A guide to assessing Active Adaptive Secondary Safety systems

Prepared for Vehicles, Standards and Engineering Division, Department for Transport

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# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>1</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>3</td>
</tr>
<tr>
<td>2 References</td>
<td>3</td>
</tr>
<tr>
<td>Appendix A: Occupant restraint systems: Frontal protection</td>
<td>4</td>
</tr>
<tr>
<td>Appendix B: Occupant restraint systems: Side impact</td>
<td>10</td>
</tr>
<tr>
<td>Appendix C: Pedestrian impact protection: Active systems</td>
<td>13</td>
</tr>
<tr>
<td>for cars</td>
<td></td>
</tr>
<tr>
<td>Appendix D: Sensors and control systems</td>
<td>21</td>
</tr>
<tr>
<td>Abstract</td>
<td>27</td>
</tr>
<tr>
<td>Related publications</td>
<td>27</td>
</tr>
</tbody>
</table>
Executive Summary

This Guidance Note for Active Adaptive Secondary Safety Systems considers three types of systems. These are: a system to protect front seat occupants in frontal impacts, Appendix A; a system to protect front seat occupants in side impacts, Appendix B; and a system that could be fitted to the front of a car to protect pedestrians in frontal collisions, Appendix C. An implicit part of all of the systems is an electronic control unit and various sensors and Appendix D is that part of the Guidance Note that relates to these components.

Active Adaptive Secondary Safety Systems improve protection afforded to the front seat occupants of a car, over that provided by current non-adaptive systems. This is achieved through the use of restraints whose performance may be varied according to the characteristics and position of a front seat car occupant. These may take into account the occupant position, size and mass, and the impending impact mechanism and severity in order to minimise the occupant injury potential.

Furthermore, both the frontal impact and side impact protection systems were tested in such a way as to evaluate the potential benefit from sensing the impact severity in advance of the impact, and adjusting the system characteristics accordingly. A moving seat was incorporated into the car body for some of these tests, thereby moving the occupant rearward or sideways away from intruding components and reducing the average acceleration. This Guidance Note is based upon performance and does not specify how the requirements should be achieved. However, it should be borne in mind that the injury potential, that must not be exceeded, has accounted for the benefits that a moving seat can provide. The guidance for car frontal and side impact was derived from the results of finite element modelling of car impacts and experimental tests.

The pedestrian protection system was developed in a series of car-to-pedestrian impact tests using bumper and bonnet-mounted airbags. The test specifications and results obtained form the basis of this Guidance Note. In addition, the results from finite element (FE) simulations of impacts using an equivalent car-to-adult FE dummy and car model were also taken into account. The pedestrian protection advice is thus based mainly upon test results but with supporting evidence from simulations.

Essential parts of an adaptive system are sensors, that detect the occupant characteristics and the control systems that adjust the safety devices accordingly. Hence, there is a requirement for separate guidance, Appendix D, to describe and define the sensor and control system performance.

The sensor and control system requirements for the pedestrian protection system are based upon the findings of the research, which indicate that airbags need to be inflated prior to an impact. Hence the need to detect a pedestrian and to determine whether the pedestrian is likely to be struck by the car. Appendix D includes a description of the requirements and performance of a pedestrian detection sensor and control system.

The extensive research project referred to above is described in TRL documents PR/SE/418/98, PR/SE/568/99 and PR/SE/219/00. These reports contain all the details of the research and the results upon which the derivation of this Guidance Note is based.

This Guidance Note is intended to assist in the assessment of advanced systems to protect car occupants in frontal and side impacts and pedestrians in collisions with car fronts. This Guidance Note is not a legal document and compliance does not guarantee compliance with any regulatory requirement.
1 Introduction

This Guidance Note for Active Adaptive Safety Systems considers three types of systems. These are: a system to protect front seat occupants in frontal impacts, Appendix A; a system to protect front seat occupants in side impacts, Appendix B; and a system that could be fitted to the front of a car to protect pedestrians, Appendix C. An implicit part of all of the systems is an electronic control unit and various sensors and Appendix D is that part of the Guidance Note that relates to these components.

Appendices A, B and C have been written so that they can be used in isolation or in combination. However, Appendix D, Sensors and Control Systems, will relate to the other Appendices, however used. It should be noted that to facilitate understanding and possible use in isolation, each Appendix is prefaced by an introduction that describes the detail and composition of the Guidance Note; those details are not repeated in this introduction.

The extensive research project referred to above is described in TRL documents PR/SE/418/98, PR/SE/568/99 and PR/SE/219/00. These reports contain all the details of the research and the results upon which the derivation of this guidance is based. However, it should be noted that all of the active systems, including the pedestrian protection system, are based upon the use of airbags. The frontal and side impact protection systems are also based upon the use of seat belt pretension devices. Both these and the airbags are designed such that their characteristics are adjusted according to the characteristics of the occupant of which, age, height and weight are typical examples.

Furthermore, both the frontal impact and side impact protection systems were tested in such a way as to evaluate the potential benefit from sensing the impact severity in advance of the impact, and adjusting the system characteristics accordingly. A moving seat was incorporated into the car body for these tests to move the occupant rearward or sideways away from intruding components. This guidance is based upon performance and does not specify how the requirements should be achieved. However, it should be borne in mind that the injury potential that must not be exceeded, has accounted for the benefits that a moving seat can provide.

Essential parts of an adaptive system are sensors that detect the occupant characteristics and the control systems that adjust the safety devices accordingly. Hence the need for a separate section, Appendix D, to describe and define the sensor and control system performance.

The pedestrian safety system requirements, Appendix C, are based upon the use of airbags on the front of a car. The sensor and control system requirements are based upon the findings of the research, which indicate that the airbags need to be inflated prior to an impact. Hence the need to detect a pedestrian and to determine whether the pedestrian is likely to be struck by the car. Included in Appendix D is a description of the requirements and performance of a pedestrian detection sensor and control system.

In conclusion, it should be noted that where possible the guidance is based upon existing or proposed regulations relating to car occupant and pedestrian protection. However, the regulations, where used, have been greatly modified to account for the needs of an active adaptive system.

2 References


Appendix A: Occupant restraint systems: Frontal protection

A1 Introduction

This document outlines the requirements for the implementation of Active Adaptive Secondary Safety (AASS) systems for the protection of front seat occupants in frontal impacts. The requirements for sensors and control systems may be found in Appendix D.

Active Adaptive Secondary Safety systems improve protection afforded to the front seat occupants of a car, over that provided by current non-adaptive systems. This can be achieved through the use of restraints whose performance may be varied according to the characteristics and position of a front seat car occupant. These characteristics may take into account occupant position, size and mass, also the impending impact mechanism and severity in order to minimise the occupant injury potential.

It is expected that the occupant and impact data will be obtained from a range of appropriate sensors in real time. This data will, in turn, be processed by a control system, in a number of ways, and used to modify the restraint system characteristics to optimise the restraint performance. It is expected that this will greatly improve the protection afforded to occupants whose characteristics differ substantially from 50th percentile. This document is a Guidance Note to define the performance requirements for such systems. It should be noted that this Appendix describes the performance requirements for the restraint system. The requirements for the sensors and control systems are given in Appendix D.

It should be borne in mind that the basis for this Guidance Note is an extensive research programme sponsored by the UK Department for Transport (DfT) and described in TRL documents PR/SE/418/98, PR/SE/568/99 and PR/SE/219/00. It is to these documents that those involved in the design of systems may refer. Part of this research was an attempt to establish the effect of human characteristics on the potential for injury. The research found that body mass index, age, gender and seating position were factors that influenced the outcome and these have been taken into account within this Guidance Note.

The current legislation is Directive 96/79/EC, on the protection of occupants of motor vehicles in the event of a frontal impact. This guidance is based upon this Directive, but the requirements have been changed substantially to account for the capability of an adaptive system.

The current frontal impact Directive specifies one impact, into a deformable barrier at a specific impact speed, the type and size of occupants (Hybrid III dummy family) and their seated position, as well as the maximum permissible injury criteria and other related data. Active adaptive systems require acceptance tests at two different impact speeds, plus the use of three discrete adult dummies, 5th, 50th and 95th percentiles, at both impact speeds to ensure adequate protection is provided for an extended range of crash types and severities.

The two full barrier impact test speeds and modified injury criteria limits quoted in this document are defined from analysis of FE modelling and physical testing of adaptive systems on one vehicle, and the injury reductions achieved were proportionally adopted. Thus if a model or test showed a potential reduction of 20% in HIC36 value, the new limit for an adaptive system for that impact condition would be 800, instead of 1000. Where a value was not considered sensible or achievable, this has been modified to be in line with the other values. The values may be modified in future with a better understanding of injury tolerance. This is particularly true for injury criteria for large and small percentile occupants. In addition, the research was necessarily based upon a full frontal barrier test and in future it is expected that offset tests into a deformable barrier may be required.

It is commonly accepted that non-adaptive airbags can improve the level of protection afforded to most correctly seated occupants from approximately 20 mile/h (32km/h) up to 50 mile/h (80km/h) for a frontal barrier impact. It can be assumed that because adaptive technology provides optimised protection for most occupants in most situations, the likelihood of surviving a higher speed impact with reduced injuries would be increased. The upper limits cannot be quantified, because there are a large number of restraint technologies purporting to be smart or adaptive, and they have different capabilities ranging from minor improvement (through mass categorising and two-level pre-tensioners for example), to fully adaptive systems. These may measure the occupants’ mass, height and position in real time, sense the potential impact severity and deploy safety system optimised for the impending impact severity. External range and velocity sensors, combined with vehicle to vehicle communication systems using Bluetooth, GSM or similar technology, or another method of categorising oncoming vehicles, may provide information about the size, mass and velocity of the oncoming vehicle. If the object struck is not another vehicle, the pre-crash sensor may be able to determine whether it is a solid object such as a wall, or a large tree, or a relatively low-density object such as a hedge or signpost.

Where a restraint system is not continuously adaptive to occupant position, mass, height or crash severity, the manufacturer must demonstrate that the system will not result in a step change in injury potential and thus ensure that occupants are always adequately protected. This may be achieved via FE modelling or physical sub-system testing and must be reported. Appendix D contains the details of system, sensor specifications and test protocols.

The ability of adaptive safety systems to use fuzzy logic, algorithms, look-up tables, and other means of categorising occupants’ position and mass data and/or impact type and severity, needs to be demonstrated. Manufacturers can achieve this through sub-system tests and the submission of appropriate reports. Where input data is conflicting, the manufacturer must provide evidence that the control system
will resolve the dilemma and output either a ‘correct’
decision for that circumstance, or a fail-safe setting. This
must be a guarantee of a satisfactory level of protection to
most occupants in most positions.

A2 Administrative provisions for the assessment of a
vehicle type

A2.1 Application for assessment
A2.1.1 Applications for assessment of a vehicle type with
regard to the protection of occupants of motor
vehicles in the event of a frontal impact, must be
submitted by the manufacturer.

A2.1.2 A vehicle representative of the vehicle type to be
assessed must be submitted to the organisation
responsible for conducting the assessment tests.

A2.1.3 The manufacturer is entitled to submit any data and
test results which make it possible to establish with
a sufficient degree of confidence that compliance
with the requirements can be achieved.

A2.2 Assessment
A2.2.1 Where the vehicle type satisfies the relevant
requirements, it can be acknowledged as
conforming with the recommendations detailed
within this Guidance Note.

A2.2.2 In case of doubt, in order to verify that the vehicle
conforms to the requirements, account must be taken
of any data or test results provided by the
manufacturer which may be taken into consideration
in establishing the validity of the assessment test
performed by the assessment authority.

A2.3 Conformity of production
A2.3.1 As a general rule, measures to ensure the
conformity of production must be taken in
accordance with the provisions laid down in
Article 10 of Directive 70/156/EEC.

A3 Technical requirements

A3.1 Scope
A3.1.1 This Guidance Note applies to power-driven
vehicles of category M1 of a total permissible mass
not exceeding 2.5 tonnes, with the exception of
multi-stage built vehicles produced in quantities not
exceeding those fixed for a small series. Heavier
vehicles and multi-stage built vehicles may be
approved at the request of the manufacturer.

A3.2 Definitions
For the purposes of this Guidance Note:

A3.2.1 ‘protective system’ means interior fittings and
devices intended to restrain the occupants and
contribute towards ensuring compliance with the
requirements set out in Section 3.3;

A3.2.2 ‘type of protective system’ means a category of
protective devices which do not differ in such
essential respects as:
• their technology;
• their geometry;
• their constituent materials.

A3.2.3 ‘adaptive’ means a device which adjusts to
occupant characteristics and position and/or
impact severity.

A3.2.4 ‘vehicle width’ means the distance between two
planes parallel to the longitudinal median plane and
touching the vehicle on either side of the said plane
but excluding the rear-view mirrors, side marker
lamps, tyre pressure indicators, direction indicator
lamps, position lamps, flexible mud-guards and the
deflected part of the tyre side-walls immediately
above the point of contact with the ground;

A3.2.5 ‘overlap’ means the percentage of the vehicle
width directly in line with the barrier face;

A3.2.6 ‘deformable barrier face’ means a crushable
section mounted on the front of a rigid block;
‘rigid barrier face’ means a rigid block; it is
permissible to place a layer of material on the
surface of a rigid barrier face to protect the impact
face - this is usually a 9-12mm thick sheet of 3- or
5-ply board;

A3.2.7 ‘vehicle type’ means a category of power-driven
vehicles which do not differ in such essential
respects as:

A3.2.7.1 the length and width of the vehicle, insofar as
they have a negative effect on the results of the impact
test prescribed in this Guidance Note;

A3.2.7.2 the structure, dimensions, lines and materials of
the part of the vehicle forward of the transverse
plane through the ‘R’ point of the driver’s seat
insofar as they have a negative effect on the
results of the impact test prescribed in this
Guidance Note;

A3.2.7.3 the lines and inside dimensions of the passenger
compartment and the type of protective system,
insofar as they have a negative effect on the
results of the impact test prescribed in this
Guidance Note;

A3.2.7.4 the location (front, rear or centre) and the
orientation (transversal or longitudinal) of the
engine;

A3.2.7.5 the unladen mass, insofar as it has a negative
effect on the results of the impact test prescribed
in this Guidance Note;
A3.2.7.6 the optional arrangements or fittings provided by the manufacturer, insofar as they have a negative effect on the results of the impact test prescribed in this Guidance Note;

A3.2.8 'passenger compartment' means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing and front bulkhead and the plane of the rear compartment bulkhead or the plane of the rear-seat back support;

A3.2.9 ‘R’ point means a reference point defined for each seat by the manufacturer in relation to the vehicle’s structure;

A3.2.10 ‘H’ point means a reference point determined for each seat by the organisation responsible for assessment, for vehicles fitted with adaptive systems this will mean the ‘H’ point for each size of occupant dummy used in tests;

A3.2.11 ‘unladen kerb mass’ means the mass of the vehicle in running order, unoccupied and unladen but complete with fuel, coolant, lubricant, tools and a spare wheel (if these are provided as standard equipment by the vehicle manufacturer);

A3.2.12 ‘airbag’ means a device installed to supplement safety belts and restraint systems in motor vehicles, i.e. systems which, in the event of a severe impact affecting the vehicle, automatically deploy a flexible structure intended to limit, by compression of the gas contained within it, the force of the contacts of one or more parts of the body of an occupant of the vehicle with the interior of the passenger compartment.

A3.3 Requirements

A3.3.1 General specification applicable to all tests.

A3.3.1.1 The ‘H’ points for each seat are determined in accordance with the procedures described in Annex III to Directive 77/649/EEC for a 50th percentile dummy, FMVSS208 for the 5th percentile dummy and with reference to SAE J826 and the manufacturer for the 95th percentile dummy. (The 95th percentile has not yet been introduced into FMVSS208 or EC Directives, and the 5th percentile has not yet been introduced into EC Directives).

A3.3.2 Specifications

A3.3.2.1 It should be noted that the values for the human tolerance criteria required for adaptive restraint systems were derived from values measured in finite element modelling and physical tests where adaptive systems were compared with non-adaptive systems. The values stated in the tables were not necessarily achieved in one test. They are, however, based upon the results of range of tests from which it was judged that the values are achievable with a carefully tuned system.

A3.3.2.2 The performance criteria recorded, in accordance with Appendix 5 of Directive 96/79/EC on the dummies in the front outboard seats must meet the following conditions:

A3.3.2.2.1 An adaptive system may fail but it must be fail-safe, and when tested in this condition at 30mile/h the head performance criterion (HPC) must not exceed 1000 and the resultant head acceleration shall not exceed 80g for more than 3ms. The latter must be calculated cumulatively, excluding rebound movement of the head. Furthermore, the values for the requirement for the 50th percentile dummy given in 3.2.1.2 and 3.2.1.3 must not be exceeded.

When tested in the normal operating mode, adaptive restraint systems must meet the requirements in Tables A1 and A2.

### Table A1 Size of occupant dummy vs. maximum HPC value and resultant acceleration for 30mile/h full frontal rigid barrier test

<table>
<thead>
<tr>
<th>Occupant dummy size</th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPC maximum value</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Resultant head acceleration</td>
<td>60g</td>
<td>60g</td>
<td>60g</td>
</tr>
</tbody>
</table>

### Table A2 Size of occupant dummy vs. maximum HPC value and resultant acceleration for 19mile/h full frontal rigid barrier test

<table>
<thead>
<tr>
<th>Occupant dummy size</th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPC maximum value</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Resultant head acceleration</td>
<td>50g</td>
<td>50g</td>
<td>50g</td>
</tr>
</tbody>
</table>

A3.3.2.2.2 The neck injury criteria (NIC) must not exceed the values shown in Figures A1 and A2; this applies to the 5th, 50th and 95th percentile dummies in the 19mile/h and the 30mile/h tests.

A3.3.2.2.3 The neck bending moment about the y axis must not exceed 57Nm in extension; this applies to the 5th, 50th and 95th percentile dummies in the 19mile/h and the 30mile/h tests.

A3.3.2.2.4 In the fail-safe condition at 30mile/h, the thorax compression criterion (ThCC) must not exceed 50mm. For the active adaptive restraint systems the values in Tables A3 and A4 must not be exceeded for the given dummy and the given test speed.
A3.3.2.2.5 In the fail-safe condition at 30 mile/h the viscous criterion (V*C) for the thorax must not exceed 1.0. For the active adaptive restraint systems the values in Tables A5 and A6 must not be exceeded for the given dummy and the given test speed.

A3.3.2.2.6 The femur force criterion (FFC) must not exceed the force-time performance criterion shown in Figure A3 of this Annex; this applies to the 5th, 50th and 95th percentile dummies in the 19 mile/h and the 30 mile/h tests.

A3.3.2.2.7 The tibia compression force criterion (TCFC) must not exceed 8 kN; this applies to the 5th, 50th and 95th percentile dummies in the 19 mile/h and the 30 mile/h tests.

A3.3.2.2.8 The tibia index (TI), measured at the top and bottom of each tibia, must not exceed 1.3 at either location; this applies to the 5th, 50th and 95th percentile dummies in the 19 mile/h and the 30 mile/h tests.

A3.3.2.2.9 The movement of the sliding knee joints must not exceed 15 mm; this applies to the 5th, 50th and 95th percentile dummies in the 19 mile/h and the 30 mile/h tests.

Table A3 Size of occupant vs. maximum ThCC value for 30 mile/h full frontal rigid barrier test

<table>
<thead>
<tr>
<th>Occupant dummy size</th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>ThCC limit (mm)</td>
<td>35</td>
<td>45</td>
<td>55</td>
</tr>
</tbody>
</table>

Table A4 Size of occupant vs. maximum ThCC value for 19 mile/h full frontal rigid barrier test

<table>
<thead>
<tr>
<th>Occupant dummy size</th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>ThCC limit (mm)</td>
<td>30</td>
<td>35</td>
<td>40</td>
</tr>
</tbody>
</table>

Table A5 Size of occupant vs. maximum V*C value for 30 mile/h full frontal rigid barrier test

<table>
<thead>
<tr>
<th>Occupant dummy size</th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>V*C limit (m/s)</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table A6 Size of occupant vs. maximum V*C value for 19 mile/h full frontal rigid barrier test

<table>
<thead>
<tr>
<th>Occupant dummy size</th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>V*C limit (m/s)</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>
A3.3.2.10 Occupant sensors must be fully operational for type-assessment tests, where possible. Where there is a technical reason why the sensing system cannot be fully operational, this must be stated and the sensor signal that corresponds to the test conditions must be applied to the control system by other means. External impact sensors and crash severity sensors must be operating normally.

A3.3.2.11 For vehicles fitted with adaptive restraint systems all leg injury criteria and upper limb contacts should be investigated to ensure that the introduction of these systems does not result in occupants sustaining injuries more severe than with a non-adaptive system.

A3.3.2.3 Residual steering wheel displacement, measured at the centre of the steering wheel hub, must not exceed 80mm in the upwards vertical direction and 100mm in the rearward horizontal direction.

A3.3.2.4 During the test none of the doors may open.

A3.3.2.5 During the test the locking systems of the front doors must not become locked.

A3.3.2.6 After the impact, and without the use of tools except for those necessary to support the weight of the dummy, the following must be possible:

A3.3.2.6.1 to open at least one door, if there is one, per row of seats and, where there is no such door, to move the seats or tilt their backrests as necessary to allow the evacuation of all the occupants; this is, however, only applicable to vehicles having a roof of rigid construction;

A3.3.2.6.2 to release the dummies from their restraint system which, if locked, must be capable of being released by a maximum force of 60 N on the centre of the release control;

A3.3.2.6.3 to remove the dummies from the vehicle without adjustment of the seats.

A3.3.2.7 In the case of a vehicle propelled by liquid fuel, no more than slight leakage of liquid from the entire fuel system may occur during or after the impact. If, after the impact there is continuous leakage of liquid from any part of the fuel system, the rate of leakage must not exceed 5 x 10^-4 kg/s; if the liquid from the fuel-feed system mixes with liquids from the other systems and the various liquids cannot easily be separated and identified, all the liquids collected are taken into account in evaluating the continuous leakage.

A3.4 Test procedure

The procedures in Directive 96/79/EC Appendices 1, 2, 3, 5, 6 and 7 shall be followed with the following exceptions:

A3.4.1 Barrier - this is currently defined in the Directive as a deformable barrier. However, for the purposes of this Guidance Note the barrier required is a rigid barrier. It should be noted that a deformable barrier may be used when the equivalent offset deformable barrier tests have been defined and the appropriate injury criteria limits have been determined.

A3.4.2 Orientation of the barrier - this is irrelevant for a rigid full frontal barrier test stipulated in this Guidance Note.

A3.4.3 Alignment of the barrier - also irrelevant for the same reasons described in A3.4.2.

A3.4.4 Position of steering wheel - for adaptive systems, if adjustable, it should be in the position defined by the manufacturer for each driver dummy installed for the test.

A3.4.5 Pedals, where adjustable, should be placed in the manufacturer’s recommended position for the driver dummy installed for the test.

A3.4.6 Position of front seats - ensure that the seat position is correct for the occupant dummy size installed for the test, according to the manufacturer and Annex III of Directive 77/649/EEC.

A3.4.7 Position of front seat-backs - ensure that the seat-back position is correct for the occupant dummy size installed for the test, according to the manufacturer and Annex III of Directive 77/649/EEC.
A3.4.8 Dummies - three dummies are required for the tests, a 5th, 50th and 95th percentile Hybrid III. The 50th percentile dummy must satisfy the requirements of 96/79/EC Annex II, Appendix 1, Section 2. The requirements for the 5th percentile dummy may be found in FMVSS208, and in SAE J826 and with reference to the manufacturer for the 95th percentile dummy.

A3.4.9 Test impact velocity and occupant definition for the test series may be found in Table A7. The tolerance applicable to all test speeds is -0 +0.625mile/h.

Table A7 Hybrid III dummy position and impact velocity requirements for active adaptive restraint full barrier impact tests

<table>
<thead>
<tr>
<th>Occupant size</th>
<th>Passenger impact velocity (mile/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>95</td>
</tr>
</tbody>
</table>

A3.5 Arrangement and installation of dummies

A3.5.1 Dummy arrangement and installation shall be according to 96/79/EC, Annex II, Appendix III for the 50th percentile, FMVSS 208 for the 5th percentile and J826 with reference to the manufacturer for the 95th percentile.

A3.6 Adjustment of restraint system

A3.6.1 The necessary adjustment shall be carried out according to 96/79/EC Annex II, Appendix III, Section 3.

A3.7 Assessment procedure for dummy

A3.7.1 The assessment procedure for Hybrid III dummies may be found in US Department of Transportation Code of Federal Regulations Part 572.
Appendix B: Occupant restraint systems: Side impact

B1 Introduction
This document outlines the requirements for the implementation of Active Adaptive Secondary Safety Systems for the protection of front seat occupants (struck side) involved in side impacts. The requirements for sensors and control systems may be found in Appendix D.

Active Adaptive Secondary Safety systems improve protection afforded to the front seat occupants of a car, over that provided by current non-adaptive systems. This can be achieved through the use of restraints whose performance may be varied according to the characteristics and position of a front seat car occupant. These characteristics may take into account the occupant position, size and mass, and the impending impact mechanism and severity in order to minimise the occupant injury potential.

It is expected that the occupant and impact data will be obtained from a range of appropriate sensors in real time. This data will, in turn, be processed by a control system, in a number of ways, and used to modify the restraint system characteristics to optimise the restraint performance. It is expected that this will greatly improve the protection afforded to occupants whose characteristics differ substantially from 50th percentile. This document is a Guidance Note to define the performance requirements for such systems. It should be noted that this Appendix describes the performance requirements for the restraint system to protect a front seat occupant on the struck side of a vehicle in a side impact. The requirements for the sensors and control systems are given in Appendix D.

It should be borne in mind that the basis for this guidance is an extensive research programme sponsored by the UK DfT and described in TRL documents PR/SE/418/98, PR/SE/568/99 and PR/SE/219/00. It is to these documents that those wishing to obtain the details of the derivation of the guidance should refer. Part of this research was an attempt to establish the effect of human characteristics on the potential for injury. The research found that body mass index, age, gender and seating position were factors that influenced the injury outcome and these have been taken into account within this Guidance Note.

The current legislation is Directive 96/27/EC, which concerns the protection of occupants of motor vehicles in the event of a side impact. The Directive does not take into account recent developments in restraint technology, which make it possible to optimise restraint performance for a variety of occupant sizes and impact conditions. In addition, the performance of the internal and external sensors is not specified. These sensors enable the characteristics of active adaptive seat belt systems, side impact airbags and other restraint system components to be optimised prior to an impact.

Reliability of detection, accuracy and reliability of the sensors are very important, even though the technology used may vary; there are specifications and regulations that sensors and control systems must meet. A selection of these is listed in Appendix D; the list is not exhaustive, since many are applicable to a specific type of technology, or are proprietary products.

Fail-safe operation is required, such that if any part of the adaptive restraint system or control unit were to fail, the restraint system will default to such settings as to deploy normally during impact as though it were a non-adaptive system. Occupant injuries shall be no worse than if a non-adaptive system were fitted. This will ensure the protection afforded to an occupant remains equivalent to the current non-adaptive systems. The onus is upon the manufacturer to prove through FE modelling, system modelling and physical testing that the system will fail safely and reliably so.

Worst case failure modes need to be identified by manufacturers and dynamically tested or FE modelled to establish potential for injury. Reports may be submitted with assessment applications and may be requested.

Where a restraint system is not continuously adaptive, for example, to occupant position, mass, height or crash severity, the manufacturer must demonstrate that either side of changeover points, the system will not result in a step change in injury potential, thereby ensuring that occupants are always adequately protected.

It is understood that a system, however sophisticated, will have limitations, either in function, injury reduction potential or accident types to which it can respond. The main conditions that may not be adequately covered by
active adaptive side impact protection systems may include extreme occupant sizes, extreme angled impacts, and higher velocity impacts. Although it is envisaged that active adaptive secondary safety systems will increase the survivable crash envelope in terms of severity and the reduction in deaths and serious injury, there will be an upper limit of effectiveness. This may not be quantifiable in practice, due to variability in injury tolerance and in vehicle design.

It is commonly accepted that optimised non-adaptive thorax airbags can produce acceptable injury values for a Eurosid 50th percentile occupant in legislative side impact barrier tests, if the vehicle structure also meets legislation. It may be assumed that because adaptive technology provides optimised protection to most occupants in most situations, the likelihood of surviving a higher speed impact with lower injuries would be increased. Side impact crashes result in higher accelerations of the occupant, potentially more injurious contact with vehicle interior trim components, and greater local intrusions than frontal impacts, thus there is a greater potential for improvement than with frontal systems.

There are a large number of restraint technologies claimed to be adaptive but it is suggested that this claim may only be justified if the system satisfies the requirements of this guidance. A reactive system is an example of a type that may not satisfy the guidance. This is because a system that reacts only during an impact is unlikely to be able to respond sufficiently to satisfy.

Conversely a fully active system should have the capacity to set the pre-tensioner travel and force, adjust the airbag performance and potentially move the seat inboard (if a moving seat is fitted), prior to the impact. This optimises the system before impact, and thus provides the most likely benefits. This cannot be assessed solely through one full-scale impact test and thus it is essential that the requirements in the sensor section are fulfilled for compliance with this Guidance Note to be granted.

It is recommended that a second full-scale impact test, to be defined, be introduced to demonstrate the restraint system capability at a different impact severity than that currently specified.

B2 Administrative provisions for the assessment of a vehicle type

B2.1 Application for assessment

B2.1.1 Applications for assessment of a vehicle type with regard to the protection of occupants of motor vehicles in the event of a side-impact must be submitted by the manufacturer.

B2.1.2 A vehicle, representative of the vehicle type to be assessed, must be submitted to the organisation responsible for conducting the assessment tests.

B2.1.3 The manufacturer is entitled to submit any data and test results as evidence that compliance with the requirements can be achieved with a sufficient degree of confidence.

B2.2 Assessment

B2.2.1 Where the vehicle type satisfies the relevant requirements, assessment will be granted.

B2.2.2 In case of doubt, in order to verify that the vehicle conforms to the requirements of this Guidance Note, account must be taken of any data or test results provided by the manufacturer which may be of use in establishing the validity of the assessment test performed by the assessment authority.

B2.3 Conformity of production

B2.3.1 As a general rule, measures to ensure the conformity of production must be taken in accordance with the provisions laid down in Article 10 of Directive 70/156/EEC.

B3 Technical requirements

B3.1 Scope

This Guidance Note applies to the lateral impact behaviour of the structure of the passenger compartment of M1 and N1 categories of vehicles where the ‘R’ point of the lowest seat is not more than 700mm from ground level when the vehicle is in the condition corresponding to the reference mass defined in Section B3.2.7, with the exception of multi-stage build vehicles produced in quantities not exceeding those fixed for small series.

B3.2 Definitions

For the purposes of this Guidance Note:

B3.2.1 ‘Passenger compartment’ means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing and front bulkhead and the plane of the rear compartment bulkhead or the plane of the rear seat-back support.

B3.2.2 ‘R point’ or ‘seating reference point’ means the reference point specified by the vehicle manufacturer which:

B3.2.2.1 has co-ordinates determined in relation to the vehicle structure;

B3.2.2.2 corresponds to the theoretical position of the point of torso/thighs rotation (H point) for the lowest and most rearward normal driving position or position of use given by the vehicle manufacturer for each seating position specified.

B3.2.3 ‘H point’ means the point as defined in Directive 77/649/EEC.

B3.2.4 ‘Transverse plane’ means a vertical plane perpendicular to the median longitudinal vertical plane of the vehicle.
B3.2.5 ‘Protective system’ means devices intended to restrain and/or protect the occupants.

B3.2.6 ‘Type of protective system’ means a category of protective devices which do not differ in such essential respects as their: technology, geometry, or constituent materials.

B3.2.7 ‘Reference mass’ means the unladen mass of the vehicle increased by a mass of 100kg (i.e. the mass of the side impact dummy and its instrumentation).

B3.2.8 ‘Unladen mass’ means the mass of the vehicle in running order without driver, passengers or load, but with the fuel tank filled to 90% of its capacity and the usual set of tools and spare wheel on board, where applicable.

B3.2.9 ‘Mobile deformable barrier’ means the apparatus with which the test vehicle is impacted. It consists of a trolley and an impactor.

B3.2.10 ‘Impactor’ means a crushable section mounted on the front of the mobile deformable barrier.

B3.2.11 ‘Trolley’ means a wheeled-frame free to travel along its longitudinal axis at the point of impact. Its front block supports the impactor.

B3.2.12 ‘Unladen mass’ means the mass of the vehicle in running order without driver, passengers or load, but with the fuel tank filled to 90% of its capacity and the usual set of tools and spare wheel on board, where applicable.

B3.3 Requirements

B3.3.1 The performance criteria, as determined for the impact test in accordance with Annex II of Directive 96/27/EC must meet the following conditions:

- The head performance criterion (HPC) shall be below 800 where an active head protection device is fitted and operating in normal mode; if there is no head contact with the protective device or vehicle trim, the HPC is not measured or calculated but recorded as ‘No head contact’. An adaptive system may fail, but must be fail-safe, and when tested to this condition, the HPC shall be no more than 1000.

- In fail-safe mode, the thorax performance criteria shall be:
  - (c) rib deflection criterion (RDC) no more than 42 mm;
  - (d) soft tissue criterion (V*C) no more than 1.0 m/s.

- The pelvis performance criterion, which is defined as the pubic symphysis peak force (PSPF) shall be no more than 6.0kN.

- The abdomen performance criterion, which is defined as the abdominal peak force (APF) shall be no more than 2.5kN internal force (equivalent to an external force of 4.5kN).

- Particular requirements not relating to injury criteria may be found in Annex II of Directive 96/27/EC

B.3.4 Impact test procedure
Refer to Directive 96/27/EC, Annex II, Appendix 1. Note that Appendix 5, Partial Test, does not apply.

B.3.5 Arrangement and installation of dummies
Refer to Directive 96/27/EC, Annex II, Appendix 4

B.3.6 Adjustment of restraint system

B3.6.1 The safety belt or restraint system specified for the vehicle must be used. Safety belts must be of an approved type, conforming to Directive 77/541/EEC and mounted on anchorages conforming to Directive 76/115/EEC.

B3.6.2 The safety belt or restraint system must be adjusted to fit the dummy in accordance with the manufacturer’s instructions; if there are no manufacturer’s instructions, the height adjustment, if provided, must be set at middle position; if this position is not available, the position immediately below shall be used.

B3.7 Assessment procedure for the dummy
Appendix C: Pedestrian impact protection: Active systems for cars

C1 Introduction

This document outlines the requirements for the implementation of Active Secondary Safety Systems for the protection of pedestrians struck by the front of cars.

Active secondary safety systems can improve the protection afforded to pedestrians over and above that provided by current passive protection. This is achieved through the use of active devices, such as airbags, and appropriate pedestrian sensors and control systems. The sensors, if required, may detect the presence of a pedestrian just prior to impact and activate the protection system accordingly.

This document is a Guidance Note to define the performance requirements for such systems. It should be noted that this Appendix describes the performance requirements for the active protection system. The requirements for the sensors and control systems are given in Appendix D.

The basis for this Guidance Note was an extensive research programme sponsored by the UK DfT and described in TRL reports PR/SE/418/98, PR/SE/568/99 and PR/SE/219/00. It is to these documents that those wishing to obtain the details of the derivation of the Guidance Note should refer.

A series of car-to-pedestrian impact tests using bumper and bonnet-mounted airbags were carried out during the Advanced Active Adaptive Secondary Safety (AASS) project, and the test specifications and results obtained form the basis of this Guidance Note. In addition, the results from AASS finite element (FE) simulations of impacts using an equivalent car-to-adult FE dummy model were also taken into account. The Guidance Note is thus based mainly upon test results but with supporting evidence from simulations.

A 50th percentile adult Occupant Protection Assessment Test (OPAT) dummy and a 6-year-old child OPAT dummy were used to assess injury potential at two impact velocities in full frontal car to pedestrian impacts with two different cars of very different front profile. The impact velocities were 25mile/h (40km/h) and 30mile/h (48km/h) and the injury potential with and without the airbag systems were compared. The test conditions and injury data produced then formed the basis for this Guidance Note.

Pedestrian sensors were also assessed during the AASS project, and are discussed, with the requirements in Appendix D. It is not stipulated which pedestrian sensing technologies may be used, merely that the manufacturer must demonstrate reliable performance over a range of pedestrian sizes, impact positions and relative velocities. These range from the ‘must sense’ threshold speed defined by the manufacturer, up to 30mile/h (48km/h). The required sensor swept area is defined in the sensor and control systems section, Appendix D.

A manufacturer must demonstrate that the active pedestrian protection system meets the requirements specified in Section C2 and C3 for impacts across the width of the car. In addition, the manufacturer must demonstrate that the sensor and control system meets the requirements of Appendix D. Further explanation is given below.

The impact test specifications in this Appendix combined with the sensor and control systems section Appendix D are intended to demonstrate that pedestrian protection systems are effective and reliable. The Guidance Note specifies three ways of meeting the impact performance requirements as follows:

Option A Sixteen full-scale impact tests; or
Option B Four full-scale impact tests plus sub-systems tests; or
Option C Four full-scale impact tests plus computer simulation using calibrated and validated FE models.

An adult and a child pedestrian dummy are specified for the tests and it is recommended that a 50th percentile adult OPAT and a 6-year-old child OPAT dummy be used for the tests. However, other pedestrian dummies approved for such use by the appropriate governing body may be substituted, such as the Honda pedestrian dummy.

For these impact tests, the pedestrian sensor, if fitted, must be active and must detect the pedestrian dummy, and the protection system must be activated via its control system or activating mechanism. If it is not possible to sense the test dummy, due to the nature of the sensor technology employed or for other reason(s) accepted by the assessment authority, the manufacturer must activate the protection system at a time chosen by them, during the impact test. This must be the same time, within acceptable limits, as the sensor system would activate the system under the equivalent real life conditions. The manufacturer must then provide evidence that this would be the case in practice. See Appendix D for details.

The manufacturer must also quote the system margin of safety to prevent a ‘late fire’, which may be a combination of factors such as variations in system performance plus an amount of time added specifically to avoid a late fire scenario.

Static detection of pedestrians within the range of the sensor is not acceptable as proof of function, since the system must work for all relative velocities up to 30mile/h (48km/h) and under all likely environmental conditions. This must be demonstrated and reported to the satisfaction of the assessment authority.

The injury limits proposed in the requirements take into account the test results and the results obtained from the finite element modelling. It should be noted that these requirements are based upon tests with a conventional saloon car and a high fronted off-road type of vehicle. Thus, they are applicable to all cars equipped with an active, pedestrian impact protection system.

Tests are required at 25mile/h (40km/h) and 30mile/h (48km/h). It is envisaged that active pedestrian safety systems will greatly reduce injury potential. However,
survivability cannot be guaranteed. Thus, manufacturers are advised to ensure that their sensor, control and protection systems function adequately at speeds in excess of 30 mile/h (48 km/h).

It is understood that no system, however sophisticated, can be without limitations, either in function or in injury reduction potential. A small portion of the pedestrian population involved in impacts may not be adequately protected by active systems. These may include very tall and/or very heavy pedestrians, and those involved in high velocity impacts.

It should be noted that this guidance is applicable to active pedestrian protection systems only, whether or not the pedestrian sensors used are active and sense prior to impact, or reactive such as bumper-mounted sensors which activate an upper body and head protection system. Passive systems are covered by the proposals from EEVC WG17 entitled ‘Improved Test Methods to Evaluate Pedestrian Protection Afforded by Passenger Cars’, December 1998. The proposed legislation from EEVC WG17 specifies sub-system tests using leg and head impactors. It does not require full-scale car-to-pedestrian dummy impacts, which are essential for the assessment of active systems.

C2 Administrative provisions for the assessment of a vehicle type

C2.1 Application for assessment

C2.1.1 Applications for assessment of a vehicle type with regard to the protection of pedestrians in the event of a frontal impact, must be submitted by the manufacturer.

C2.1.2 A vehicle representative of the vehicle type to be assessed must be submitted to the organisation responsible for conducting the assessment tests.

C2.1.3 The manufacturer is entitled to submit any data and test results which make it possible to establish with a sufficient degree of confidence that compliance with the requirements can be achieved.

C2.2 Assessment

C2.2.1 Where the vehicle type satisfies the relevant requirements, assessment will be granted.

C2.2.2 In case of doubt, in order to verify that the vehicle conforms to the requirements of this document, account must be taken of any data or test results provided by the manufacturer which may be taken into consideration in establishing the validity of the Guidance Note assessment performed by the assessment authority.

C2.3 Conformity of production

C2.3.1 As a general rule, measures to ensure the conformity of production must be taken in accordance with the provisions laid down in Article 10 of Directive 70/156/EEC.

C3 Technical requirements

C3.1 Scope

C3.1.1 This Directive applies to power-driven vehicles of category M1 of a total permissible mass not exceeding 2.5 tonnes, with the exception of multi-stage built vehicles produced in quantities not exceeding those fixed for a small series; heavier vehicles and multi-stage built vehicles may be approved at the request of the manufacturer.

C3.1.2 This guidance is also intended to offer a means of demonstrating that an active device meets the spirit of the EEVC WG 17 test requirements, at least until active systems are covered in more specific terms in any future development of the WG17 proposals.

C3.1.3 This specification applies to the frontal surfaces of all new passenger cars in categories M1, and to N1 vehicles derived from M1 as defined in Directive 70/156/EEC and intended for use in the EU.

C3.1.4 This specification has the purpose of reducing injuries to pedestrians and other vulnerable road users who are struck by the frontal surfaces of vehicles.

C3.2 Definitions

The definitions in Section 2 of Annex II of the EEVC WG 17 final report 1998 apply, with the addition of the following:

C3.2.1 ‘A’ pillar is defined as that portion of the vehicle structure supporting a side of the windscreen and connected to the ‘A’ post and vehicle roof.

C3.2.2 ‘Windscreen’ is defined as the clear or tinted multi-layer glass (or other material) layer mounted in and attached to the vehicle structure to permit forward vision from within the vehicle.

C3.2.3 ‘Scuttle’ is defined as the area in front of the base of the windscreen, between the bonnet rear edge and the windscreen. The scuttle may be considered to extend laterally to the sides of the bonnet. It may contain windscreen wiper mounting spindles, air intake grilles, and other such items.

C3.2.4 ‘Header rail’ if present, is defined as that portion of the vehicle structure supporting the top edge of the windscreen.
C3.2.5 ‘Correlated FE model’ means a finite element model of car and dummy, whose peak injury values during the primary impact match those from the equivalent full-scale test conducted under legislative conditions, to within 10%. Dummy contact points shall be within 50mm, measured in any direction, event timings shall be within +/-5ms and dummy trajectory for head, torso and lower limbs shall also be demonstrated to be similar by whatever means is acceptable to the assessment authority.

C3.3 Requirements

C3.3.1 Compliance with the requirements in Table C1 shall be checked in accordance with the methods set out in Section C3.4 and subsequent sections. A full-scale test includes the initial impact, and any subsequent impacts with the vehicle. This Guidance Note does not specify requirements for secondary impacts with other objects or the ground. FE models must be correlated to full-scale tests to the satisfaction of the assessment authority and must also meet the injury requirements in Table C1.

C3.3.2 The tabulated injury limit values may be modified in future with the advent of improved knowledge of injury mechanisms and tolerance, new or modified test dummies or changes to the assessment procedure.

C3.4 Test procedure

C3.4.1 To satisfy the requirements, manufacturers may perform the sixteen full-scale impact tests defined in Section C3.4.2, or use either of the alternative methods defined in Section C3.4.3 or C3.4.4. Data from all tests, whether full-scale or sub-system must be recorded as unfiltered and filtered data files, and be filmed using a high-speed camera(s) at a minimum of 400 frames per second. The recommended camera position(s) are shown in Figure C1. This should form part of the report submitted for approval.

C3.4.2 Option ‘A’. Sixteen full-scale vehicle tests.

C3.4.2.1 The manufacturer must supply the vehicle, which must be representative of those sold in the market place. The variant chosen must, in agreement with the assessment authority, be considered to be the worst-case variant for pedestrian protection.

Table C1 Maximum injury criteria values permissible for active pedestrian safety systems in full-scale impact tests and correlated FE models at 25mile/h (40km/h) and 30mile/h (48km/h)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Chest acceleration resultant 3ms exceedence (g)</th>
<th>Pelvis acceleration resultant 3ms exceedence (g)</th>
<th>Knee acceleration resultant 3ms exceedence (g)</th>
<th>Knee lateral shear force (kN)</th>
<th>Knee angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEVC WG17</td>
<td>1000</td>
<td>60</td>
<td>60</td>
<td>15</td>
<td>4.0</td>
</tr>
<tr>
<td>50%ile adult male OPAT</td>
<td>500(800)</td>
<td>45(60)</td>
<td>45(45)</td>
<td>100(100)</td>
<td>3.0(3.0)</td>
</tr>
<tr>
<td>6-year-old child OPAT</td>
<td>500(800)</td>
<td>55(60)</td>
<td>45(45)</td>
<td>100(100)</td>
<td>3.0(3.0)</td>
</tr>
</tbody>
</table>

The values for the injury tolerance criteria required for pedestrian protection systems were derived from values measured in finite element modelling and physical tests, where active systems were compared with passive systems. The injury limits stated in the Table are judged to be achievable for all cars with a carefully tuned system. EEVC WG17 limit values are included for reference.

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Figure C1 Orientation of the test dummy and recommended camera positions
C3.4.2.2 The vehicle must be tested as produced on the production line without further modification. The bumper and bonnet may be cleaned prior to each test with a cloth, and such cleaning agents as do not leave any residue on any vehicle surface.

C3.4.2.3 All devices designed to protect pedestrians shall be correctly activated during each test. It shall be the responsibility of the applicant for assessment to show that devices will act as intended in a pedestrian impact. Refer to C1 Introduction for further details.

C3.4.2.4 Any vehicle component which could change shape or position, such as ‘pop up’ headlights, other than active devices to protect pedestrians, shall be set to a shape or position that the assessment authority considers to be the most appropriate for the test, unless the manufacturer can demonstrate that the protection system repositions or re-shapes such devices appropriately before impact.

C3.4.2.5 A 50th percentile adult OPAT and a 6-year-old-child OPAT dummy will be impacted in separate tests by the front of the test vehicle travelling at the specified test velocity. This may be achieved through towing, using a suitable test facility, driving the vehicle or using a remote control system. Refer to Table C2 for test details.

C3.4.2.6 The orientation of the test dummy shall be 75° +/-5° from the direction the vehicle is travelling (as if a person was walking across the road and was struck from the side, but was facing slightly towards the oncoming vehicle). See Figure C1. This is to ensure that the arms do not interfere with the trajectory of the upper torso. Both legs must be straight and in mid-stride position, leading (instrumented) leg nearest the test vehicle. The angle between legs must be 15° - 20°. The dummy torso must be vertical within 5° and the head positioned looking straight ahead of the torso within +/-5°. The analysis of data is mainly concerned with resultant accelerations, thus orientation has little effect on the data produced. Where acceleration or its derivatives along individual axes is analysed, care must be taken to analyse trajectory and contact points to ensure injury potential conclusions can be substantiated.

C3.4.2.7 The dummy may be free standing in the test position, or held in position (recommended) by a connector attached to the dummy’s head, which must be released prior to impact. This support system must not have any measurable effect on the head trajectory or injury value recorded. Any attachment device connected to the dummy must not add more than 50g to the mass of the head, or affect the dynamic behaviour of the dummy during the test.

C3.4.2.8 The test dummy must be wearing clothing appropriate for the test. This includes appropriate shoes, and leg and torso covering, such as thin cotton trousers and a long sleeved tee shirt. The use of materials other than cotton is not permitted unless it can be shown that the friction coefficient is similar to that of cotton on car surfaces likely to be contacted during the test. Materials used for frontal impact testing dummy clothing are suitable.

C3.4.2.9 The test vehicle must be travelling at a constant forward velocity in a straight line at the moment before the impact, but may be braked after the dummy makes first contact with an impact protection device or vehicle component.

C3.4.2.10 Table C2 defines the conditions for the 16 full-scale impact tests. The assessment authority will define the worst-case impact position, which may be different for the adult and child dummies. This may be in line with headlamps, suspension struts, battery housings or other components or features believed to have the greatest potential for causing injury within the boundary of the bonnet. The choice of impact site and position of this feature(s) must be recorded and submitted as part of the test report. Bonnet edges may also be considered worst case for impact tests but may not ensure a head strike on the vehicle or protection system being assessed, so should be avoided as impact sites if possible. Option ‘C’ contains bonnet edge modelling requirements, and this may prove a more suitable method of assessing a ‘glancing blow’.

C3.4.2.11 In order to demonstrate protection for a range of pedestrian sizes and all potential impact sites, it is recommended that manufacturers conduct sub-system tests at appropriate sites, such as those proposed by EEVC WG17, even where the full-scale test results are acceptable.
C3.4.3 Option ‘B’. Four full-scale impact tests plus sub-system tests.

C3.4.3.1 Manufacturers may wish, as an alternative means of seeking assessment, to conduct the four full-scale impact tests defined in Table C3, combined with the sub-system tests defined in Section C3.4.3.2 to prove the protection system meets the requirements over the full width and depth of the car frontal surfaces. The assessment authority will choose the worst-case full-scale impact test sites, which may differ for adult and child dummy tests due to location of head strikes, for example. The choice of site and the logic behind the choice must be recorded and reported.

Table C3 Option ‘B’: Full-scale impact tests

<table>
<thead>
<tr>
<th>Test speed</th>
<th>50th percentile adult</th>
<th>6-year-old child</th>
</tr>
</thead>
<tbody>
<tr>
<td>25mile/h</td>
<td>30mile/h</td>
<td>25mile/h</td>
</tr>
<tr>
<td>(40km/h)</td>
<td>(48km/h)</td>
<td>(40km/h)</td>
</tr>
</tbody>
</table>

C3.4.3.2 Sub-system tests. Legform, upper legform and child and adult headform impactors shall be manufactured as described in the EEVC Working Group 17 report on sub-system test procedure and specification, which may be obtained from the EEVC website - www.eevc.org, and shall be calibrated and maintained as described in those documents.

C3.4.3.2.1 Legform impactor tests

C3.4.3.2.1.1 The complete vehicle or such complete sub-assembly shall be tested as defined in the EEVC WG17 final report or subsequent applicable regulation. This is intended to establish the conformance of active leg protection devices to the requirements.

C3.4.3.2.1.2 The test conditions, impact sites, impact velocity and requirements shall be as per the EEVC WG17 proposal or subsequent applicable regulation.

C3.4.3.2.1.3 The activation of active safety device(s) shall be set and recorded for the test, such that it coincides with the nominal activation time +/-5ms of such a device in an equivalent full-scale test, validated FE model or sub-system test.

C3.4.3.2.1.4 The distance from the legform impactor release point to active device first contact point shall be such that the impactor shall be in ‘free flight’ for a minimum of 100mm before contact is made and such that the test results are not influenced by legform rebound.

C3.4.3.2.2 Upper legform to bumper tests

C3.4.3.2.2.1 The complete vehicle or such complete sub-assembly shall be tested as defined in the EEVC WG17 final report or subsequent applicable regulation. This is intended to establish the conformance of active leg protection devices to the requirements.

C3.4.3.2.2.2 The test conditions, impact sites, impact velocity and requirements shall be as per the EEVC WG17 proposal or subsequent applicable regulation.

C3.4.3.2.2.3 The activation of active safety device(s) shall be set and recorded for the test, such that it coincides with the nominal activation time +/-5ms of such a device in an equivalent full-scale test, validated FE model or sub-system test.

C3.4.3.2.2.4 The distance from the upper legform impactor to active device first contact point shall be such that the impactor shall be travelling at a constant velocity for a minimum of 100mm before first contact is made and such that the safety device does not contact the propulsion system. If this contact is unavoidable, steps should be taken to understand the influence of the contact on the test results, either by simulation or by repeating the test with a ‘free-flight’ impactor of equivalent mass.

C3.4.3.2.3 Upper legform to bonnet leading edge test.

C3.4.3.2.3.1 This test may be removed for specific vehicles if preliminary tests with active and/or adaptive systems show no difference in results between this test and the upper legform to bumper test.

C3.4.3.2.3.2 The complete vehicle or such complete sub-assembly shall be tested as defined in the EEVC WG17 final report or subsequent applicable regulation. This is intended to establish the conformance of active leg protection devices to the requirements.

C3.4.3.2.3.3 The test conditions, impact sites, impact velocity and requirements shall be as per the EEVC WG17 proposal or subsequent applicable regulation.

Table C3 Option ‘B’: Full-scale impact tests

<table>
<thead>
<tr>
<th>Impact position</th>
<th>50th percentile adult</th>
<th>6-year-old child</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst case</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Test type</td>
<td>Full scale impact</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>
C3.4.3.2.3.4 The activation of active safety device(s) shall be set and recorded for the test, such that it coincides with the nominal activation time +/-5ms of such a device in an equivalent full-scale test, validated FE model or sub-system test.

C3.4.3.2.3.5 The distance from the upper legform impactor to active device first contact point shall be such that the impactor shall be travelling at a constant velocity for a minimum of 100mm before first contact is made and such that the safety device does not contact the propulsion system. If this contact is unavoidable, steps should be taken to understand the influence of the contact on the test results, either by simulation or by repeating the test with a ‘free-flight’ impactor of equivalent mass.

C3.4.3.2.4 Headform to bonnet top tests

C3.4.3.2.4.1 The complete vehicle or such complete sub-assembly shall be tested as defined in the EEVC WG17 final report or subsequent applicable regulation. This is intended to establish the conformance of active head protection devices to the requirements.

C3.4.3.2.4.2 The test conditions, impact sites, impact velocity and requirements shall be as per the EEVC WG17 proposal or subsequent applicable regulation.

C3.4.3.2.4.3 The activation of active safety device(s) shall be set and recorded for the test, such that it coincides with the nominal activation time +/-5ms of such a device in an equivalent full-scale test, validated FE model or sub-system test.

C3.4.3.2.4.4 The distance from the headform impactor release point to active device first contact point shall be such that the impactor shall be in ‘free flight’ for a minimum of 100mm before contact is made and such that the test results are not influenced by headform rebound.

C3.4.3.2.5 Headform to scuttle, header rail and windscreen impact tests.

C3.4.3.2.5.1 These areas were specifically excluded from EEVC WG17’s remit, but for the purposes of this Guidance Note these sites are required to be tested on small and medium-sized vehicles, where the assessment authority believes that a head impact may occur at that site.

C3.4.3.2.5.2 The windscreen surrounding areas are usually stiff because of other requirements such as roll-over and roof-crush protection. Thus, where contact with these sites is considered by the assessment authority to be possible in a 40km/h (25mile/h) impact then these sites must be tested to ensure that the active pedestrian safety system offers some protection on contact with these sites.

C3.4.3.2.5.3 Tests on these sites are with an adult dummy head only, because it is considered highly unlikely that a child would contact such sites. However, the assessment authority may test with a child headform instead of an adult headform if it is considered that a child could strike the scuttle or header rail in a 40km/h (25mile/h) impact.

C3.4.3.2.5.4 The complete vehicle or such complete sub-assembly shall be tested as defined in the EEVC WG17 proposal or subsequent applicable regulation. This is intended to establish the conformance of active pedestrian safety systems to the requirements.

C3.4.3.2.5.5 The test conditions, impact velocity and requirements shall be as per the EEVC WG17 proposal or subsequent applicable regulation.

C3.4.3.2.5.6 The activator of active safety device(s) shall be set and recorded for the test, such that it coincides with the nominal activation time +/-5ms of such a device in an equivalent full-scale test, validated FE model or sub-system test.

C3.4.3.2.5.7 The distance from the headform impactor release point to active device first contact point shall be such that the impactor shall be in ‘free flight’ for a minimum of 100mm before contact is made and such that the test results are not influenced by headform rebound.

C3.4.3.2.5.8 The vehicle rear may be lifted if required, as per Annex VI Section 1.2.2 of EEVC WG17 report, or subsequent regulation.

C3.4.3.2.5.9 One test shall be conducted at the site considered by the assessment authority to represent the worst case.

C3.4.3.2.5.10 Headform impact sites are to be chosen using the following method, and must be those considered by the assessment authority to represent the worst case.
C3.4.3.2.5.11 Scuttle

C3.4.3.2.5.11.1 If the bonnet covers the scuttle completely, there is no requirement to test, because the bonnet is already included as a test site. When this condition does not apply the vehicle shall be tested according to the following criteria.

C3.4.3.2.5.11.2 Where there is sufficient clear space for the headform to impact the scuttle, as defined by the adult headform diameter of 165 +/-1 mm and an impact accuracy tolerance +/-10 mm, and a suitable 'worst case' site can be aimed for by the propulsion unit, a test shall be performed. A similar assessment shall be made where the child headform test is chosen.

C3.4.3.2.5.11.3 Where the scuttle is too narrow to permit a test to be performed correctly, the assessment authority must decide whether a headform test shall be conducted and what may be inferred from it. For example a bonnet rear strike may or may not be considered injurious, but may permit sufficient deflection to allow contact with a windscreen wiper spindle or other protrusion or surface. The assessment authority shall judge such cases and include in the report the reasons for the decisions.

C3.4.3.2.5.11.4 It should be noted that there is not a requirement to substitute a child headform for an adult headform on the grounds of accessibility alone. Moreover, it is envisaged that most, worst-case tests will be at the site of the windscreen wiper spindle, although other sites may be considered more injurious.

C3.4.3.2.5.11.5 The impact inclination angle shall be as near to the vertical as is practically possible within the limitations of the propulsion unit and the ability to raise the rear of the vehicle. In instances where it is not possible for the impactor to be vertical then the direction of the impactor shall lie, to a tolerance of +/-2°, within a vertical plane parallel to the vertical plane passing through the vehicle fore/aft centreline.

C3.4.3.2.5.12 Header rail

C3.4.3.2.5.12.1 One worst-case test shall be performed at a site chosen by the assessment authority and be reported upon.

C3.4.3.2.5.12.2 The impact orientation shall be parallel to a vertical plane coincident with the fore/aft axis of the vehicle and perpendicular to a tangent running fore/aft at the windscreen surface top edge.

C3.4.3.2.5.12.3 The headform centreline shall pass through a point on the header rail nearest to the headform along the impact axis.

C3.4.3.2.5.13 Windscreen

C3.4.3.2.5.13.1 One impact test shall be at the centre of the windscreen, within +/-10 mm measured horizontally and vertically. The impact direction shall be perpendicular to a plane tangential to the surface within 2°.

C3.4.3.2.5.13.2 The legform and head impactor tests must be conducted for all vehicles fitted with active pedestrian safety devices. It is noted that certain vehicles are likely to be exempt from some impactor tests in the existing proposals and some bonnet sites, toward the rear, will not be tested.

C3.4.4 Option ‘C’. Four full-scale impact tests plus correlated FE models.

C3.4.4.1 If the manufacturer wishes to conduct full-scale tests 4, 8, 12 and 16 from Table C4, and submit correlated FE models for the rest of the conditions, as evidence of compliance with the requirements, a detailed report containing the correlated models defined in Table C4 will be required in addition to the test reports. The assessment authority will choose the worst case impact sites, which may be different for the adult and child dummies, and must record and report their choice and reasoning.

<table>
<thead>
<tr>
<th>Table C4 Four full-scale impact tests and correlated FE models</th>
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</thead>
<tbody>
<tr>
<td>OPAT dummy</td>
</tr>
<tr>
<td>Test speed</td>
</tr>
<tr>
<td>Impact position</td>
</tr>
<tr>
<td>Test type</td>
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</table>

Bonnet edge worst case left or right to be chosen by manufacturer. If there is no bonnet edge, or it coincides with the worst case full scale impact test site, the manufacturer must model the next worst case.
C3.4.2 Other positions determined by the manufacturer or assessment authority to be of concern, should also be modelled and reported. These may be chosen for head, chest or leg impact severity or other reasons.

C3.5 Certification procedure for the dummy
The specification governing OPAT adult and 6-year-old-child dummies, data acquisition and filtering, as well as calibration procedure and frequency and maintenance may be obtained from TRL Impact Test Group.
Appendix D: Sensors and control systems

D1 Introduction
Active adaptive secondary safety systems require appropriate sensor systems and control systems to guarantee their reliable performance in real life conditions. This Appendix of the Guidance Note gives the requirements for the use of sensors and control systems within, and attached to, cars. These requirements include measures of reliability, accuracy of detection, and some special test procedures. However, it should be noted that an extensive range of technologies is available to manufacturers, and thus the requirements contained herein should not, in their entirety, necessarily be considered to be applicable or sufficient.

It is intended that this Appendix be applied to a protection system in conjunction with one or more of the previous Appendices. The guidance relating to occupant frontal impact protection systems may be found in Appendix A, occupant side impact protection systems in Appendix B and pedestrian impact protection systems in Appendix C.

This guidance may be subject to change as new technologies emerge and are adopted by manufacturers and more data is collected in respect of the performance of active adaptive restraint systems. The term 'pedestrian' should not be interpreted to include other vulnerable road users, for example pedal cyclists and scooter riders, because they were neither simulated using finite element modelling techniques nor assessed by physical tests.

A control system will be required, independent of the active protection system(s) provided on the vehicle, whether it be frontal, side or pedestrian protection systems. Thus the section on control systems is applicable to all three systems included in this Guidance Note.

For the purposes of this Guidance Note a control system will comprise:

- Outer case.
- Connectors and wiring.
- Signal processor and amplifier.
- Central processor unit (cpu) with memory, input/output devices, information processor interface between signal processor and programmable cpu (e.g. analogue to digital converter).
- Output actuators with electronic signal conditioning.
- Software.
- Printed circuit board.

The requirements for control systems are divided into the following sections: general specification, reliability of function, reliability of detection, system logic and output type. The control system is considered to be a complete unit, thus reliability of function includes connector failure rates as well as systematic or random software failure rates.

Sensors designed to detect objects external to the vehicle may be fitted externally and will thus need to endure the elements, whilst operating with a high degree of reliability. Thus radar is frequently used for example, in automatic cruise control (ACC), and the research for this project has shown radar to be suitable for application in active restraint systems and it has thus been included within this Guidance Note. Other sensor technologies also considered are 3D laser scanners, infra red camera arrays and phased array radar systems. The task of sensing a pedestrian to the exclusion of other moving objects is particularly complex.

Internal occupant sensors operate in a less harsh operating environment, but may be required to function more accurately and with greater resolution. In the simplest systems, infrared or ultrasonic sensors may be used as position sensors, and force transducer systems may be mounted in the seat frame for the task of assessing occupant mass distribution. These sensors are more likely to be part of a linked sensor system, whereby the control system has inputs from two or more sensor types and makes a decision based on statistical confidence levels, or other decision-making processes.

It is not the intention of this guidance to restrict the choice of system available to a manufacturer. Thus, the specifications and requirements are defined to allow the assessment authority to approve a system by alternative means if such means are judged by the assessment authority to be appropriate.

It should be borne in mind that the basis for this Guidance Note is an extensive research programme sponsored by the UK DfT and described in TRL documents PR/SE/418/98, PR/SE/568/99 and PR/SE/219/00. It is to these documents that that those wishing to obtain the details of the derivation of the guidance should refer.

D2 Sensors
D2.1 Occupant sensors, front and side impact systems
D2.1.1 General
It is expected that sensors with the potential to detect front seat occupant presence and position, mass, height, gender and age may be used for frontal and/or side impact adaptive protection systems. The operation of these systems may or may not have been partly evaluated in the Guidance Note impact tests depending upon whether or not the sensors are sensitive to an impact test dummy. Nevertheless, the sensors must comply with the requirements of this section but the assessment authority may agree that some parts of these requirements may have been adequately examined in such tests.

D2.1.2 Operational frequency.
All occupant sensors must be capable of refreshing the information at a rate of 20Hz, every 0.05s, across the operating range of the sensor, when the vehicle is being driven and during the first 20ms of an impact.

D2.1.3 Accuracy requirements for occupant sensors.
D2.1.3.1 Occupant position must be accurate to within 15mm (0.015m).
D2.1.3.2 Occupant mass must be measured to within 1 kg.

D2.1.3.3 Occupant height, to top of head, chin or other specified feature, must be measured to within 15mm (0.015m).

D2.1.3.4 Age and gender may be detected and the manufacturer must provide information on the reliability and accuracy of detection. The manufacturer must also provide details of the technology used and the benefits and disadvantages.

D2.1.4 Reliability.
Overall reliability including the detection of the presence of an occupant must be in excess of 99.999%. In the event of a child seat or object on the front passenger seat being detected and identified, the control system must deactivate the restraint system for the front seat passenger. If the vehicle is fitted with an Isofix anchorage system for child seats then an integrated sensor for this purpose is acceptable.

D2.2 External object sensors, front and side impact systems

D2.2.1 General.
Some vehicles may be equipped with systems that incorporate sensors to detect an impact in advance of the event. A manufacturer must demonstrate that such sensors operate reliably in a wide range of weather conditions, including mist, heavy rain, snow, fog and with an excess of external debris such as mud. Manufacturers must also demonstrate that such a system can detect an impending impact reliably. Furthermore, if the system is designed to predict the severity of an impact by way of relative velocity and/or relative mass then it must also be demonstrated that these features operate correctly and reliably. In particular, the manufacturer must demonstrate that a system will fire when intended, and not fire inadvertently over a range of operating conditions commensurate with those that would be encountered during the life of the vehicle.

D2.2.2 Operational frequency.
All external object sensors must be capable of refreshing the information at a rate of 20Hz, every 0.05ms, across the operating range of the sensor, when the vehicle is being driven.

D2.2.3 Object detection.
The manufacturer must state clearly the operating range of the detection system and then demonstrate the successful operation as follows. The sensor system shall be tested, installed in a vehicle or mounted on a device, such as a trolley, that can be propelled at velocities up to the maximum required for the tests. The tests shall be of the sensor system travelling towards a range of static objects, at velocities ranging from the maximum velocity at which the system shall definitely not fire, up to 50mile/h, 80km/h.

D2.2.4 A report detailing the tests undertaken must be submitted with the request for Guidance Note assessment.

D2.2.5 The objects to be detected must include a typical small high volume car for example a Ford Ka, Renault Clio or Daewoo Matiz when viewed from the front, side and at a 45° angle. Other objects shall include a metal and wooden pole, of diameter 0.2-0.3m, and a concrete object 0.5m diameter and 1 m in height.

D2.2.6 Detection range must be verified in real time up to 40m and must be within 5% of the actual distance to the object in real time.

D2.2.7 Relative velocity must be calculated to within 5% of the actual value in real time over the range of angles of impact. These are +/-30° from the straight-ahead direction for frontal and +/-30° from perpendicular for side impacts.

D2.2.8 Bearing (if not covered in D2.2.7) must be calculated or recorded to within 5% of the actual value.

D2.2.9 Mass (if applicable): in addition to the requirements in D2.2.5, the system must recognise an articulated heavy goods vehicle and a bus or coach from the front, side and rear.

D2.2.10 External object sensors must perform to the requirements for reliability and detection in a wide range of weather conditions including heavy rain, snow, sleet and fog and with an excess of external debris such as mud. In addition, the manufacturer must show that the system is not adversely affected in conditions prevailing during lightning. Such conditions will need to be simulated using a transient electromagnetic field of suitable strength and duration. A list of specifications may be found in Section D3.5 and D3.7, but each manufacturer will, in addition, be required to submit proprietary specifications and a report describing the function and limits of the proposed technology when tested to their proprietary specifications. Where the results are marginal, the assessment authority may permit a pass to be awarded if the conditions causing the marginal performance are considered abnormal.

D2.3 Sensors for the detection of pedestrians

D2.3.1 The detection of a pedestrian needs to be demonstrated if an active pedestrian protection system, as defined in Appendix C, is fitted to a vehicle. Systems that rely upon an airbag(s) for protection will need to demonstrate that a pedestrian can be detected in advance of an impact such that the pedestrian is not struck by an expanding airbag and thereby thrown to the ground in front of the vehicle.
D2.3.2 Pre-impact sensing is a requirement for fully active systems, in which case, the capability to identify and track pedestrians whilst the car is travelling at up to 30 mile/h (48 km/h) must be demonstrated satisfactorily by the car manufacturer. The sensor system shall be tested installed in a vehicle or mounted on a device, such as a trolley, that can be propelled at velocities up to the maximum required for the tests. The tests shall be of the sensor system travelling towards or moving past volunteer human pedestrians or with a manikin exhibiting human-like response to the sensor including simulated walking, running and turning. The test velocity shall range from the maximum velocity at which the system shall definitely not fire, up to 30 mile/h (48 km/h). The tests may be a combination of the two methods, vehicle mounted and moving device (trolley) mounted. A report demonstrating capability must be submitted with the application for Guidance Note assessment.

D2.3.3 Sensor detection area for pedestrian protection systems. Refer to Figure D1.

![Figure D1 Pedestrian sensor detection area](image)

D2.3.3.1 For a pedestrian detection system, the sensor detection area required is defined as follows: the manufacturer shall identify the two points at the front of the car that represent the nearside and front offside corners. A 90° arc shall be drawn from each of these points such that the arc begins when the radius is at 90° to the longitudinal axis from the vehicle and ends when the radius is parallel to the longitudinal axis. A line at 90° to the longitudinal axis shall join the two segments as shown in Figure D1. The resulting area defines the area in which a pedestrian must be detected. The radius of the arcs must be the same and must not be less than 10 m.

D2.3.4 The sensor must be capable of detecting a child or adult anywhere in the detection area, with a reliability of 99.999%.

D2.3.5 Range and relative velocity measured must be to within 5% of actual values and a report submitted to the assessment authority.

D2.3.6 Operational frequency: pedestrian sensors must be capable of refreshing the information at a rate of 10 Hz, every 0.10 s, across the operating range of the sensor, when the vehicle is being driven.

D2.3.7 Pedestrian sensors must satisfy the environmental tests referred to in Section D3.5 and D3.7.

D2.4 Sensor abuse tests, accelerated ageing tests and multiple unit operation

There are a large number of specifications and regulations that sensors and control systems must meet. A selection of these is listed in Section D3.5 and D3.7; the list is not exhaustive, since many not listed are applicable to one technology, or are proprietary documents. General specifications include tests specific to a manufacturer. These may relate activation in error or maliciously, and accelerated environmental ageing tests to establish that a system has a 15-year life expectancy consistent with current non-adaptive restraint systems and automatic cruise control (ACC) systems, for example. In addition, sensors and control systems must satisfy current requirements for immunity from and emission of electromagnetic contamination (EMC) and must not interfere with the normal operation of other in-vehicle or stationary systems.

D3 Control systems

D3.1 General

All the protection systems included in this Guidance Note will have a similar control system and thus only one section is required on control systems. The section is divided into separate topics, since it is easier to provide lists of specifications and procedures. Where a topic is applicable to only one system or technology, this is stated.

D3.2 Control system capabilities

D3.2.1 It is required that the control be equipped with at least the following capabilities:

- Self-diagnostics of internal functions
- Self-diagnostics of squib lines, to detect, for example, resistance that has become high or low relative to the correct value including a short to earth and a short to the supply voltage.
- Fault recording.
- Crash recording
- Crash algorithm
- Communication bus (IS09141 and/or CAN)
- Warning lamp control and diagnostics, buzzer (possibly via CAN, only to the instrument panel control hardware)
**D3.3 Control system decision-making**

D3.3.1 It must be demonstrated that the control module correctly decides on the output(s) at every stage in the control system and that this output is provided at the correct time. Decision-making includes interpretation of input data, processing and categorising occupant or pedestrian data and whether or not to activate a system at a given time. Methods likely to be used include look-up tables, algorithms, fuzzy logic, neural networks and confidence/probability assessments. Manufacturers may undertake specific tests under known conditions and this evidence of compliance should be supported by results of extensive road trials and in sub-system tests. These shall be detailed in a report submitted to the assessment authority.

D3.3.2 Examples of decision-making include:
- Occupant mass, height and/or position categorisation.
- Selection of the pre-tensioner force and movement.
- Selection of airbag vent area, if the vent can be varied.
- Crash severity estimation, from pre-impact sensors or from analysis of car acceleration levels during the first part of the impact.
- Occupant restraint system characteristics must be correctly selected even though one or more inputs may be missing, from a look up table for example, or where the inputs are confusing, such as when a tall driver is positioned close to the steering wheel.
- To be able to differentiate between a pedestrian and a pedestrian-like object.
- An object detected is a small to medium sized car, of unknown mass, but it is travelling at a much higher velocity than the subject car on an intersect course.

**D3.4 Output resolution**

D3.4.1 The characteristics of some protection systems will be continuously variable and will thus provide a smooth change in output for any change in input signal. Where this is not the case, such as in multi-stage devices, the car occupant will be afforded a step change in restraint system performance.

D3.4.2 The control system must be capable of deciding where the step change is applied, and must then be capable of providing an appropriate restraint performance for the occupant. The maximum change permitted is one that corresponds to a change of 20% in any injury criteria specified in the following appendices. Sub-system tests or simulation using FE models containing the Anthropomorphic Test Device (ATD) specified for assessment of that system may demonstrate this. Such an assessment must include the use of 5th, 50th and 95th percentile dummies for frontal restraint systems.

**D3.5 Functional reliability of control systems**

D3.5.1 Control systems must be reliable, and compliance with the following specification relating to civilian control systems may be accepted as proof of reliability.
- IEC 61508, especially level ‘4’ (or better) failure rate over time. Levels are defined as the probability of a dangerous failure occurring per hour of continuous operation. The probability of a failure for level 4 reliability is between $1 \times 10^{-9}$ and $1 \times 10^{-8}$.

D3.5.2 Manufacturers are also required to report the following: parts count, component quality and reliability, number and type of redundant sensors, use of parallel signal processing, dual memory, dual processors, arbiter systems and watchdog systems.

D3.5.3 The sensors, control system and safety system performance must not degrade more than 10% during a 15 year in-vehicle life.

**D3.6 Failure modes**

D3.6.1 The ‘worst case’ failure modes must be identified by manufacturers and dynamically tested or simulated using finite element (FE) models to establish the potential for injury. The failure mode may be a non-activation or inappropriate activation of the whole protection system or part of it. This must be fully understood and the consequences established and reported, because such occurrences may cause injuries to be sustained by an occupant or pedestrian that are more severe than if the system were not fitted. A report on all the likely failure modes of the control system and their effects must be submitted with Guidance Note assessment applications.

D3.6.2 The manufacturer must declare ‘must fire’ and ‘no-fire’ thresholds, and evidence to support this choice must be provided to the assessment authority. Such evidence may be obtained from sub-systems tests or FE models. See D5 Definitions for a definition of ‘must fire’ and ‘no fire’ thresholds. The manufacturer must demonstrate that the control system can respond correctly at these thresholds.

D3.6.3 The control system must perform adequately in a fail-safe mode for all dummies specified in tests to assess each system. The potential injury severity specified for each system in FE modelling, dynamic sub-system tests (including sled tests) and/or in full-scale vehicle tests as required must not be exceeded. This potential injury severity must be no greater than is specified for current systems. Manufacturers may wish to perform sub-system tests rather than full-scale tests for the fail-safe mode tests, and the report must be submitted with the request for Guidance Note assessment.
D3.6.4 Spurious input signals must not effect the control system. Fuzzy logic, neural networks or other similar methods are acceptable for this purpose. Comments on tests to assess and eliminate this type of effect must be included in the report supplied to the assessment authority.

### D3.7 General specifications and design, development and validation procedures for sensors and control systems

**D3.7.1** The sensor and control system must satisfy the following requirements:
- EC Regulation 95/54/EC - Type approval for vehicle electromagnetic emissions.
- ISO 11898 or SAE J2284 Controller Area Network specification.
- IEC 68-2-2 High temperature test.
- IEC 68-2-1 Low temperature test.
- IEC 68-2-6 (BS EN 60068-2-6) Vibration (sinusoidal) test.
- IEC 68-2-32 (BS EN 60068-2-32) Free fall (drop test).
- SAE J551-1 Performance levels and methods of measurement of electromagnetic compatibility of vehicles and devices (60Hz to 18GHz).
- ISO 11452-3 Electrical disturbances by narrow band radiated electromagnetic energy part 3- TEM cell
- ISO 11452-4 Electrical disturbances by narrow band radiated electromagnetic energy part 4- BCI
- ISO 11452-5 Electrical disturbances by narrow band radiated electromagnetic energy part 5- Stripline
- ISO 11452-6 Electrical disturbances by narrow band radiated electromagnetic energy part 6- Parallel Plate
- ISO 10605 Road Vehicles -Electrical disturbances from electrostatic discharges
- MIL-STD 461 D Requirements for the control of electromagnetic interference emissions and susceptibility
- CISPR 25 Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles (see also CISPR 11, 12, 16, 22 and 26)
- SAE J1113 Electromagnetic compatibility measurement procedure for vehicle components. (see also J551-1).

**D3.7.2** Electrical and electronic specifications applicable to control systems and some sensor technologies. There are many specifications that are technology specific or manufacturer specific, but in the UK may include the following:
- ISO 7637-1 (BS AU 243:Part2) Electrical disturbance by conduction and coupling
- ISO 11452-2 Electrical disturbances by narrow band radiated electromagnetic energy part 2- absorber lined chamber
- ISO 3795 Determination of burning behaviour of interior materials (flammability).

**D4 Environmental considerations**

**D4.1** It should be noted that all components and assemblies used in or on vehicles must not harm or injure vehicle occupants, other drivers, vulnerable road users or animals, birds or humans through long- or short-term exposure. They must also not, through chemical reaction with cleaning agents or during or after a fire, cause chemical products to be released into the environment that could prove harmful.

**D4.2** There are a number of regulations that apply to this statement, and the manufacturer must state with which of these their control system complies. These may include:
- ISO 3795 Determination of burning behaviour of interior materials (flammability).
- Refer to Directive 95/28/EC Burning behaviour of internal materials.
- ECE Regulation No. 34 Prevention of fire risks.
- Refer to FMVSS 302 Flammability of interior materials.
- Manufacturer specific: Cleaning fluid resistance.
- Manufacturer-specific: Resistance to dust and water ingress.
- Manufacturer-specific: Resistance to salt spray - depends on likely exposure of components and assemblies to the elements.
- Manufacturer-specific: Noise & Vibration - in addition to those specified in Section D3.7.
- Manufacturer-specific: Colour fastness to light; sun/UV resistance.

D5 Definitions

D5.1 ‘No fire’ threshold - the impact speed or crash severity at and below which the protection system must not activate with a reliability of 99.999%.

D5.2 ‘Must fire’ threshold - the impact speed or crash severity at and above which the protection system must activate with a reliability of 99.999%.
Abstract

This Guidance Note is intended to assist in the assessment of advanced systems to protect car occupants in frontal and side impacts and pedestrians in collisions with car fronts. It is based on a programme of research carried out by TRL Limited and considers three types of systems. These are: a system to protect front seat occupants in frontal impacts; a system to protect front seat occupants in side impacts, and a system that could be fitted to the front of a car to protect pedestrians. An implicit part of all of the systems is an electronic control unit and various sensors and a section relates to these components.

This Guidance Note is not a legal document and compliance does not guarantee compliance with any regulatory requirement.

Related publications


CT47.3 Pedestrian accident studies update (2000-2002) Current Topics in Transport: selected abstracts from TRL Library’s database (price £20)

CT73.3 Air bag safety system update (2000-2002) Current Topics in Transport: selected abstracts from TRL Library’s database (price £20)


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