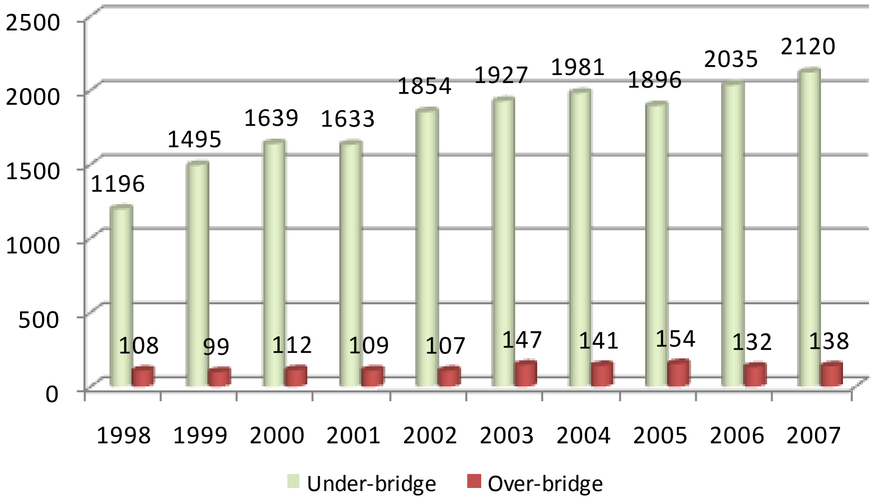
To conclude, the questionnaire was a useful exercise to undertake, in that it confirmed that Ireland does have a bridge strike problem when put in the European context. For the size of our railway network we have a high proportion of bridges and earlier analysis of road haulage activities would suggest we have a dependence on road transport. The responses confirmed that the railway undertaking in Ireland is proactive in its asset management, employing what would appear to be good practice, in terms of signage, mitigation measures etc. However, it did high-light the issue of vehicle heights, where it would appear that the maximum road vehicle height, to be set in Ireland, is far higher than that elsewhere.

5.2 Great Britain Comparison

The writer, prior to taking up this current appointment, worked in the GB railway maintenance industry and, therefore, had some knowledge that bridge strikes were an issue. Given this background knowledge, in January 2008 the writer contacted Network Rail (NR) through a contact in the Office of Rail Regulation and arranged a meeting with Network Rail's national Bridge Strike Champion. This interview, which proved more of a two way discussion, took place in March 2008. The aforementioned questionnaire was completed and pertinent issues discussed, such as the current status of bridge strikes in the UK, the measures currently in use, the top hit bridges, forums and working groups etc, all with a view to gaining a greater appreciation of the extent to which the industry is affected.

The management of NR's assets, which includes their bridges, is undertaken under the stewardship of 5 Territory Engineers and, between them, they look after 19271 over-bridges and 27210 under-bridges (RSSB, 2008).

If we look at the GB figures for bridge strikes, from 1998 to 2007, as illustrated in graph 16 (below), it shows there is a steady rise in the numbers of under-bridge strikes, while the number of over-bridge strikes has remained largely constant. This is similar to the experience in Ireland, albeit with numbers a factor of 10 higher.



(Source data Courtesy Network Rail)

Graph 16: GB Bridge strikes, 1998 - 2007

It is apparent from the above that GB has a similar problem with bridge strikes, suffering in excess of 2000 per year. If we consider the data for the period 1st April 2007 – 31st March 2008 there were 2355 bridge strikes, representing an increase of 206 (9.6%) on the 06/07 figure. The breakdown of this figure as can be seen in table 19 with the percentage change from 2006/07 given in brackets. Meanwhile the * indicates those bridge strikes that were recorded but without being classified, footbridge strikes and rail over rail strikes.

Bridge Class	No. of strikes
Road under Rail (underline)	2161 (+6.9%)
Road over Rail (overline)	143 (+13.5%)
Other*	50

(Source data courtesy Network Rail)

Table 19: GB Bridge strikes, 2007-2008

There is one clear difference in terms of bridge strike trends between the GB and Ireland and that is the fact that NR experience on average one bridge strike per week that involves a public service vehicle (plate 18).

(Courtesy Network Rail)

Plate 18: The aftermath of a bus on bridge collision

Clearly, these buses are off route and are, in the main, travelling empty. In Ireland, Dublin is the only city with a substantial fleet of double decker buses and, even with its numerous vulnerable low bridges, to date there have been no such recorded incidents here.

As is the case in Ireland, NR has a number of problematic under-bridges, in particular bridges in Grantham on the A607, Springfield Road and Harlaxton Road, and on the A52, Barrowby Road, in Lincolnshire and with Whitehouse Road in Swindon to name just a few. These bridges are on average struck between 10 and 20 times each year, with no real sign of improvement. In an Irish context the Grantham bridges are the Portlaoise equivalent, however, given the fact that there is a diversionary route now in place it is hoped that the Portlaoise bridge strike figures will subside.

(Courtesy Network Rail)

Plate 19: Grantham under-bridges, Springfield Road (left) & Barrowby Road (right)

From the above statistics and images it is clear GB has a problem with bridge strikes and NR have introduced a number of measures to reduce the trend. NR key deliverables in terms of bridge strikes are prevention, mitigation and response and, true to this mandate, a number of techniques have been employed and a sample of these are discussed later.

It is important to note that the rail industry in Great Britain differs from that in Ireland in that the infrastructure owner and maintainer do not operate trains. There are contracts in place between NR and numerous Train Operating Companies (TOCs) and, under schedule 8 of these contracts, there is a penalty clause. This means that, should a train be delayed as a result of a bridge strike, NR must make a payment to the TOC who is operating the train. These amounts are sizable, for example, in January to September 2007, this amounted to £5,080,945 with an average cost per incident of £4101 (RSSB, 2008). Clearly, there is a major incentive for NR to prevent, mitigate and respond to bridge strikes, however, it is recognised that the primary incentive is safety, particularly given that the NR mission statement is to provide a safe, reliable and efficient railway fit for the 21st century.

5.2.1 Network Rail's Bridge Strike Management

NR has dedicated staff to monitor and champion the area of bridge strikes and the company has approximately 2300 Bridge Strike Nominees. These BSNs, as they are referred to, tend not to be engineers but rather are from an operations background. However, these individuals are competent, having attended a 1 day course, to inspect a bridge following a strike and to assess the severity of the impact. To assist in this regard NR have produced a number of guidance notes and procedures to assist in the management of their bridges. These include:

NR/GN/CIV/201 - Managing Bridge Strike Incident – A good practice guide for Bridge Strike Nominees;

NR/GN/CIV/202 - Management of the risk of Bridge Strike Incident;

NR/SP/CIV/076 - Management of the risk of bridge strikes from road vehicles and waterborne vessels.

Iarnród Éireann have introduced similar training in recent years, with a 1 day course for patrolmen (track inspectors) and a 3 day course for divisional engineering staff. However, IÉ might consider producing similar guidance notes for its track inspectors (BSN equivalent).

IÉ10	**Produce Guidance Note for Bridge Inspectors.** IÉ should consider producing a guidance document, similar to the NR 'Good Practice Guide for Bridge Strike Nominees' for their own staff involved in the inspection of bridges.
Priority	Medium
Timescale	9 Months
Cost	Printing costs

Having reviewed the above literature, in particular the good practice guide for BSNs it is obvious that the standard of bridge strike reporting in NR far exceeds that of Iarnród Éireann (IÉ). IÉs bridge strike report is a single page, while NR's is an extremely comprehensive 4 page document. Having reviewed IÉ's bridge strike database, there would appear to be many empty fields where data has either not been collected or was unavailable. That said, producing a similar guidance note and providing the necessary training could ensure that the data collected is more thorough and accurate. As a consequence the data would be beneficial in terms of prosecutions and statistical analysis. Indeed NR has assisted in the production of other guidance, namely maps. In conjunction with the Automobile Association (AA) a Truckers Atlas of Great Britain which clearly identifies the location of over 4700 low bridges, narrow and weight restricted bridges and level crossings has been produced. It also provides a table on the third page of the top 25 most frequently struck bridges. While it is appreciated that the geographic size of Britain is substantially larger than that of Ireland, it would be in IÉ's interest to approach cartographers to see if similar arrangements could be made. However, it should be noted that IÉ have a series of maps for the major city centres, i.e., Dublin, Cork, Limerick etc available on their website. They have also produced a specific railway bridge map, in conjunction with the Ordanance Survey, that covers the national primary and secondary road network and major cities and towns. This map was widely distributed in 2006 to all licensed road hauliers in the country.

IÉ11	**Contact cartographers regarding mapping of headroom restricted bridges** IÉ should consider writing to the Ordnance Survey (OSi) and the Automobile Association (AA) suggesting that all their city, town and discovery series maps show headroom restricted bridges
Priority	Medium
Timescale	6 Months
Cost	NA

Another measure employed by NR is in the area of bridge visibility and, in many locations, NR in conjunction with local authorities have improved lighting, cut back vegetation etc. However one example of where visibility has been taken quite literally is at bridge number 7712 in Swindon. As may be seen in plate 20, the entire parapet has been painted to make it as conspicuous as possible. Unfortunately it is still hit on average 17 times a year and, indeed, in the period 2002-2007 (September) this bridge was struck 122 times (RSSB, 2008).

(Source, Railway Safety (RSSB))

Plate 20: Bridge 7712, Whitehouse Road, Swindon

This bridge carries six tracks, including two lines with a maximum speed of 85 mph and, given its mass concrete construction there is little possibility of movement following a strike. For this reason it is a bridge where dispensation for train movements prior to an examination exists, and this process is now explained.

5.2.2 NR's Train delay mitigation

Since 2004, NR has had in place a national bridge strike initiative to reduce the consequence of bridge strikes. The robustness of underline bridges to withstand a strike by road vehicles was assessed and this led to the production of Signal Box Special Instructions (SBSI) for each bridge. This means the signaller can instruct train drivers as follows, (where the colour represents the signal aspect the signaller displays to the train driver).

Green: for such massive bridges that a strike has no consequence to the structure.

Double Amber: the first train approaches the bridge under caution from the signaller at 5mph and reports on any debris or damage; if there is no debris, the line returns to normal speed.

Amber: all trains approach under caution, the first at 5mph and, if no debris is seen, following trains at 20mph, until the bridge has been examined.

Red: all trains are stopped until the bridge has been examined.

Such a scheme is not in use in Ireland as it was deemed unnecessary. The system in Ireland is that all bridges are effectively 'red bridges' in that all trains are stopped until the bridge has been examined. In a safety sense this is a more conservative approach, however, IÉ are perhaps fortunate to own, maintain and operate services over bridges and, as a result, penalty payments are not payable, should a train be delayed.

5.2.3 The measurement of bridge height

What is interesting to note is that, in the UK, the measurement of height at low bridges, which is based upon the regime outlined in chapter 4 of the Traffic Signs Manual, states that:

> *"The figure shown on the signs to indicate the available headroom should be at least 3 inches less than the measured height to allow a safety margin and should be expressed to the nearest multiple of 3 inches."*

Similarly, for metric height the figure shown to two decimal places is always rounded down to the nearest centimetre and the following formula is used.

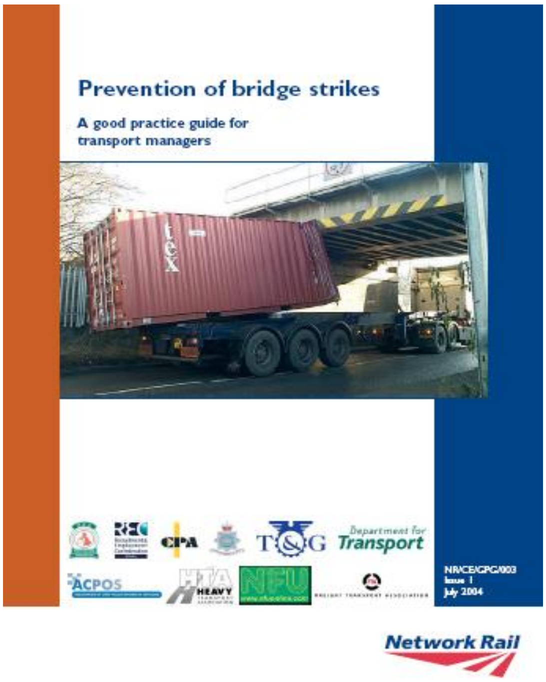
- If the second decimal digit is an 8 or 9, delete the digit and sign the bridge with the remaining number e.g., measured height 4.19m sign at 4.1m
- If the second digit is a 7 or less, delete it and reduce the first decimal digit by 1 e.g., measured height 4.25m sign at 4.1m

This would appear to be more conservative than the method used in Ireland which, as was outlined in chapter 2, uses the measured height from a 40ft chord, simulating a truck wheel base, to the lowest point on the bridge.

5.2.4 Bridge Strike Prevention Group (BSPG)

Network Rail formed the above group similar to the RRSWG in Ireland. The primary difference is that the BSPG only considers the risk of bridges being struck at underline bridges and does not address the risk from level crossings, over-bridges or at other road rail interfaces. It does deal, however, with the same issues pertaining to under-bridges, i.e., focusing on statistics to date, measures proposed or work in progress etc. BSPG members include representatives from Network Rail (Chair), Department for Transport (Rail and traffic signs policy) Rail Accident Investigation Branch (RAIB), Her Majesty's Railway Inspectorate (HMRI), Confederation of Passenger Transport, Transport for London, London Underground Ltd, the Highways Agency, Road & Freight Haulage Associations and representatives from the County Surveyors Society (CSS) and from the London Borough of Brent.

The BSPG or members thereof have also produced a suite of 'Good Practice Guides' for various user groups. These include a guide for professional drivers, a guide for professional drivers of passenger vehicles, a guide for transport managers and one for operational staff.



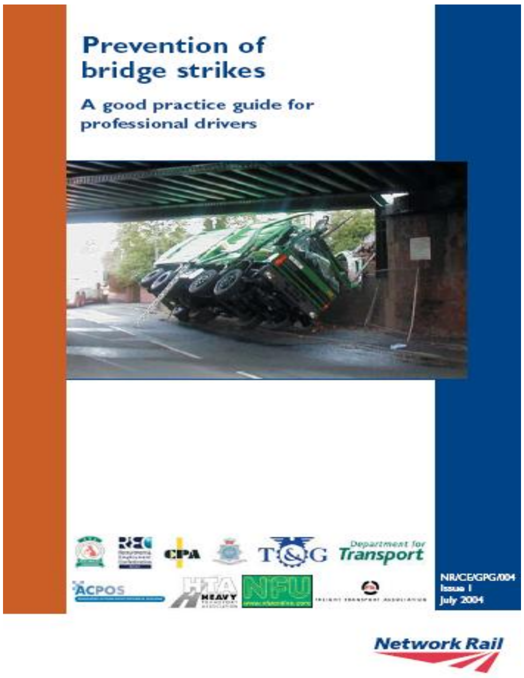


Figure 7: 'Good Practice Guides' published by NR

Similarly the CSS produced a protocol for highway managers and bridge owners and these measures are something the RRSWG should consider producing.

RSC3	**RRSWG to produce good practice guides.** Under the direction of the RSC the RRSWG should review the NR ‘Good practice guides’ to determine if there is a need to produce similar documents.
Priority	Medium
Timescale	6 Months
Cost	Minimal, possibly printing costs if adopted.

6 Legal Perspective

Vehicle height / load restriction (SI 319 of 1990) set a vehicle height of 4.25m in force, however, due to an infringement of EU law, this SI repealed. However, recent legislation (S.I. No. 366 of 2008) set the maximum road vehicle height at 4.65m, and this is considerably higher than that of the 1990 figure. Furthermore this Regulation does not apply to existing road vehicles, until 1 November 2013 and therefore the possible benefits in terms of a reduction in the number of bridge strikes will not truly be seen for another 4 years.

Unfortunately, 73% of headroom restricted bridges have a clearance of 4.65m or less, thereby making minimal improvement in the level of risk. This compares to 57% of railway bridges across public roads having a headroom clearance of 4.25m or less. Clearly, the lower the limit set the better, for example, if the limit were set at 4.0m as is the case in numerous countries in the EU, this figure would be reduced to 46%. This is still a sizable number, 192, however, it would be far better than the 301 involved, should the 4.65m limit be imposed.

6.1 Railway Bridge Signage

In Ireland, traffic signs are numerous, however, they are divided into three broad categories:

- Regulatory
- Warning and
- Information

The first type is the regulatory sign and in the context of railway bridges they should be clearly visible on a height restricted bridge (under-bridge).

Figure 8: Railway Bridge Regulatory Signage

Regulatory signs show the course a driver must follow and any action they are required to take or are forbidden to take. They are generally circular and have a red border and black symbols or letters on a white background.

In the case of arch bridges, the sign-posted height is only available over a certain width of the arch and this width is indicated by what is referred to as 'goalposts'. (See plate 21)

Plate 21: Masonry arch under-bridge with goal-posts.

Articles 137 and 138 of the Railway Safety Act 2005 pertain to road traffic and bridge strikes in particular, although, upon closer review, it is specific to under-bridges only. This particular part of the Act (Part 17), along with the Road traffic Acts 1961 to 2004, are cited together as the Road Traffic Acts 1961 to 2005 and this is explained by article 137. Article 138 essentially states that, where the height of a structure is displayed in accordance with regulations, a person shall not drive or attempt to drive under the structure if their load equals or exceeds the height indicated on the traffic sign. The article further states that a person who contravenes the previous subsection is guilty of an offence and is liable to a fine or imprisonment or both.

Clearly, this should be an ample deterrent to goods vehicle drivers and, indeed, any driver of a high vehicle or vehicle with a high load. However, in Ireland there is no legal requirement to know the height of your vehicle or load, as is the case in the UK, under the Road Vehicles (Construction and Use) Regulations 1986, SI No. 1078. These regulations require vehicles to display the maximum height of the vehicle in feet and inches on a notice in the cab if the overall height when travelling is more than 3 metres. Furthermore, the same regulations require a visual warning to be in the cab of vehicles if the equipment it is carrying is in a raised position whilst being driven.

RSA2	**Mandate drivers of goods and similar vehicles to know vehicle / load height** The Road Safety Authority should consider making law to require drivers of HGV's, goods vehicles and other oversized vehicles or those carrying abnormal loads to know the height of their vehicle or load.
Priority	High
Timescale	3 Months
Cost	Minimal.

The second category is the warning sign that should be clearly visible as one approaches a height restricted bridge (under-bridge). Warning signs are diamond or rectangular in shape and have a black border and black symbols or letters on a yellow background (figure 9). This differs from those in many other countries, such as the UK, who use yellow triangles with a black boarder.

Figure 9: Reduced Headroom warning signage

The sign indicates the highest vehicle that will be able to pass under the structure, typically a bridge. The height is referred to as the maximum headroom and is written first in feet and inches and then in metres.

The final category is the information signage and is shown on the potential approach to a height restricted bridge.

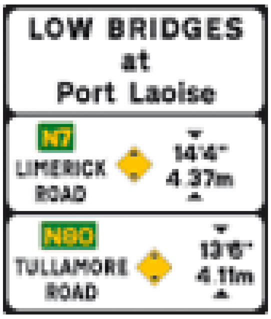


Figure 10: Advance information sign for low clearance railway bridges

IÉ use additional information signs positioned on both their under and over-bridges. Granted that actual ownership of the bridges is debatable, but while IÉ have safety of the line responsibility they are the party that is contacted and not the road authority, as is the case in some instances in the UK.

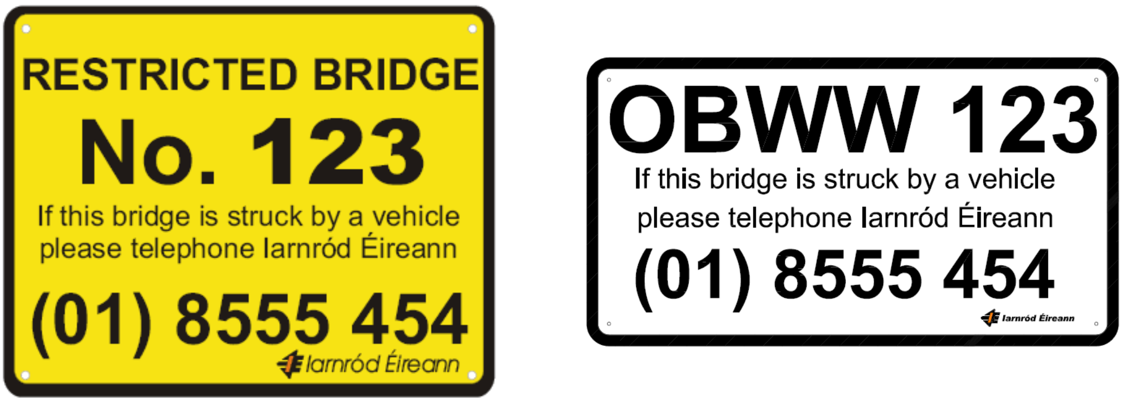


Figure 11: Height Restricted bridge (left) & over-bridge identification plates

As can be seen from figure 11, the bridge identification plates are relatively simple in appearance, clearly stating the bridge number and the emergency telephone number. The restricted bridge number is a unique number while the over-bridge identification plate identifies the line, i.e., the 'WW' reference is replaced by an 'R' for the Rosslare line or 'T' for the Tralee line etc. However the writer found during random site inspections signage is not always in place and, in this regard, the following recommendations are made.

IÉ12	**Install bridge signage where necessary** IÉ should inspect all height restricted bridges and vulnerable interface bridges and erect identification plates where necessary. These sites could be tabulated and presented county by county to each County Council (Roads section).
Priority	High
Timescale	6 Months
Cost	Staff time and signage cost estimate €10000

IÉ13	**Install bridge signage trackside** IÉ might consider installing the roadside bridge identification plates trackside, particularly where there is a history of that bridge being hit. This would ensure train drivers and track staff can readily identify their location and ensure correct reporting.
Priority	Low
Timescale	12 Months
Cost	Staff time and signage cost estimate €10000

6.2 Promoting Road Safety

The Road Safety Authority (RSA) is the administrative body in Ireland for establishing the new Driver Certificate of Professional Competence (CPC). The Driver CPC is an EU requirement under EU Directive 2003/59/EC and its primary objective is to improve road safety by setting and maintaining high standards of safety and driving among drivers of trucks and buses. The Directive makes it compulsory for European member states to have a Driver CPC for professional drivers, where a professional driver is defined as an individual who drives a truck or bus for a living and holds a particular category of licence.

Drivers of buses and HGVs will not be able to drive their vehicles without having first obtained the Driver CPC from 10th September 2008 and 10th September 2009 respectively. This is of course in addition to the driver holding a full driving licence in the appropriate category. Annex 1 to the directive stipulates that new drivers will have to undergo a 4 hour theory test followed by 2 hours of practical tests. Furthermore all drivers will have to renew their CPC every 5 years following 35 hours of periodic training. The RSA is currently drafting the training syllabus which, following the consultation process with which the RSC were involved, will include a section on height restricted railway bridges and the risk posed to these vulnerable structures if struck.

7 Bridge Strike Vulnerability & Prevention

Some works in the vicinity of the railway can increase risk to its safe operation. The most serious consequence of this increased risk is an incident leading to collision or derailment of the train. Unlike other forms of transportation, train drivers have no control over horizontal movements (i.e., steering). The driver has control only over the longitudinal movement.

The concept of train operation is that a route is available for a train to run with a guaranteed fenced right of way between signals and it is important to appreciate that a train travelling at 90 mph (145 km/h) requires approximately 2 km to stop. This is not the case for road vehicle drivers who have the freedom to steer and brake with much greater efficiency then that of a train. Distraction is clearly open to all drivers, be the trains or road vehicles. Clearly, there are a greater number of distractions to road drivers, such as radios, back seat passengers etc and, unfortunately, distraction of road vehicle drivers can lead to horizontal movements outside of the carriageway, resulting in over-bridge parapets being struck by vehicles and/or striking an under-bridge.

7.1 Bridge Strike Vulnerability

Bridges are vulnerable for many reasons, the fundamental reason being that they interface with third parties who are not restrained by any horizontal guides, such as rails. One such example of vulnerability is with road re-surfacing as illustrated below.

Plate 22: Road Surfacing under a height restricted bridge

Road authorities are often unaware of the risks posed by their actions to the railway above or below its road and, clearly, education is an important element in reducing the risk at under and over-bridges.

In June 2008, the writer in conjunction with IÉ made a presentation relating to vulnerability and road-rail interfaces and high-lighted their responsibility under the legislation. Feedback suggested it was a worthwhile exercise and one who should continue with other road authorities.

IÉ14	**Educate all agencies of railway risks associated with railway bridges** IÉ should contact all appropriate agencies and arrange a programme of presentations, jointly with the RSC to highlight the risk posed to the railway by road works in the vicinity of the railway in particular at railway bridges
Priority	Medium
Timescale	12 Months
Cost	Minimal, travel and expenses.

The road surfacing took place in Dublin city centre, under a height restricted bridge, UBLL38, on Amiens Street. The 50mm of hot rolled asphalt effectively reduced the clearance by two inches and a goods vehicle driver who can today fit under the bridge, strikes the bridge tomorrow as unbeknown to him/her the clearance has been reduced. Clearly, such activities pose significant risk to the railway and education about these risks imparted upon the railway must be provided to those who pose the risk.

Another method might be to consider erecting signage on all bridges with the following text "WORKING ON/UNDER THIS BRIDGE? IF YES, HAVE YOU CONTACTED IRISH RAIL?". This accompanied by a number might prompt the contractor or whoever is undertaking the work to contact the railway undertaking. Typically the work to be undertaken by the contractor would involved some site reconnaissance prior to the works taking place and it is likely that such a sign might prompt notification to Iarnród Éireann. Iarnród Éireann has been particularly proactive in this area and is more than familiar with vulnerable road-rail interfaces. In this regard IÉ have created a database of vulnerable interfaces at bridges, particularly over-bridges. Information pertaining to road geometry, alignment, road speed, bridge type, levels of containment provided, type and volume of rail traffic etc are all assessed and a final risk rating calculated. Individual bridges can then be ranked so that a picture is established of where the most vulnerable bridges are located. Having this information enables Iarnród Éireann engineers to target future safety investment.

7.2 Bridge Strike Prevention

It is accepted that there are many vulnerable road-rail interfaces, namely at level crossings and at under and over-bridges. In terms of bridges there are techniques for bridge strike avoidance and detection and some of these techniques are now presented.

7.2.1 Satellite Navigation Systems

Clearly, one area that could be utilised for disseminating height restricted bridge information is in the field of satellite navigation (Sat Nav) and Global Positioning Systems (GPS). Anecdotally, their use is on the increase, unfortunately, so to is the fact that some drivers have actually been involved in bridge strikes having been directed under headroom restricted bridges. However, it would seem a relatively simple task if one could visit a website and download a free map update with low clearance bridge information for ones existing Sat Nav.

RSC4	**RSC should contact Satellite Navigation systems, companies.** The RSC / RRSWG should consider contacting companies that provide satellite navigation systems to discuss whether low bridge height information could be included with their digital maps and pre installed on their various products.
Priority	Medium
Timescale	6 Months
Cost	None

One such example relatively new to the market is the Syrius S2000 PROLINE with TRUCKMATE by Snooper which retails at just under €475. It is marketed as being the first portable satellite navigation system, covering the UK and Ireland, to include dedicated routing designed specifically for trucks and large vehicles such as coaches, buses and mobile homes (figure 12).

This equipments software will create a route based on the attributes of your particular vehicle. Simply tell the unit the size and weight of your vehicle, plus the type of load if applicable and the software will calculate a safe, truck friendly route. Routes are then calculated based on roads with adequate height and width, excluding roads with low clearance or weight restricted bridges.

(Website Ref: No. 14)

Figure 12: Syrius Proline with Truckmate Low bridge software

Another example of a GPS based bridge avoidance tool is ‘Bridgeclear’. It compares the position of a road vehicle in real time with that of a comprehensive database of height restricted bridges. As a vehicle comes within a 1 km radius of a low bridge, an audible and visual warning is given in the driver’s cab. This system is in use in GB and mapping has been undertaken for Ireland. The price for a unit would be in the region of €700, which it is recognised is a sizeable cost if a haulier has a number of vehicles in his/her fleet.

7.2.2 Advance warning structures

Advance warning structures warn drivers of a restriction ahead, usually height. They are typically located between 20-50m in advance of the restriction and act as a sacrificial structure. There are in essence only two systems in use and they are the portal frame or hanging bell arrangement.

(Courtesy Finnish Rail Agency (left) & Hungarian State Railways Company (right))

Plate 23: Portal frame on the approach to a headroom restricted bridge

Portal frames (plate 23) are widely used throughout the world and also in Ireland, but usually only at entrances to car parks and rarely on public roads. This is because of the potential risk to pedestrians, other vehicles or other assets. This would suggest we are more worried about these factors then we are about a bridge strike and risk to persons on board a train. Other measures in use in many countries include hanging bell or chain type arrangements such as those shown below (plate 24).

Plate 24: Hanging chain (GB) and bell (Korea) arrangements

Again for some unknown reason they are not used in Ireland. Both systems would be relatively cheap to install and it is perhaps an area where Iarnród Éireann could consider at trial locations.

IÉ15	**IÉ to consider installing advance warning structure.** IÉ should consider identifying possible locations to trail the installation of some form of advanced warning structure. They should then liaise with the appropriate road authority as appropriate.
Priority	Medium
Timescale	12 Months
Cost	Dependent upon installation, estimation €10-20k per site.

Another method in use, although not really an advance warning structure is the installation of collision protection beams or bash beams as they are sometime referred to. They are positioned adjacent to the bridge itself and take the impact instead of the bridge deck. Bash beams have been installed at seven under-bridges, 6 on the Dublin to Cork line, including UBC145 in Portlaoise (plate 25) and 1 on the Dublin to Sligo line.

Plate 25: Advance structure – collision protection beam

7.2.3 Traffic Calming

Clearly, traffic management has a vital role in the area of bridge strike avoidance. An understanding of one's surroundings can have a significant impact in terms of railway safety. Often routes are identified without considering the potential impact they may cause if followed. For drivers without local knowledge they can easily be directed under headroom restricted railway bridges and depending on the type of vehicle and load they are carrying (if applicable) can impact upon the railway, literally. Measures that may reduce the number of bridge strikes or at least minimise their severity include using simple traffic calming measures such as speed-bumps, rumble strips or introducing road narrowing techniques. These should cause traffic to slow down and reduce the likely impact between a road vehicle and the bridge thereby preventing track distortions from occurring.

Plate 26: Examples of traffic calming

Advanced signage where height restricted under-bridges are near junctions could be installed, similar to that undertaken when a level crossing is near a junction. The photo below illustrates the scenario.

Plate 27: Pre junction warning of railway infrastructure

By simply replacing the warning signage, for a level crossing ahead (with lights and barriers in this case) with the equivalent warning signage for low bridge ahead (see figure 9, chapter 6) may provide sufficient notice to a driver to consider his/her options regarding the route they take. Similarly the distance, e.g., 300m, to the height restricted bridge could be entered as is done in GB (plate 12, chapter 4).
Directional signage can be problematic also, as may be seen in the photo below (plate 28). The N1 and N2 are national primary roads and are heavily used by HGVs. Drivers unfamiliar with this location may follow the signage, not realising there is a height restricted bridge on this route and either hit the bridge or cause traffic related problems.

Plate 28: Traffic signage as part of traffic management

What might work in this instance is if the above sign stated that high vehicles bound for the N1 or N2 should turn left at the junction thereby avoiding the two low bridges. Unfortunately this is not the case and, as can be seen on the right, both bridges are prone to being struck by over-sized road vehicles.

One more radical means of traffic calming is to close roads to over-size vehicular traffic or make traversing under the bridge pedestrian only. Certainly, in the majority of cases this might not be possible, but placing restrictions not only on the number of axles a vehicle has but also on vehicle heights might work in built up areas, such as in cities and towns.

7.2.4 Infra red detection

Infra-red detection equipment was installed on the approaches to both Portlaoise under-bridges, i.e., UBC145, and UBC146 in March 2007. The equipment was installed by IDT (Integrated Design Techniques) UK Ltd who had undertaken similar installations in GB for Network Rail, e.g., in West Wales and Wiltshire.

The system is comprised of essentially 2 roadside parts, an over-height sensor and a variable message sign (VMS). Upon the sensor being triggered it immediately transmits a signal by secure radio link to the VMS which displays an instruction to the driver to take an alternative route. Birds and other objects can cause false activations, however, an optional presence detector can be installed to prevent/minimise such as occurrence.

The IDT system also has a means to remotely advise up to three individuals using the GSM text message facility, if there is a fault with the system. The only negative at this stage would be the initial high cost of purchase and the ongoing maintenance costs involved.

Plate 29: Infra red detection equipment installed in Portlaoise

As seen in plates 29 the components are relatively simple and installed easily with minimal disruption to road traffic or pedestrians. However, as can be seen from the bottom left photo the system will not work if it is damaged, assumedly by some goods vehicle. As discussed earlier in chapter 4, both Portlaoise bridges, UBC145 and 146, have been hit since the installation, however, it is hoped that as people become familiar with them the instances will decrease and it is clearly a valuable method of potentially preventing a bridge strike.

7.2.5 Educate and improve knowledge

Clearly, the more people that are aware of the risks at road rail interfaces the better. This may be undertaken through a number of means, including on the job training, advertising on TV and in the media, undertaking direct mail shots etc. It is widely accepted that under-bridges are in the main hit by HGVs and, given this information, one could focus attention to educating these professional drivers. In particular those who haul containers should be targeted as it accepted that those who drive curtain-sided vehicles tend to come off far worse than most bridges.

Given the IRHA are represented at the RRSWG it would seem possible that annual bridge strike statistics should be published on their website, in road haulage journals / magazines and bulletins, as appropriate.

RSC5	**Produce annual bridge strike statistics and circulate to road haulage journals/magazines and to the IRHA.** The RSC should produce annual bridge strike statistics in a simple format, suitable for publication in road haulage journals/magazines. They should encourage the IRHA to publish these statistics on their website and promote to their members in the form of an annual safety report.
Priority	Medium
Timescale	6-9 Months and ongoing
Cost	NA

Similarly, the more staff trained in bridge strike reporting in Iarnród Éireann the better. Staff should be reminded of the importance of completing the bridge strike report forms, capturing all salient information. Having more detailed information might aid the targeting of future safety investment. Given the lack of legislation on vehicle heights in the country at present there is no legal requirement for a haulier to know the height of his/her vehicle. This is not the case in the UK as it is an offence if the overall travelling height of your vehicle is over 3 metres and the correct maximum height is not displayed in the driver’s cab (Network Rail, 2004). Similar provisions need to be imposed in Ireland and simply requiring a haulier to know his height is not an onerous task.

Simple and relatively cheap measures could be employed that include hauliers using telescopic poles, e.g., the Height Staff by Transporter Engineering Ltd to measure the height of their load. This, in conjunction with a simple in cab display, could act as a reminder to persons who regularly drive different loads, such as crane drivers and low loaders. Such instrumentation costs less than €95 per unit, with postage only a further €20 and their use should be promoted by the representative bodies.

RSC6	**Promote use of height measuring devices and in cab displays** The RSC/RRSWG should write to the Construction Industry Federation (CIF) and discuss with the IRHA to encourage the use of height measuring devices and in cab displays They should research the various devices available and suggest to their members their recommended device/s.
Priority	High
Timescale	3 Months and ongoing
Cost	NA

Cartographers such as the Ordnance Survey should be encouraged to ensure their mapping is accurate. Having reviewed their Dublin city map and a number of Discovery series maps a number of errors relating to bridges and their heights exist. In many instances the railway is shown to go under the road, suggesting there is an over-bridge when in fact an under-bridge exists. This creates the risk of incorrect route planning by drivers of tall vehicles and consequent bridge strikes.

RSC7	**Advise Ordnance Survey of mapping errors as they are identified** The RSC/RRSWG should write to the Ordnance Survey (OSi) identifying the mapping anomalies with a view to having these corrected in subsequent mapping publications. IÉ should then take the initiative forward advising the OSi of errors as they are identified. Furthermore the OSi should be encouraged to include headroom restricted bridge details on their street maps.
Priority	Medium
Timescale	6 Months and ongoing
Cost	NA

The press will always seek a gripping headline, as seen in figure 13, which in the writer's opinion often does not help the situation. This is because the reports often make the story more light-hearted than it actually is. Unfortunately, one cannot simply ask the press to improve their reporting. However, Iarnród Éireann public relations could do better than dumb down the issue. The road hauliers are for the most part professional drivers and the few that hit bridges should not tarnish the majority, nonetheless there is room for improvement. What should be reported, if at all possible, is the fact that Road haulier *Joe Bloggs Ltd* who was involved in striking railway bridge *x* was carrying freight for, say *Microsoft or Sony*.

Figure 13: Sample press headlines

Clearly, Microsoft, Sony or whomever would not want to be associated with a firm that are deemed to be incompetent. If facts such as these were written about by journalists, road haulage companies might take a little more care when planning the routes they take.
Similarly there have also been a number of TV adverts that have used what is arguably inappropriate scenes involving bridge strikes. These have included adverts for bread and crisps (figure 14).

(Website Ref: No. 12 & 13)

Figure 14: TV adverts depicting bridge strikes

While there is no malicious intend in such adverts they do conjure up light hearted tones and can therefore make some people unaware of the actual risk imposed to the railway. Advertising agencies and marketers would be well advised to avoid such campaigns and this is perhaps substantiated by the fact that the advert for crisps received in excess of 90 complaints' from viewers (Yorkshire Post, 2008).

Other means of improving knowledge, and indeed IÉ have been proactive in recent years, is that of advertising the risk. They have taken out numerous TV adverts at peak viewing times and have had adverts in numerous newspapers, asking truck drivers to watch their head height. The statistics for 2007 as discussed in chapter 4 suggest that there has been some success as a result of the campaign.
It is hoped that IÉ will continue to promote these safety concerns and think of other means of getting the message across.

7.2.6 Techniques for Bridge Strike detection &/or notification

Electronic bridge strike detection systems are in use in many countries but anecdotal evidence from both Iarnród Éireann and Network Rail would suggest that current systems are not sufficiently advanced that the information provided can be the sole basis for decisions for controlling train movements. They simply relay information confirming that a bridge has been hit. Clearly, they provide early detection of the strike, the time of incident, and perhaps, even the severity of the incident. However, installations are expensive, costing in the region of £50k, require routine maintenance, require competent staff to interpret outputs and are often susceptible to false alarms.

Yet one such example of this technology is that used on the Mass Transit Railway (MTR) system in Hong Kong. They utilise a collision notification system advising whether the bridge over the Rambler Channel has been struck (plate 30). Since its installation in December 2000 it has successfully reported ship booms and hoists striking the bridge. Using fibre optic cables installed in the parapets, strikes are relayed to the control room in Tsing Yi station, located next to the channel.

Plate 30: MTR Hong Kong, Ship impact detection system

Fortunately, strikes are a rare occurrence, with only 1-2 incidents per year, however, given the intensity of their operations, such systems are vital in managing train delays as a consequence.

Another system referred to as BashChex / Bridge Bash with intelligent rights belonging to Deltarail (formally AEA Technology) was developed by BR Research in the 1990s. Unfortunately, it was never developed into a full scale product. However, it was available for one-off installations. Bashchex used both infra-red beams and accelerometers fixed to the bridge that detect if the bridge is struck by an oversized vehicle. It also uses cameras that could be trained on the vehicle number plate (Martin & Mitchell, 2004). The writer consulted Deltarail who confirmed that there had been no such project for several years and any new opportunity would have to restart development, albeit based on the experience gained at the time.

7.2.7 CCTV

In April 2008, IÉ installed CCTV and new 'Low Bridge' signage at UBR60 on South Lotts Road (plate 31). The bridge located on the outskirts of the city centre has been repeatedly hit over the years and, more often than not, without capturing anyone in the act. Hence, IÉ have decided to pilot CCTV monitoring on the bridge. Footage is recorded and, if a notification of a bridge strike is received, the video tapes are viewed to try and identify the culprit. If nothing is reported the tapes are recorded over on a continuous cycle. Indeed IÉ have plans to install CCTV on another height restricted bridge in Dublin City and, depending on their success, may roll out the use of CCTV as an additional deterrent countrywide.

Plate 31: CCTV Surveillance at Restricted Bridge No. 107, South Lotts Road

7.2.8 Enforcing the Law

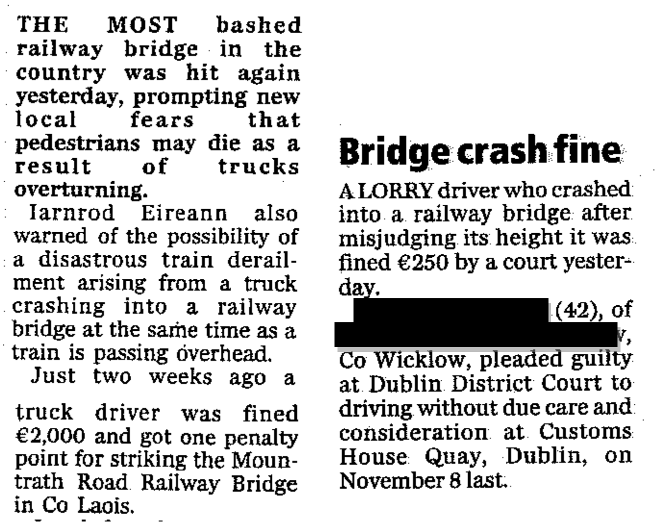
As was previously discussed in chapter 4, in February 2007 a 5+ axle ban was implemented in Dublin city centre with the intention of alleviating the increased traffic volumes. Unfortunately, the ban is not strictly enforced, as over-size vehicles and those delivering goods to businesses in the city centre are given special permits and pre-defined routes into and out of the city. Sadly, a number of headroom restricted bridges are on these routes and, therefore, the Gardaí need whatever assistance necessary from Iarnród Éireann to ensure prosecutions are made against drivers of vehicles involved in bridge strikes. It is important to note that bridge strikes have reduced in the city centre (chapter 4) and enforcement of the ban by the Gardaí will ensure this continues.

Figure 15: No entry to goods vehicles (by reference to number of axles)

The same is also true outside of Dublin city centre in that the Gardaí are provided with whatever assistance is necessary from Iarnród Éireann to ensure that persons involved in bridge strikes are prosecuted. Unfortunately hit and runs are all too common. However, section 138 of the Railway Safety Act specifically deals with bridge strikes and clearly states that, if a bridge is struck, the individual responsible is required to notify the bridge owner. The section also states that, provided the bridge has the required signage a person who hits the bridge is guilty of an offence and is liable to a fine and/or imprisonment.

To date there have been very few prosecutions (figure 16) and, in this, regard Iarnród Éireann need to improve their incident management and reporting to ensure the Gardaí are provided with all the necessary evidence to bring cases forward.

IÉ16	**Improve bridge strike data gathering through training.** IÉ should consider providing training to Permanent Way Inspectors and station staff to ensure that those who arrive first on the scene of a bridge strike know what details are required by the Gardaí to ensure they have the necessary evidence to prosecute negligent drivers.
Priority	Medium
Timescale	6 Months
Cost	Minimal (if undertaken in-house)



THE MOST bashed railway bridge in the country was hit again yesterday, prompting new local fears that pedestrians may die as a result of trucks overturning.

Iarnrod Eireann also warned of the possibility of a disastrous train derailment arising from a truck crashing into a railway bridge at the same time as a train is passing overhead.

Just two weeks ago a truck driver was fined €2,000 and got one penalty point for striking the Mountrath Road Railway Bridge in Co Laois.

Bridge crash fine

A LORRY driver who crashed into a railway bridge after misjudging its height it was fined €250 by a court yesterday.

[redacted] (42), of [redacted], Co Wicklow, pleaded guilty at Dublin District Court to driving without due care and consideration at Customs House Quay, Dublin, on November 8 last.

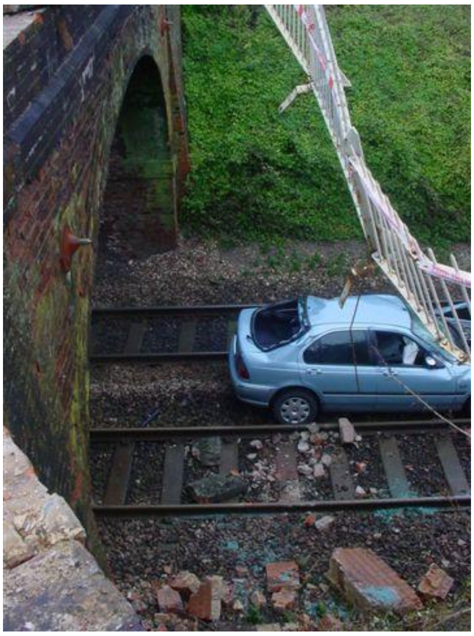
(Courtesy Irish Independent Newspapers)

Figure 16: Driver prosecutions following bridge strikes

7.2.9 Specific Measures at over-bridges

Clearly, many of the above measures can be implemented on the approach to an over-bridge, such as introducing traffic calming measures. Measures such as rumble strips, anti skid surfacing and warning signage at and on the approach to an over-bridge will generally cause traffic to slow down and reduce the likely impact between a road vehicle and the bridge parapet. Similarly reduced speed restrictions will cause many drivers to slow down, reducing the potential of a vehicle loosing control and crashing into a bridge parapet.

The installation of safety barriers as shown at Rathmore, (plate 11, chapter 4) can reduce the likelihood of damaged parapet debris or a vehicle from falling onto the railway lines below (plate 32).



(Courtesy Network Rail)

Plate 32: Over-bridge strike and debris on the line

With new bridges, there is less of a risk of vehicles crashing through bridges and falling onto the rails below due to the fact that bridge parapets must be designed to specific European and national standards. These include;

- CEN EN 1317 – Road restraint systems
- NRA Design Manual for Roads & Bridges - TD 19/04 Safety Barriers
- NRA Design Manual for Roads & Bridges - BD 52/07 The design of highway Bridge parapets.
- BS 6779 - Highway parapets for bridges and other structures. Specification for vehicle containment parapets of metal construction

These standards stipulate that specific levels of containment must be provided for road bridges over railways. In this regard, BD 52/07 states that for a bridge carrying any road over a railway the normal containment requirement is H4a. This level of containment is explained in EN 1317 and is defined as very high containment capable of withstanding an impact from a rigid goods vehicle travelling at 65km/h at an impact angle of 20^o.

All new infrastructure, including over-bridges must be approved by the RSC prior to construction. In this regard the level of containment provided over the bridge and on the approach to it is checked for adequacy.

7.3 Human Factors

In ergonomics people are often considered to be lazy, difficult and stupid. If we treat people as stupid, after a time they will often start to behave this way, i.e., they live up to the expectations that are placed on them. Professional drivers in the main do not hit bridges, however, most drivers rely on their spatial awareness every day as they negotiate traffic, undertake parking manoeuvres etc. The same is true for drivers of high vehicles. As was reported in chapter 4 (section 4.2), many fleet managers stated that 'drivers should know if they are going to fit'. This then relates to the concept of spatial awareness and visual perception.

Yellow and black are colours used on height restricted bridges and on arch bridges and these colours would be associated with danger, such as with warnings on products. Unfortunately, as the statistics presented in chapter 4 show, these measures will not prevent bridges being hit by over-sized vehicles. Being spatially aware is totally open to individuals and no two people will react in the same way. However, in terms of bridge strikes, they should be preventable as suggesting they are accidents would suggest there is certain probability that a bridge will be hit. One simple method that could be trailed would be to improve the visibility of the structure by installing lighting and by removing distractions such as advertising hoardings (plate 33).

Plate 33: Advertising signage at a height restricted city centre bridge

IÉ17	**Remove advertising hoardings from bridges.** IÉ should consider removing advertising hoarding at all headroom restricted underline bridges and at vulnerable over-bridges
Priority	Medium
Timescale	12-24Months
Cost	Low (excluding loss of revenue from advertisers)

This could be taken further as was adopted by the Dutch town of Drachten, where they removed all street signage and traffic lights as an experiment. The resultant accident figures dropped significantly as drivers became more cautious (McDonald, 2008).

Unfortunately in the context of under and over-bridges the writer is of the opinion that this idea would not work, since the bridges are usually away from traffic lights and junctions and height signage is legally required to be displayed.

Clearly, slowing traffic down reduces the severity of a bridge strike and installing some of traffic management (see also 7.2.2) such as flexible bollards in the centre of the road may reduce traffic speeds. The logic here is that most drivers tend to slow down when negotiating road works and traffic cones. The presence of obstacles such as flexible bollards located along a centreline might prompt a driver to pay attention to his/her width and as a consequence should slow down.

Introducing road markings specific to railway bridges might provide a visual and tactile reminder of the danger ahead, be that a low clearance bridge or a vulnerable over-bridge (figure 17). On the approach to a railway bridge, 3 consecutive red chevrons could be painted followed by the words ‘Low Bridge Ahead’ or ‘Slow Dangerous Bridge Ahead’ for an over-bridge. The chevrons could effectively be rumble strips similar to the texture felt when one drives over the central median line on a motorway or major road. Alternatively for an under-bridge, 3 consecutive yellow chevrons could be painted followed by the advance warning diamond for a low bridge.

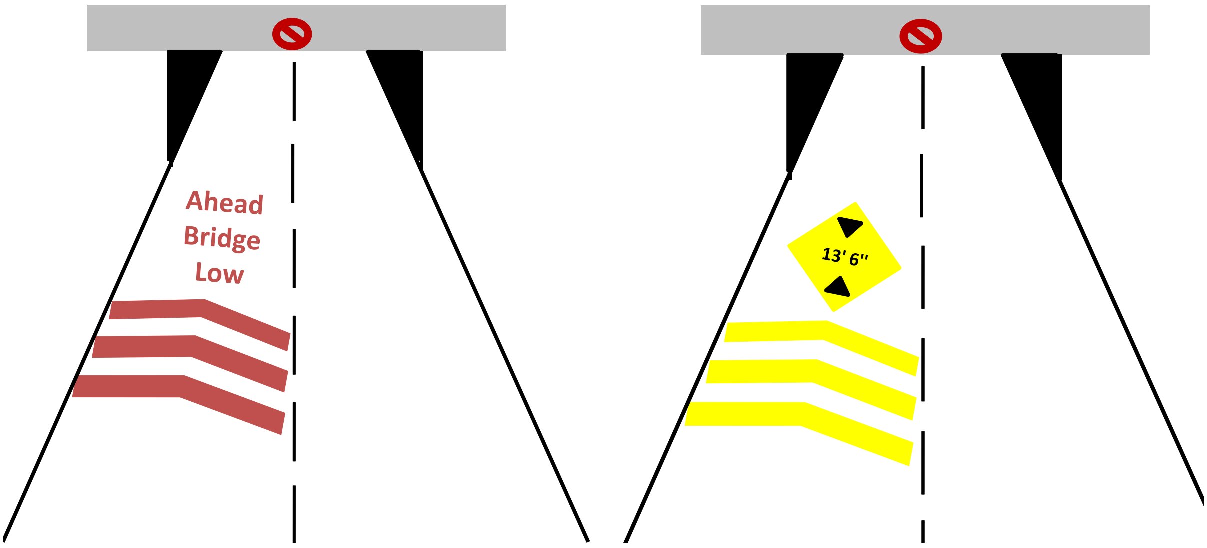


Figure 17: Possible road markings on the approaches to railway under-bridges

Specifically at arch under-bridges, roads could be painted to guide high vehicles into the centre of the road ensuring they align themselves with the goalposts (plate 34). In human terms, scare tactics often work and signage could be placed on the approach to a bridge saying this bridge has been hit *x* no of times in 2007 for example, similar to the number of road deaths signs that many county’s erect at their boarders.

(Courtesy Network Rail)

Plate 34: Road Markings at arch under-bridges, Harlaxton Road, Grantham

Obviously, further research could be undertaken in the field of human factors to try and understand driver behaviour at such interfaces with a view to identifying possible mitigation measures.

8 Conclusions

The statistical analysis undertaken as part of this research suggests that bridge strikes in Ireland are rising. While it is recognised that there was a significant decrease in under-bridge strikes in 2007, the opposite is true for over-bridge strikes. It is fortunate that there has not been a significant accident since 1999. However, this study has highlighted the potential a bridge strike could have. It is possibly because there has not been such an accident, that the risk is not taken seriously enough. If, following the bridge strike in 1999, a train had hit the vehicle that fouled the line, and there were multiple fatalities, it is likely there would be a national programme in place ensuring no such reoccurrence would occur. Education of all parties concerned is vital but what is more important is complete buy-in from all concerned and a joint road and rail strategy developed.

If we consider the images, in chapter 4.3, of the incident in Longford in 1974, where the track's horizontal alignment was distorted due to a road vehicle striking the over-bridge. If the railway undertaking demonstrated an indifference to track maintenance which had similar results, then he would be scorned. The media would, and dutifully, high-light the significant malpractice and incompetence of the company concerned. The question then is; why the social and political indifference to the activities of road users?

Taking it a bridge too far...

A TRUCK got into a tight scrape when it went a bridge too far yesterday.

The driver tried to zip under the Ballinderry railway bridge in Mullingar, Co Westmeath but there was one big problem — the truck.

It was too large for the bridge and got wedged for two hours. Traffic hold-ups ensued but nobody was hurt and there was little damage.

[redacted] from the Dundalk road haulage company [redacted] told *The Star*: "The driver was fine but it did take two hours to sort out. We ended up having to let the air out of the tyres and that did the trick."

(Courtesy the Star News group)

Figure 18: Bridge Strike press article

The way in which articles such as the one above (figure 18) are written tend to make the incident more light-hearted than it actually is. Having read this, many feel sorry for the driver of the vehicle. While sympathy is reasonable, in that no one wishes any harm to come to a road vehicle driver, the focus should be placed on the risk posed by the driver's actions. The greater risk is to the railway as they can carry in excess of 1800 passengers on some trains. The fear of a derailment following such an incident is the real risk and it should be this that the media drive home to the reader.

Similarly at bridges over the railway, drivers should have no excuse for not slowing sufficiently to safely negotiate the road geometry that exists. Clearly, roads authorities have a role to play in this regard, by ensuring the road is fit for purpose and the hazard suitable signed.

8.1 Findings & Recommendations

Iarnród Éireann has been and continues to be proactive in their approach to eliminating / reducing the risk to the railway at these third party interfaces. Many of the initiatives they employ would appear to be 'good' if not 'best practice'. However, this research has identified a number of areas where improvements could be made, in terms of bridge signage, training and incident reporting. However, there are many other stakeholders with varying degrees of responsibility and IÉ, in conjunction with the RSC, need to work with these parties to improve knowledge and ensure that if something can be done, it is done.

Throughout the text the writer has identified areas where improvements can be made and developed a number of recommendations. If some of these recommendations were implemented, the writer is confident that a reduction in the number of bridge strikes would follow. Below is a summary of these recommendations and for ease of reference they are provided in tables applicable to the assigned owner, those being, IÉ-Iarnród Éireann, the IRHA- Irish Road Haulage Association, the RSA-Road Safety Authority and the RSC-Railway Safety Commission.

Number	**Area**	**Priority**
RSA1	Revise the Rules of the Road.	Low
RSA2	Mandate drivers of goods and similar vehicles to know vehicle / load height	High

Number	**Area**	**Priority**
IÉ1	Classroom Based Training.	Medium
IÉ2	Increase numbers of competent bridge inspection staff	Medium
IÉ3	Liaise with Tipperary County Council re: OBC196 Lisduff	High
IÉ4	Liaise with Sligo County Council re: OBS582 Drumfin	Medium

Number	Area	Priority
IE5	IÉ should promote their Bridge Map and town maps	Medium
IE6	IÉ should consider discussing all Ireland mapping with the AA.	Low
IÉ7	Have advance warning signage installed at all vulnerable under-bridges.	High
IE8	Liaise with local authorities and NRA regarding signage at OB's	Medium
IÉ9	Undertake periodic review of Bridge Register and site assessment of headroom restricted bridges.	Low
IÉ10	Produce Guidance Note for Bridge Inspectors.	Medium
IÉ11	Contact cartographers regarding mapping of headroom restricted bridges	Medium
IE12	Install bridge signage where necessary	High
IÉ13	Install bridge signage trackside	Low
IE14	Educate all appropriate agencies of railway risks associated with railway bridges	Medium
IE 15	IÉ to consider installing advance warning structures.	Medium
IE16	Improve bridge strike data gathering through training.	Medium
IE17	Remove advertising hoardings from bridges.	Medium

Number	Area	Priority
IRHA1	Promote use of height measuring devices and in cab displays	High

Number	Area	Priority
RSC1	Communicating with Garda Síochána (Police Service).	Medium
RSC2	Facilitate roundtable talks between stakeholders regarding the Portlaoise under-bridges.	High
RSC3	RRSWG to produce good practice guides.	Medium
RSC4	RSC/RRSWG should contact Satellite Navigation systems, companies.	Medium
RSC5	Produce annual bridge strike statistics and circulate to road haulage journals/magazines and to the IRHA.	Medium
RSC6	Promote use of height measuring devices and in cab displays	High
RSC7	Advise Ordnance Survey of mapping errors as they are identified	Medium

Table 20: Recommendations summary

Clearly, there is much to digest and reflect upon. It is hoped that all the recommendations will be accepted with a view to implementing them as time and budgets permit. IÉ have reviewed the report and in principal have accepted the recommendations and are keen to discuss further with all the relevant stakeholders.

8.1.1 What was done well

The statistical analysis of the bridge strike register proved particularly interesting. However, to undertake the analysis required significant cross referencing to other databases as there were many instances when data was incomplete. As part of the research it was necessary to visit bridge sites, which was a valuable exercise in itself as being the railway regulator it is important to be aware of problem areas.

The writer was particularly pleased with the enthusiasm shown by the ERA and the promotion the member state questionnaire received. The opportunity to make a presentation to the National Safety Authorities was especially rewarding.

Similarly the response rate to the questionnaire far exceeded the writer's expectations, receiving 16 out of 22 responses. This was also true of the road haulier survey, as it had been anticipated that willing participants would be few. Many of those surveyed stated their appreciation for being contacted as they felt there was often a lack of consultation with road hauliers regarding such matters.

8.1.2 What could have been improved

There were a number of items that with the benefit of hindsight could have been improved upon. These were;

1. The first is in relation to the questionnaire that was sent to the various EU member states. While the response rate was reasonably high, some of the responses were a little vague and hence difficult to draw any conclusions from. Perhaps trailing the questionnaire in advance of the formal request would have been a worthwhile exercise and could have improved the quality of some returns.
2. Ideally the telephone interviews that were undertaken with road haulage companies would have been conducted with a greater population and perhaps expanded to hauliers in other countries. This would have given a more detailed picture of the views of road haulage firms.
3. The writer would have liked to undertake more site inspections at some of the more vulnerable bridges identified through the statistical analysis. Unfortunately with other work requirements, this was not possible.
4. The writer should have contacted Northern Ireland Railways to discuss the status of bridge strikes north of the boarder, to see if they have similar issues. Similarly it would have been interesting to understand what measures they use to protect their assets in particular their bridges.

8.2 Next Steps

It would be prudent to arrange a workshop with all relevant stakeholders present to discuss the recommendations and agree on the priorities, timescales for delivery, etc. It is the writer's intension to suggest this takes place at the next RRSWG meeting, scheduled for February 2009.

At the request of the ERA the writer hopes to make a further presentation at a future plenary meeting of the NSAs outlining the findings of this research. This will hopefully take place in early 2009. At the request of many of the Rail Regulators that contributed to this research, a copy of this report will be mailed to all participants. The writer also intends to ensure that the report is available on the RSC's website.

The writer having contacted and met with Northern Ireland Railways representatives, proposes to determine review any bridge strike data NIR have to determine if there is any correlation between our respective statistics.

The writer intends to continue to study the ongoing statistics and monitor trends with a view to annually producing a league table of 'bad actor' bridges and distributing this to the various stakeholders. Further analysis will be undertaken to ascertain how many bridge strikes are by over sized vehicles, i.e., not road hauliers, subject to improved data collection by Iarnród Éireann.

Clearly, the recommendations made throughout this report should be tracked for implementation and it is suggested that this be undertaken by a different RSC inspector thereby providing an unbiased approach.

9 References

9.1 Documents

Railway Safety Commission. (2008). RSC 2007 Annual Report. Dublin.

Republic of Ireland. Department of Finance. (2007) National Development Plan 2007-2013 *"Transforming Ireland – A better quality of life for all"*. Dublin: Stationery Office

Strauss, AL & Corbin, JM, (1997). *"Basics of Quantitative Research – Techniques and Procedures for Developing Grounded Theory"* 2nd Ed. Sage Publications, London

Republic of Ireland. Department of the Environment. (1996) *"Traffic Signs Manual"* Dublin: Stationery Office

Iarnród Éireann. (2007) *"Annual Report and financial Statements 2006"* Iarnród Éireann, Dublin.

Road Safety Authority. (2007). "*Rules of the road"*. Dublin: Stationery Office

Arthur D Little (2006), *"A review of railway Safety and of the Role & Function of the Railway Safety Commission"*. Arthur D Little, Cambridge, UK.

European Communities, Energy & Transport DG. (2007) *"Road Safety: How safe is your country doing?".* European Commission, DG Tren, Brussels.

Dept of Transport & Energy (1974), *"Report on Passenger Train Derailment near Longford on 27-2-74"*, Railway Inspecting Officer, DoT, Dublin.

Coras Iompair Eireann (1974), *"Joint Enquiry into the Derailment of the 07.45 passenger train, Slogo/Connolly Stn at 76 miles 1166 yards in Dromad/Longford section Sligo/Mullingar branch on 27th February 1974"*, CIE, Dublin

Transport Accident Investigation Commission. (2005) *"Railway Occurrence Report No. 04-125, Collision between an over-dimensioned road load and rail over road bridge No. 98"* TAIC, Wellington, New Zealand.

Mac Aongusa, B. (2005), *"Broken Rails – Crashes and Sabotage on Irish Railways",* Currach Press, Dublin

Health & Safety Executive. (2002). "*The track obstruction by a road vehicle and subsequent train collisions at Great Heck 28 February 2001"* HSE, Norwich, UK.

Railway Safety & Standards Board. (2008). Road-rail interface safety performance report. RSSB London.

Martin. A and Mitchell. J (2004) *"Measures to reduce the frequency of over-height vehicles striking bridges"*. Transport Research Laboratory, Berkshire, UK

Network Rail (2006), *"Guidance Note: Managing Bridge Strike Incidents – Good Practice Guide for Bridge Strike Nominees"* Issue 3. Network Rail. London.

Network Rail (2006), *"Guidance Note: Management of the Risk of Bridge Strikes"* Issue 1. Network Rail. London

Network Rail (2004), *"Prevention of Bridge Strikes – A good practice guide for professional drivers"* Issue 1. Network Rail. London

County Surveyors Society (2007), *"Prevention of Strikes on Bridge over highways – A protocol for highway managers and bridge owners"* Issue 1. County Surveyors Society. Wiltshire, UK.

McDonald. F (2008). "Transport chiefs Dublin Plan: confuse drivers to cut crashes". The Irish Times, 9th June 2008. Dublin.

National Roads Authority (2007) *"BD 52/07 The Design of Road bridge parapets."* NRA. Dublin.

European Committee for Standardisation (1998), *"CEN EN 1317 – Road restraint systems"* European Committee for Standardisation. Brussels.

European Parliament. (2003) *"EU Directive 2003/59/EC Compulsory Initial Qualification and Periodic Training for Professional Drivers of Road Vehicles for the Carriage of Goods or Passengers "*. European Parliament, Brussels.

9.2 Web Site Links

1. http://www.garda.ie/statistics98/rtastats_longterm.html - for road traffic deaths (consulted 10th June 08)

2. http://www.irha.ie/ - for details regarding the road haulage association (Consulted 21st May 08)

3. http://www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/casualtiesmr/rcgbmainresults2007 – for road death figures for Great Britain (Consulted 1st September 08)

4. http://www.statistics.gov.uk/CCI/nugget.asp?ID=6 - for confirmation of Gb population in 2007(Consulted 1st September 08)

5. http://www.garda.ie/trfinfo.html - for details regarding the traffic bureau (Consulted 11th June 08)

6. http://www.dublinport.ie/news/singlenews/article/trade-throughput-in-dublin-port-reaches-record-levels-in-2007//2/ - for details of Dublin Port Traffic (Consulted 27th June 08)

7. http://www.networkrail.co.uk/aspx/3563.aspx - for details of bridge strike publications (Last consulted 8th July 2008)

8. http://www.rssb.co.uk/pdf/reports/Bridge%20Strikes%20-%20Special%20Topic%20Report.pdf – for copy of Special Topics Report (Consulted 6th October 2007)

9. http://www.hse.gov.uk/humanfactors/index.htm - Background reading (Consulted 2nd May 08)

10. http://www.transporter-engineering.com/ - for details of the Height Measuring Staff and in-Cab Overall Height Indicator (Consulted 26th July 2008)

11. http://www.trl.co.uk/content/overview.asp?pid=94 – for details of company background relating to unpublished report by A. Martin & J. Mitchell (Consulted 24th June 2008)

12. http://www.yorkshirepost.co.uk/news/Crisp-company-pulls-bus-crash.3927499.jp - for details of crisp advert showing bridge strike (Consulted 20th May 2008)

13 http://www.irishpride.ie/news/article06.asp - for details of bread advert showing bridge strike (Consulted 20th May 2008)

14. http://www.snooper.co.uk/snooper-s2000-truckmate.htm for details of Satellite navigation system specific for truckers (Consulted 11th August 2008)

9.3 Interviews

- An interview was conducted with Mr. Keith Ross, National Bridge Strike Champion, of Network Rail on the 13th March 2008, at 40 Melton Street, London, regarding bridge strikes in GB.
- Two interviews were held with Ms. Fand Cooney, Structural Engineer – Infrastructure, of Iarnród Éireann, at Inchicore Works, Dublin on the 14th April and 11th August 2008, where specific bridge strike cases, road haulage survey and vulnerable interfaces were discussed.
- Telephone interviews were conducted with the following road hauliers

Mr. Barry Lord	Lord International Ltd.
Mr. John Behan	John Behan Transport
Mr. Ciaran Dowling	Globetrotter Trucking Ireland
Mr. John Breen	Breen Transport Ltd.
Mr. Denis Molloy	Denis Molloy Sand & Gravel
Mr. Michael McManamon	McManamon International Haulage
Mr. John Farrelly	John Farrelly Haulage Ltd.
Mr. Gerry McGinley	McGinley Haulage
Mr. Eugene Drennan	Spa Transport Ltd.
Mr. George Mills	Mills International Transport

10 Bibliography

British Standard (1998), "*BS 6779 - Highway parapets for bridges and other structures. Specification for vehicle containment parapets of metal construction"* BSi, London.

Dul, D. & Weerdmeester, B (2003), Ergonomics for Beginners – A quick reference guide, 2nd Ed, Taylor & Francis, London.

Forster, M. (2007), *"Berkshire bottleneck"*, Rail, Issue 563 (April 11 – April 24 2007), Emap Publishing, Kent, UK, pp 54

Forster, M. (2007), *"Menace of the Megatrucks"*, Rail, Issue 579 (November 21 – December 4 2007), Emap Publishing, Kent, UK, pp 32-37

Iarnród Éireann (2005), "*Infrastructure-Structures Standard, I-STR-6510 - Structural Inspections"* Issue 1.0. Iarnród Éireann. Dublin.

MSc in Railway Systems Engineering and Integration Module LMR05 Lecture Notes

National Roads Authority (2007) *"TD 19/07 Safety Barriers."* NRA. Dublin.

Network Rail (2006), *"Prevention of Bridge Strikes – A good practice guide for operational staff"* Issue 2. Network Rail. London.

Network Rail (2004), *"Prevention of Bridge Strikes – A good practice guide for transport managers"* Issue 1. Network Rail. London.

Network Rail (2004), *"Prevention of Bridge Strikes – A good practice guide for transport managers"* Issue 1. Network Rail. London.

Network Rail (2006), *"Prevention of Bridge Strikes – A good practice guide for professional drivers of passenger vehicles"* Issue 2. Network Rail. London.

Sweeney, J (ed.). (2008), *"Newsletter of the Irish Road haulage Association"*, Fleet Transport, February 2008, JJDS Publications Ltd., Mayo, Ireland, pp 27

Wolmer, C. (2008), *"Bridge Nuisance could become tragedy"*, Rail, Issue 582 (January 2-January 15 2008), Emap Publishing, Kent, UK, pp 16-17

Appendix A : Road Haulier Survey

Road Haulage Telephone Interview Questions

1. Have any of your vehicles been involved in a bridge strikes?
    a. As fleet manager would your drivers tell you?
2. Do you provide any driver training?
    a. If yes what does this entail?
3. Would this training include a briefing on vehicle heights, restricted height bridges etc?
4. Do you vehicles have tracking systems fitted?
5. Do your vehicles/drivers carry IÉ’s map showing the location of all height restricted bridges?
6. Do your drivers know the height of their vehicles?
    a. If ‘yes’ how do they measure the height?
7. Are you aware of the maximum road vehicle height due to be implemented shortly?
8. It is 4.65m, do you believe this is too low, high, about right
9. What are the heights of your vehicles (HGVs)?
10. How many vehicles (HGV) are in your fleet?
11. How many drivers do you have?
12. What are their demographics, county of origin?
13. Is there a minimum age of a driver for HGV vehicles’?
14. During a HGV driver theory test are there questions on height, weight and width restricted bridges?
15. What do you believe Irish Rail should be doing with regards to these low bridges?
16. Following a bridge strike do you know what procedure should be followed?
    a. Would you report anomalously or provide contact details?
17. Following a bridge strike whose fault do you see at as being?
    a. Would you accept some responsibility?
18. Do your fleet have satellite navigations systems installed?
    a. If yes what manufacturer?
    b. If you could purchase a low bridge database that could be installed onto your satellite navigation systems would you be interested in this service?
19. Are you aware of weight and/or width restricted bridges?
20. Is there anything else you wish to add?

Appendix B : PRESENTATION TO NATIONAL SAFETY AUTHORITIES AT THE ERA

Bridge Strike Trends in Ireland

Anthony Byrne

Senior Inspector, NSA-Ireland

An Coimisiún Sábháilteachta Iarnróid

Railway Safety Commission

What is a Bridge Strike?

Type 1: A incident where a road vehicle impacts upon a road over railway bridge, (Over-bridge).

Wrought Iron Parapet

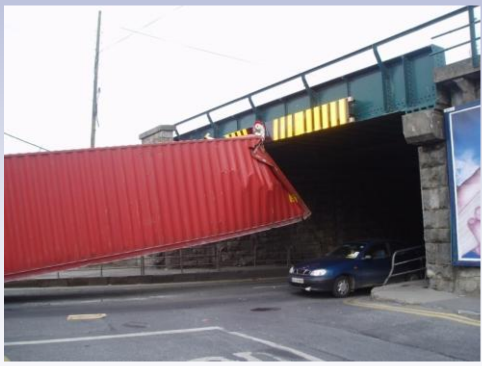
Masonry Parapet

An Coimisiún Sábháilteachta Iarnróid

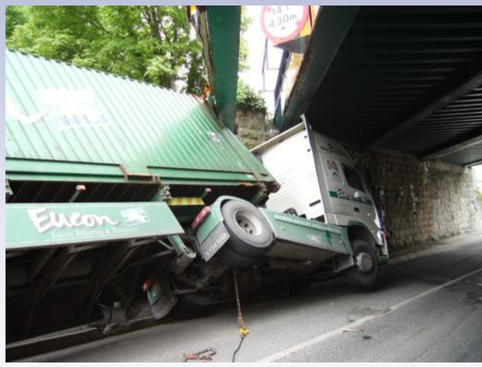
Railway Safety Commission

What is a Bridge Strike?

Type 2: A incident where a road vehicle impacts upon a road under railway bridge, (Under-bridge).



Steel beam bridge



Steel beam bridge with bash beam

An Coimisiún Sábháilteachta Iarnróid

Railway Safety Commission

Longford - 1974

An Coimisiún Sábháilteachta Iarnróid

Railway Safety Commission

Cain Bridge 1975

An Coimisiún Sábháilteachta Iarnróid Railway Safety Commission

Dublin City Centre - 2006

Wrought Iron Lattice/Truss

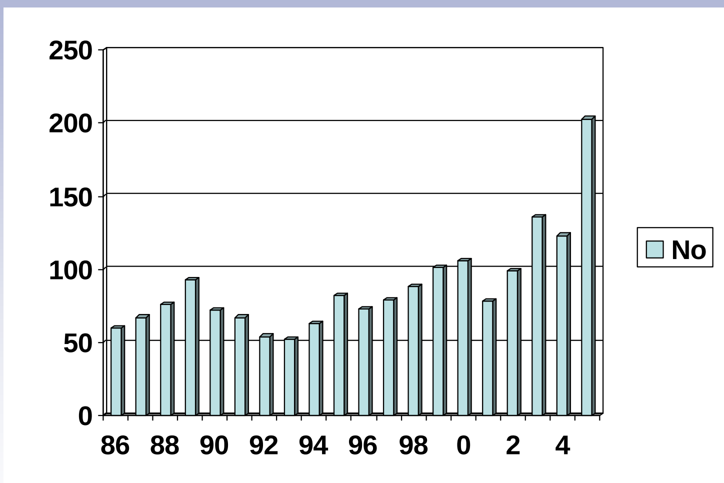
An Coimisiún Sábháilteachta Iarnróid Railway Safety Commission

Recent Statistics (Under-bridges)

2001	2002	2003	2004	2005	2006
78	99	136	123	203	200

An Coimisiún Sábháilteachta Iarnróid Railway Safety Commission

Last 20 years (Under-bridges)



An Coimisiún Sábháilteachta Iarnróid Railway Safety Commission

Statistics

- 200 per annum – 4 a week
- Strikes have doubled in 4 years
- Increasing HGV traffic levels nationwide
- Statutory road vehicle height limit now set
- Bridge Strike train delays in 2006 amounted to 5127 train minutes representing 3.5% of total train mins delays in that year

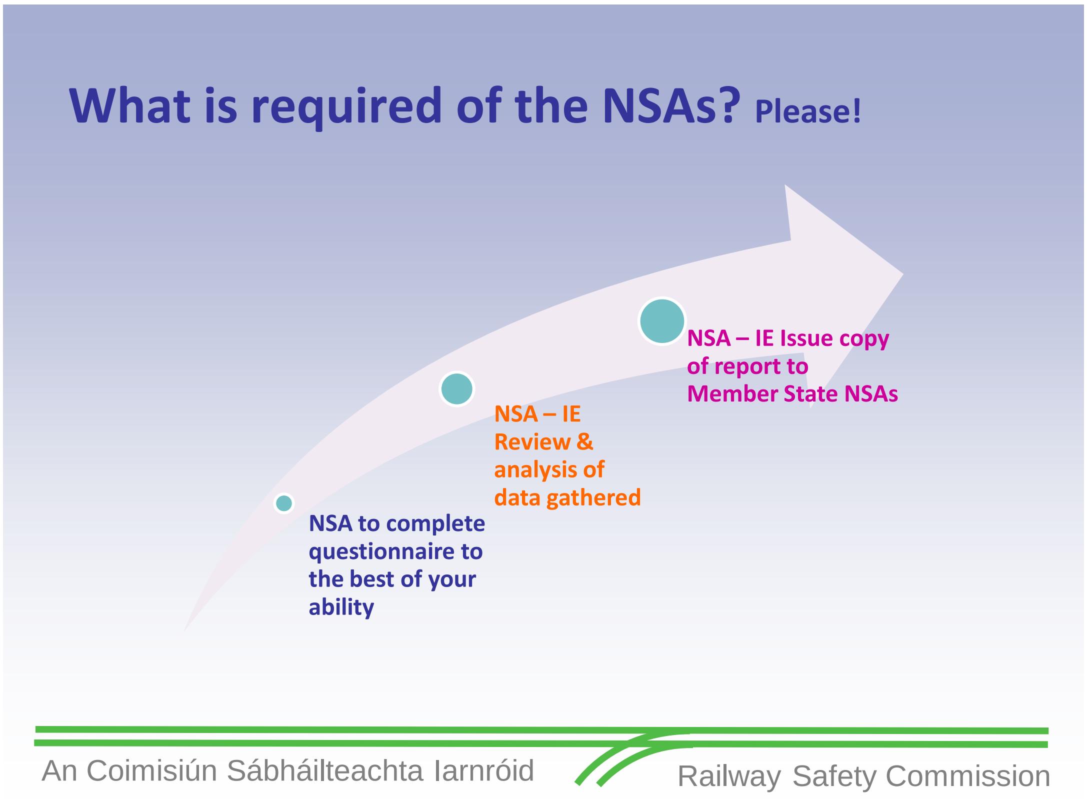
An Coimisiún Sábháilteachta Iarnróid Railway Safety Commission

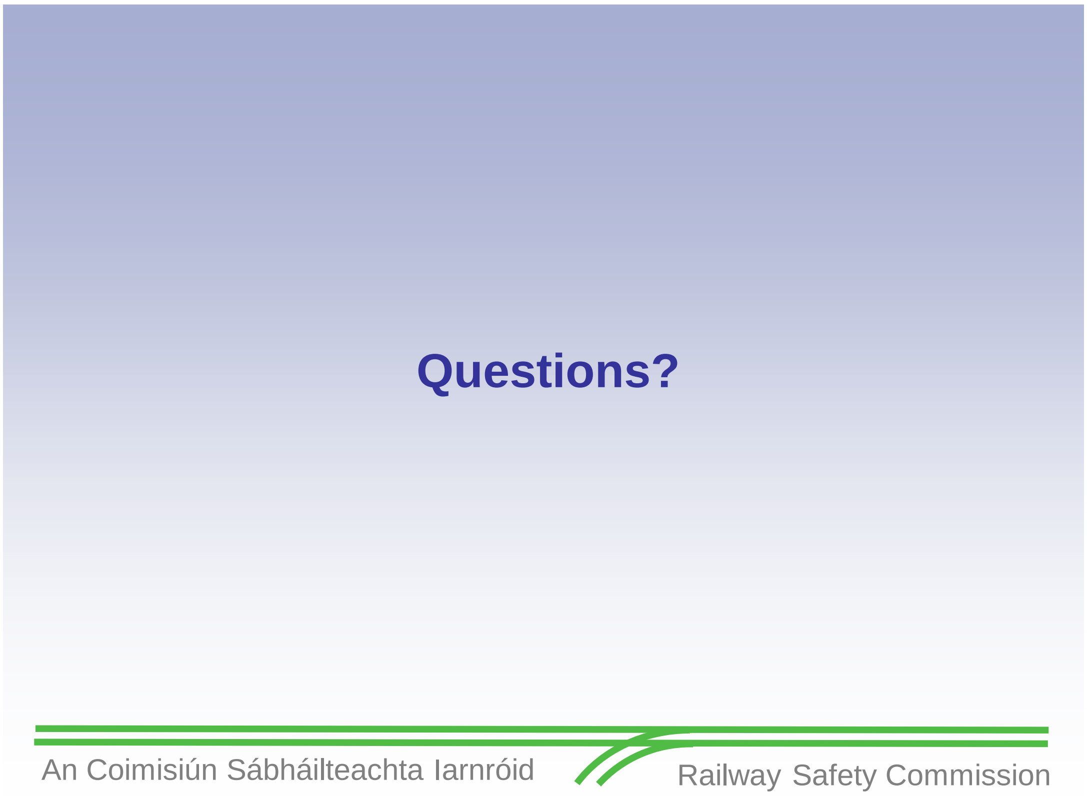
Current methods of reducing the risk

- New bridges designed for impact loading – UIC Code 777-1
- Clearances increased during design phase
- Bridges are strengthened where possible
- Bash beams are installed
- Regulatory Height signs fitted
- Infra-red beam & warnings displays
- Publicity
- Enforcement by police

Bridge Signage

An Coimisiún Sábháilteachta Iarnróid Railway Safety Commission


What is required of the NSAs? Please!
NSA to complete questionnaire to the best of your ability
NSA – IE Review & analysis of data gathered
NSA – IE Issue copy of report to Member State NSAs
An Coimisiún Sábháilteachta Iarnróid
Railway Safety Commission


Questions?
An Coimisiún Sábháilteachta Iarnróid
Railway Safety Commission

Appendix C : EU Member State Questionnaire

Bridge Strikes

This questionnaire is being used to determine the scale of such incidents, throughout the various member states and what safety measures are being taken with the purpose of promoting best practice.

Explanatory Note

Q. What is a bridge strike?

A. There are two primary classifications of bridge strike.

1. A road over railway (Over-bridge) strike, where a road vehicle strikes a bridge parapet and the vehicle, load or debris falls onto the railway below.
2. A road under railway (Under-bridge) strike, where a road vehicle impacts upon the deck or wing wall of a bridge carrying the railway.

1. Over-bridge **2. Under-bridge**

Clearly, both classes of incident impact upon the railway and this survey and subsequent study it is hoped may provide valuable information leading to the promotion of best practice.

Why am I looking for this information?

The Railway Safety Commission (the National Safety Authority in Ireland) is undertaking a study in this area in order to understand trends and to identify any best practise that exists.

In addition this research will contribute towards an MSc I am undertaking at the University of Birmingham, in the UK.

Please note that all information will be referenced and treated confidentially as necessary.

Once the study has been completed a copy of the report will be issued to all contributors and may benefit the Member State National Safety Authorities (NSA).

Completing this questionnaire

PLEASE ANSWER ALL QUESTIONS. This can be done by either highlighting in **bold** your chosen response, underlining your response or by deleting the responses that is/are not relevant or don't apply. Questions that require a numbered or written response can be answered by typing in the relevant answer area. Spreadsheets or other data forms may also be included.

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE

PLEASE RETURN COMPLETED RESPONSES BY

Friday 1st February 2008 TO:

Mr. Anthony Byrne, Railway Safety Commission, Trident House, Blackrock, Dublin, Ireland. Alternatively completed questionnaires may be emailed to :

anthonybyrne@rsc.ie

Bridge Strike Questionnaire

Please make **BOLD,** change colour, or underline your response, alteratively delete those that do not apply.

1. **LOCATION OF RESPONDENT / Member State : ________________________**

2. **Do you collect statistics on under-bridge strikes?**

   YES NO

3. **Do you collect statistics on over-bridge strikes?**

   YES NO

4. **Do you believe Bridge Strikes pose a safety risk?**

   YES NO UNDECIDED

5. **Do you believe that one class of bridge strike poses more of a risk to the railway?**

   YES NO UNDECIDED

   If Yes, which class and why?

6. **What risk mitigation measures/deterrents are used for under-bridge protection; (Enter Y for yes,' are used' to all that apply)**

No.	Measure	Y/N
1	Bash / collision protection beams	
2	Infra-red beam and variable message displays.	
3	Other automatic height detection systems	
4	Hanging bells / chains	
5	Regulatory road signage	
6	Prosecution (Fixed penalty fines and/or penalty points)	
7	Other (please list below)	

7. What risk mitigation measures/deterrents are used for over-bridge protection; (Enter Y for yes,' are used' to all that apply)

No.	Measure	Y/N
1	High containment parapets	
2	Safety barriers on approaches to an over-bridge	
3	Traffic calming, e.g. speed bumps, rumble strips	
4	Road markings	
5	Regulatory road signage inc. reduced speed limits	
6	Prosecution (Fixed penalty fines and/or penalty points)	
7	Other (please list below)	

8. How many bridge strikes have there been in the past 7 years, please provide year by year totals? (Please complete with whatever information is available)

	2007	*2006*	*2005*	*2004*	*2003*	*2002*	*2001*
Underbridge							
Overbridge							

9. Is warning signage present on the highway approach to restricted height bridges?

YES NO DON'T KNOW

10. Do road vehicles have a maximum height in your country?

YES NO DON'T KNOW

11. What is this height?

12. Is this written in legislation?

YES NO DON'T KNOW

13. Are hauliers/heavy goods vehicle drivers required to know the height of their vehicle?

YES NO DON'T KNOW

14. How many road under railway (under-bridges) do you have in your country? (Please state whether figure is exact or approximate)

15. Do you have low underbridges, i.e., with restricted overhead clearance?

YES NO DON'T KNOW

If yes how many low under-bridges do you have (most current figure)?

16. What do you classify as a low bridge, i.e., under what clearance height?

17. How are low bridges identified? Please include photos if available.

18. Do you have road maps indicating low bridges?

YES NO DON'T KNOW

19. What is the breakdown of under-bridges by type, as a percentage? (If known)

No.	Measure	Percentage (%)
1	Masonry Arch	
2	Concrete beam	
3	Steel girder/Truss	
4	Wrought Iron	
5	Other	

20. How do you determine the clearance height of an arch bridge?

21. How many road over railway (over-bridges) do you have in your country? (Please state whether figure is exact or approximate)

22. How are bridge strikes reported?

23. Do you have an emergency telephone number, for the public to call in an emergency?

YES NO DON'T KNOW

If yes, is this number displayed on the structure of vulnerable bridges?

YES NO DON'T KNOW

24. Are road vehicle drivers involved in bridge strikes prosecuted in your country?

YES NO DON'T KNOW

If yes, does a prosecution include penalty points?

YES NO DON'T KNOW

If yes, how many?

25. How many penalty points must a driver accumulate to be disqualified?

26. Do you believe that there is sufficient regulation of road hauliers to maintain safety standards?

YES NO UNDECIDED

27. Have there been any train accidents caused as a result of a bridge strike?

YES NO DON'T KNOW

28. Have there been any fatalities as a result of a bridge strike?

YES NO DON'T KNOW

If yes, can you provide any details, i.e., year, number of fatalities, circumstances, etc.?

29. How many route kilometres are there on your railway network?

30. How many train kilometres (Passenger & Freight) are made each year (most recent figure available)?

Please record any other comments that you have.

Thank you most sincerely for your time