Work Package 1
Barrier Performance from Real Life Accidents

Task 1.2
Acquisition of detailed data on real life impacts

by G L Williams, TRL Ltd.

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Proposal Number: GRD1-2002-70021 - ROBUST

ROBUST Deliverable Number 1.2.1

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ROBUST, TASK 1.2:
Acquisition of detailed data on real life impacts

Version: 2

by Mr G L Williams, TRL Limited

Prepared for: Proposal Number: GRD1-2002-70021 - ROBUST
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Executive Summary

The European Standard EN 1317 identifies testing methodologies, performance classes and impact test acceptance criteria for vehicle (or road) restraint systems.

The aim of the ROBUST project is to evaluate the relevance of EN 1317 test methods and test acceptance criteria, to real life road safety. The project will also assess the repeatability of the EN 1317 testing regime by examining the effect of different testing methods and vehicle makes and models on the results of full-scale impact tests. In addition, the use of computational mechanics as a complement to full-scale testing will be assessed.

This document reports on the second Task within the first Work Package of the ROBUST project, i.e. to acquire detailed data on real life impacts. This involved the collection of statistical data relating to single vehicle accidents with vehicle restraint systems, with the aim of identifying an accident which could be recreated through use of full-scale testing and computer simulation within other of the project’s Work Packages.

The report outlines the methodology used to obtain data relating to single vehicle accidents impacting vehicle restraint systems, on all road types.

After an extensive analysis of the accidents received, it was decided by the Consortium that none of the accidents were suitable for this Task. This was due to the information relating to the accident being restricted, unavailable and/or incomplete.

As a result, it was decided by the Consortium to substitute the accident reconstruction activity with a study into the improvements which could be made to the repeatability of testing to EN1317 through the implementation of the ROBUST results.

In addition the simulation houses also performed simulations using the final version of their vehicle model against a solid rigid wall.

Both activities could then be compared to similar exercises performed at the start of the ROBUST project, and the improvements seen through a comparison with these initial results.

Both of these activities are reported separately under the relevant work packages (WP4 for the full-scale testing, and WP5 for the computational mechanics).
1 Introduction

The definition of terms and acronyms used within this report can be found in Sections 6 and 7, and are defined within relevant Sections of the report.

1.1 Background to the European Standard EN 1317

In order to improve and maintain highway safety, the design of safer roads requires the installation, on certain sections of road and at particular locations, of devices to restrain vehicles and pedestrians from entering dangerous zones or areas. The vehicle restraint systems (VRS) designated in EN 1317 are designed to specified performance levels, to contain and redirect errant vehicles safely for the benefit of the occupants and other road users. Several levels of performance are given for the three main criteria relating to the restraint of a road vehicle:

— the containment level, i.e. the weight, speed and angle of an impacting vehicle for which the VRS can restrain and redirect a vehicle;
— the impact severity levels, i.e. the extent of deceleration on the vehicle during the impact;
— the deformation as expressed by the working width, i.e. the distance over which the VRS deflects during an impact.

The different performance levels of VRS will enable National and Local Authorities to specify the performance class of a safety barrier to be installed. Factors to be taken into consideration include the class or type of road, its location, geometrical layout, the existence of a vulnerable structure, potentially hazardous area or object adjacent to the road. The description of a safety barrier system conforming to this Standard incorporates the relevant classes and performance levels of the product.

Quality of manufacture, installation and durability all contribute to the fulfilment of important safety criteria that have to be considered in the application of these systems.

The objective of the Standard is to provide a procedure whereby the National standards and regulations, which existed in member countries, can be harmonized to form a common European Standard.

The Standard itself identifies impact test tolerances and vehicle behaviour criteria that need to be met to gain approval. The design specification, for vehicle restraint systems entered in the test report, identifies the on-road site conditions under which the vehicle restraint system should be installed.

EN 1317 also provides a common basis for vehicle impact test data collection and European studies and research. These data and reports can then be analysed with a view to improving future specifications and reviewing the measurement of impact severity. The ROBUST project is one of the first programmes to attempt this.

The range of possible vehicular impacts into an in-service vehicle restraint system is extremely large in terms of speed, approach angle, vehicle type, vehicle performance, and other vehicle and road conditions. Consequently the actual on-road impacts which occur may vary considerably from the specific standard test conditions required by
EN 1317. An objective of the ROBUST project is to examine the in-service performance data of VRS with the view to updating and developing the Standard to incorporate the findings from current accident statistics.

1.2 The ROBUST Project

A Consortium of participants will complete the work contained within the ROBUST project, and these are outlined below. The Consortium consists of a team which blends together test laboratories, design and manufacturing companies, universities and research centres.

The Consortium has a high number of competencies, including groups experienced in European Standards, full-scale testing, the use and development of advanced simulation tools, crash phenomena, and real life accidents. The Members of the Consortium are described below:

<table>
<thead>
<tr>
<th>Organisation Name</th>
<th>Country</th>
<th>Main Area of Activity</th>
<th>Role in project</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLITECNICO DI MILANO</td>
<td>Italy</td>
<td>University, Department of aerospace</td>
<td>Main Contractor, project co-ordinator, Data collection, Developer of Numerical and Theoretical Models. It will select and buy concrete barriers for tests.</td>
</tr>
<tr>
<td>TRL Limited</td>
<td>UK</td>
<td>Transport Research, Research Centre, Test House</td>
<td>Collection of accident and test data, full-scale crash testing, other test work, numerical simulation, analytical input.</td>
</tr>
<tr>
<td>LIER</td>
<td>France</td>
<td>Test House</td>
<td>Collection of test data, full-scale crash testing, other test work.</td>
</tr>
<tr>
<td>ERF</td>
<td>Belgium</td>
<td>Service organisation, non profit, representing European road sector</td>
<td>Collection of existing data, Dissemination activity.</td>
</tr>
<tr>
<td>CIDAUT</td>
<td>Spain</td>
<td>Motorway manager, Research centre in the vehicle and road field</td>
<td>Collection of test data, full-scale crash testing, computational mechanics.</td>
</tr>
<tr>
<td>AUTOSTRADE</td>
<td>Italy</td>
<td>Motorway manager, Test House</td>
<td>Collection of test data, full-scale crash testing, other test work.</td>
</tr>
<tr>
<td>NPRA</td>
<td>Norway</td>
<td>National infrastructures Ministry</td>
<td>Computational mechanics, provide existing data.</td>
</tr>
<tr>
<td>Volkmann &amp; Rossbach</td>
<td>Germany</td>
<td>Barrier manufacturers</td>
<td>Provide steel barriers for tests and existing data.</td>
</tr>
</tbody>
</table>

The aim of the ROBUST project is to evaluate the relevance of EN 1317 test methods and test acceptance criteria, to real life road safety. The project will also assess the repeatability of the EN 1317 testing regime by examining the effect of different testing methods and vehicle makes and models on the results of full-scale impact tests. In addition, the use of computational mechanics as a complement to full-scale testing will be assessed.

The results of the ROBUST project will be formulated into documents for submission to the CEN Committee structure (see Section 6). These documents will contain recommendations for the updating of EN 1317 based on the results of the Work Packages contained within the ROBUST project. The recommendations will be made to Task Group 1 (TG1) for review and implementation. They will then formally submit their proposals to Working Group 1 (WG1). Again, after review,
amendments/inclusions to the Standard will be submitted to Technical Committee 226 (TC226) for inclusion in subsequent revisions of the Standard.

Specifically, the aims of the ROBUST project are to:
1. Consider the relevance of EN 1317 in respect of real life safety and provide data to assist with updating EN 1317;
2. Develop a deeper knowledge and understanding for acceptance that will address some of the questions which are still open to interpretation in EN 1317;
3. Definition of improved methodologies for measurements and data acquisition in impact testing;
4. Improvement of the reliability and efficiency of computational mechanics applications for impacts against vehicle restraint systems;
5. Development of a sound and generally acceptable scientific basis for the standard severity criterion for vehicle restraint systems.

In order to address these aims, the ROBUST project is divided into eight separate areas of work known as Work Packages, (WP), each headed by a 'Work Package Leader' (WPL):

<table>
<thead>
<tr>
<th>WP Number</th>
<th>WP Title</th>
<th>Aim</th>
<th>WPL</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Barrier performance from real life accidents</td>
<td>To focus the correlation among roadside barrier standards and roadside safety; Improved understanding of severity indices and their adequacy as barrier performance indicators.</td>
<td>TRL</td>
</tr>
<tr>
<td>2</td>
<td>Collection of test data from EU laboratories</td>
<td>To evaluate the homogeneity and repeatability of test results from different laboratories; To identify possible difficulties or weaknesses in the test methods of EN 1317.</td>
<td>AUTO</td>
</tr>
<tr>
<td>3</td>
<td>Instrumentation and measurement</td>
<td>To harmonise the measurement practice in the European laboratories and remove possible discrepancies from different transducer and test set-ups.</td>
<td>POMI</td>
</tr>
<tr>
<td>4</td>
<td>Full scale tests</td>
<td>To provide an accurate and exhaustive benchmark for computational mechanics evaluation and validation; To evaluate the effect of different transducer installations, the effect of different vehicle makes and vehicle loading; To correlate test results and to assess the prescribed tolerances of impact parameters; To provide data for the severity indexes evaluation.</td>
<td>LIER</td>
</tr>
<tr>
<td>5</td>
<td>Computational mechanics</td>
<td>To enhance the capability of reconstruction of real life accidents: criteria and procedures for the validation of computational mechanics results will be validated, comparing test results.</td>
<td>NPRA</td>
</tr>
<tr>
<td>6</td>
<td>Comparison and selection of severity criterion</td>
<td>To develop a common severity criterion for test acceptance and barrier performance measurement in Europe.</td>
<td>POMI</td>
</tr>
<tr>
<td>7</td>
<td>Dissemination</td>
<td>Efficient and wide dissemination of the project results at National and European level to decision-makers and other interested parties.</td>
<td>ERF</td>
</tr>
<tr>
<td>8</td>
<td>Management of the project</td>
<td>Project management, co-ordination of all tasks, transferring of all technical and non technical information to partners, contact with CEC responsible for the project.</td>
<td>POMI</td>
</tr>
</tbody>
</table>
This report examines the first of these Work Packages:

1.2.1 Work Package 1 - Barrier performance from real life accidents

The aims of this Work Package are as follows:
- To focus the correlation among roadside barrier standards and roadside safety;
- Improve the understanding of severity indices and their adequacy as barrier performance indicators.

The objectives of this Work Package are as follows:
- Investigate the relevance of roadside barrier standards to roadside safety;
- Examine the adequacy of severity indices as barrier performance measures;
- Improve the understanding of severity indices.

Each Work Package is subdivided into separate ‘Task’ areas. In the case of Work Package 1, there are two Tasks:

Task 1.1 - To evaluate the relevance of EN 1317 test methods and test acceptance criteria to real life road safety.
The Task involves the collection of statistical data relating to single vehicle accidents with vehicle restraint systems, to evaluate the impact and the relevancy of EN 1317 to roadside safety, and the potential for possible improvements.

Task 1.2: To evaluate the effect of differences in test parameters and vehicle make on the results of full-scale impact tests.
The acquisition of data on real life impacts with safety barriers, will (within WP4 and WP5) allow a reliable reconstruction of an accident through computational mechanics and testing. Data collected within Task 1.2 will include information required to enable these reconstructions to take place, for example information such as the impact conditions, accurate photographic descriptions of exterior and interior vehicle damage and the severity and cause of occupant injuries.

This report considers Task 1.2.

Work Package 1, Task 1.2 - Participants
The following Members of the Consortium have contributed to this Task:

- TRL Limited (Work Package Leaders)
- Politecnico di Milano
- CIDAUT
2 Method of Approach

2.1 Accidents considered within this Task

To identify accidents occurring with parameters similar to the testing specifications of EN 1317, it was essential that relevant accident data were obtained. For the purposes of this project, it was agreed amongst the Consortium that accidents with the following criteria would be examined:

- Single vehicle accidents;
- On all roads (including both major and minor roads);
- Occurring between 1990 and 2003 inclusive;
- In which a vehicle restraint system had been impacted.

These preliminary filters were applied to ensure that a detailed and representative data set could be examined, without collecting such a expansive amount of data that they could not be examined accurately and efficiently. The decision to examine single vehicle accidents would negate complications associated with injuries and/or damage caused by impacting another vehicle. A single vehicle is used during testing to EN 1317, and this was a second reason to select only accidents involving one vehicle.

The data collected during this initial phase of the Task is reported in the ROBUST Deliverable 1.1.1, “Task 1.1: Collection of statistical data from real life use of barriers” [1]. The report provides a general overview of the results obtained by an analysis of the accident statistics.

The objective of Task 1.2 was to obtain additional information on these accidents such that they could be reconstructed using both testing and computational mechanics techniques in WP4 and WP5 respectively. In order for such activities to take place, the following restrictions were then placed on the data collected within Task 1.1:

- The vehicle must impact the barrier in a stable condition - for the purposes of testing within WP4;
- Impact conditions (e.g. weight, speed and angle) should be known, or reported in the accident report by a qualified accident investigator - for the purposes of testing within WP4;
- Details of the safety fence type and its post spacing should be known, and the barrier should be available - for the purposes of testing within WP4;
- The ground conditions at the accident site would be useful although they are not essential - for the purposes of testing within WP4;
- The vehicle in the impact should be a small car for which a computer model already exists (the Geometro can represent vehicles such as the Suzuki Swift, Ford Fiesta, Subaru Justy, Opel Corsa, Peugeot 205) – for the purposes of computer simulation within WP5;
- Only one impact to take place (i.e. the vehicle impacting the barrier can only suffer damage from the barrier impact) – to enable an accurate comparison between severity indices and actual injuries sustained;
- Injuries sustained to the vehicle occupants should be known (a single occupant is preferable for the purposes of testing, but is not essential) – to enable an accurate comparison between severity indices and actual injuries sustained.
3 Accident Data Collation

Accident details were received from three sources; TRL’s co-operative crash injury study (CCIS) accident database, the Police Department of Trento’s Italian accident database (provided by the Politecnico di Milano), and the Spanish road accident database (an extract of which was provided from CIDAUT).

3.1 UK CCIS (Co-operative Crash Injury Study) data (supplied by TRL)

3.1.1 Background

The Co-operative Crash Injury Study (CCIS) is a successful project which has been running for 20 years and helps to improve car safety through detailed accident research. Unlike the STATS19 data used within Task 1.1, the CCIS database contains more detailed information about accidents and the resulting casualties. This unique project provides a vital insight into how people are injured in car crashes; helping to identify the causes of a crash, the consequences and how countermeasures can be developed for the future.

When an accident occurs the vehicle involved undergoes a detailed examination and a questionnaire is sent to the occupants. TRL is then notified of the occupant and the hospital they are attending and works closely with the hospital who provide vital injury information. This valuable information is then coded and entered into an anomalised database.

The database contains a comprehensive set of data including:

- Nature and severity of the accident and impact severity;
- Details on age, gender, height, weight, etc…
- Details of the injuries sustained;
- Injury/causation/mechanisms;
  Effectiveness of restraints; seatbelts/airbags etc…

This enables a correlation and analysis of the car and injury data; for example, a passenger head injury being consistent with windscreen damage. The analysis then enables the identification of trends both in car design and road safety practice. This in turn helps the CCIS project to gain a detailed understanding of accident causes and consequences and helps work in developing effective countermeasures.

The project is funded by the UK Department for Transport and is supported by the Department for Health and the Vehicle and Operator Services Agency (VOSA)

Data relating to all accidents is contained within the scope of the CCIS database and hence, a search is required to highlight those in which a safety barrier has been impacted (see Section 3.1.2). Although data relating to the safety barrier is not generally reported in the CCIS database, the database can be cross referenced to STATS19 data (used in Task 1.1) to establish the location of the accident. A visit to the accident location, or correspondence with the local maintaining agent, is then necessary to establish the type of safety barrier at the accident scene and the associated post spacing and ground conditions, etc.
3.1.2 Searching on the CCIS database

In order to assess which of the reported accidents involved a vehicle impacting a vehicle restraint system, a search was made on the CCIS records database. A search can be made for any combination of criteria relating to the information collected on the CCIS report forms.

For the purpose of the ROBUST project, the criteria outlined in Section 2.1 were applied as far as possible to the CCIS accident database for the years 1993 to 2000.

3.1.3 The results of the search on the CCIS database

The search resulted in a list of 54 accidents. Of these, only three were considered suitable due to the vehicle involved in the accident. As a result, each of these accidents was investigated in more detail to assess the suitability of the accident for the purposes of reconstruction through both testing (in Work Package 4) and computer simulation (in Work Package 5). Sketch drawings of each of the accidents are given below:

![Figure 1: Accident proposal 1](image1.png)

This accident was rejected as the vehicle is traversing in a rotational motion as it impacts the barrier – this would be very difficult to recreate during Work Package 4 (i.e. full-scale impact testing).

![Figure 2: Accident proposal 2](image2.png)
This accident was rejected as the vehicle impacts a bridge pier after breaching the safety barrier and hence, it would be difficult to ascertain whether the injuries and vehicle damage sustained were as a result of the initial impact with the safety barrier, or from the secondary impact with the bridge pier.

![Figure 3: Accident proposal 3](image)

This accident was rejected as further investigation revealed that after the initial contact with the safety barrier, the two vehicles collided with each other. Hence, again it would be difficult to ascertain whether the injuries and vehicle damage sustained were as a result of the initial impact with the safety barrier, or from the secondary impact with the other vehicle.

Following the rejection of the three accidents proposed above, it was decided by the Consortium to widen the scope of the search to any vehicle so long as it was within, or close to, the requirements of EN1317 vehicle specifications. This search highlighted one further accident:

![Figure 4: Accident proposal 4](image)

Analysis of the accident revealed that the two vehicles shown did not impact each other, and that the Citroen Picasso only impacted the safety barrier (the type and post spacing of which were known) at approximately 75 degrees. However, again, the Consortium rejected this accident as the impact angle and vehicle’s centre of gravity were too far removed from the requirements of EN1317. The injuries sustained by the vehicle occupants were also considered to be slight (a minor injury to a hand).

For these reasons it was felt that any comparison between the injuries sustained during the impact and severity indices would not give any useful information.
3.2 Italian Data Supplied by the Politecnico di Milano.

These data have been collected by the Police Department of Trento region (a medium-sized region in the Northern part of Italy). The data were collected during the last 4 years to create a statistical data base. This data base contains all accidents in which an item of roadside furniture has been involved (from a bicycle to a 38 tonne truck).

For the purposes of the ROBUST project, this large database has been filtered so that accidents in which a single vehicle has struck a vehicle restraint system (on any road) have been analysed.

Unfortunately for the purposes of reconstruction, the impact speed is only reported in a small number of cases, and in no instance is the impact angle noted. In addition, details of the first point of vehicle contact with the barrier are not given for the same accidents as the condition of the road surface. The first of these is important to allow a search to be made on the type of impact, whilst computational mechanics has shown the importance of wheel to ground friction (which could be affected by the condition of the road surface at the time of the accident).

As a result, it was decided that none of these accidents would be suitable for reconstruction.

3.3 Spanish Accident Proposal received from CIDAUT

3.3.1 Background

CIDAUT contributed with information from their own database which includes accidents occurring since 2003, i.e., within the duration of the ROBUST project. For this purpose, CIDAUT works with accident investigation teams that collaborate in close cooperation with police forces, medical services, forensic surgeons, garages and scrap yards, and travel to the accident scene immediately after the accident takes place to perform an ‘in-depth investigation’. When it is not possible to move immediately to the accident spot, a retrospective investigation is made if sufficient information can be gathered. Complete scene and vehicle analysis equipment and software are used.

3.3.2 Accident selection

For this accident data collection, the sampling area was located within the Valladolid province (8202 km²), covering both urban and non-urban roads. Accident selection was based on random notification from police control rooms, with different police corps involved depending on whether accidents took place on urban or non-urban areas.

Among those accidents available, one was chosen for a detailed analysis. As in the rest of cases, it was intended that the vehicle involved was as similar as possible to the ones defined by the EN-13137 Standard, and that the impact kinematics, could be reproduced during the crash testing activity (WP4).
3.3.3 Analysed accident

The following accident proposal was delivered by CIDAUT, Spain for consideration:

![Figure 5: Accident proposal from CIDAUT](image)

The accident featured an Opel Corsa impacting a steel guardrail. Although a large amount of detail was available about this accident, this was considered to be unsuitable for reconstruction as the safety barrier present at the accident scene is no longer available. Although a similar barrier is currently in production, the effects resulting from this change in barrier were considered to be unknown and hence, the accident was rejected.
4 The Alternative to Accident Reconstruction

Although a large number of accidents had been examined, it was concluded by the Consortium that, due to the requirement to reproduce the accidents through both testing and modelling, none identified were suitable for reconstruction. This was due to either the parameters of the accident and/or the resulting injuries being insufficient to make an assessment regarding a correlation between real-world injury and severity indices.

In many cases, the information relating to the accident was either restricted, unavailable and/or incomplete and hence, a full reconstruction of an accident was not considered to be possible.

As a result, it was decided by the Consortium to substitute the accident reconstruction activity with a study into the improvements which could be made to the repeatability of testing to EN1317 through the implementation of the ROBUST results. This would involve TRL and LIER identifying and harmonising on those information and techniques which have been identified by the ROBUST project as having an influence on testing results, for example test installation, accelerometer mounting and location, ground conditions and data processing.

In addition the simulation houses also performed simulations using the final version of their vehicle model against a solid rigid wall.

Both activities could then be compared to similar exercises performed at the start of the ROBUST project, and the improvements seen through a comparison with these initial results.

Both of these activities are reported separately under the relevant work packages (WP4 for the full-scale testing, and WP5 for the computational mechanics).
5 Conclusions

An extensive search has been made to identify an accident which could be recreated through full-scale impact testing and computer modelling within WP4 and WP5 of the ROBUST project.

However, due to the information available about relevant accidents, it was decided by the Consortium that none of the accidents were suitable for this Task.

As a result, it was decided by the Consortium to substitute the accident reconstruction activity with a study into the improvements which could be made to the repeatability of testing to EN1317 through the implementation of the ROBUST results.

In addition the simulation houses also performed simulations using the final version of their vehicle model against a solid rigid wall.

Both activities could then be compared to similar exercises performed at the start of the ROBUST project, and the improvements seen through a comparison with these initial results.

Both of these activities are reported separately under the relevant work packages (WP4 for the full-scale testing, and WP5 for the computational mechanics).
6 Definitions

Accident: Involves personal injury on the public highway (including footways) in which at least one road vehicle or a vehicle in collision with a pedestrian is involved and which becomes known to the police within 30 days of its occurrence. [2]

CEN Committee: The CEN Committee structure is mandated to draft and write Standards on specific technical subjects. In the case of VRS, this is overseen by TC226. Underneath sits sub-committees who draft the standards using their extensive technical knowledge and experience. In the writing of EN 1317, the CEN Committee Structure is as follows:

- **Technical Committee (TC) 226**
  - **WG1**
  - **TG1**
  - **WG2**
  - **TG2**
  - **WG3**
  - **...**

Major Road: Includes motorways and all class ‘A’ roads. These roads usually have high traffic flows and are often the main arteries to major destinations. [2]

Minor Road: These are ‘B’ and ‘C’ classified roads and unclassified roads and are all maintained by the local authorities [2]

Passengers: Occupants of vehicles, other than the person in control who is the driver or rider. [2]

Performance Class: The containment class of a system, i.e. the weight, speed and angle of an impacting vehicle for which a VRS can restrain and redirect a vehicle.

Safety Barrier: A road vehicle restraint system installed alongside, or on the central reserve of, a road. [4]

Severity: Of an accident; the severity of the most severely injured casualty (either fatal, serious or slight). Of a casualty; killed, seriously injured or slightly injured. [2]

Small car: A vehicle used for TB11 testing to EN 1317.

STATS 19: These data are based on reports sent to the UK Department for Transport (DfT) by police forces following an accident in which the police have attended and human injury has occurred to one or more persons. The accident report form known as STATS 19 is used for such purposes.

TB11: A full-scale impact test defined by the Standard EN 1317 which requires an impact on a VRS by a 900kg vehicle travelling at 100kph, impacting at 20 degrees to the line of the barrier. [3]

Vehicle Restraint System (VRS): A system installed on the road to provide a level of containment for an errant vehicle [4]
7 Acronyms

CEN Comité Européen de Normalisation
CIDAUT Centre for Automotive Research and Development
ERF European Union Road Federation
LIER Laboratoire d’Essais Inrets Equipements de la Route
NPRA Norwegian Public Roads Administration
ROBUST Road Barrier Upgrade of Standards
TC226 Technical Committee 226
TG1 Task Group 1
TRL Transport Research Laboratory
UK United Kingdom
VRS Vehicle Restraint System
WG1 Working Group 1
WP Work Package
WPL Work Package Leader

8 References


9 Acknowledgements

The work described in this report was carried out in the Safety and Environment Division of TRL Limited.

The author is grateful the members of the ROBUST Consortium who carried out the quality review and auditing of this report.

The author would also like to thank all those Members of the Consortium who provided information relating to this first Task of the ROBUST project.