Road Safety Data, Collection, Transfer and Analysis

Deliverable 5.2
Catalogue of the Current Safety Systems

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EXECUTIVE SUMMARY

This document reports on the 2 complementary activities undertaken in sub-task 5.2.3 of EC DaCoTA regarding safety systems fitted to vehicles. The first describes current or proposed safety systems and the second identification procedures to recognise if such systems are fitted to vehicles.

Development of safety system descriptions to support work on drivers' needs and evaluations of safety benefit

When considering how safety systems fulfil drivers' needs, leading to an evaluation of overall benefit, it is important to understand the overall functionality of the system, as many design parameters as possible and consider previous evaluation work. Therefore, as a tool for the analysts carrying out the drivers' needs and safety benefit evaluations in Work Package 5 of DaCoTA, a set of Excel sheets has been created using a standard template. For each of the 31 safety systems covered the following are considered:

- Aims of the system
- Functions covered by the system (intentional and unintentional)
- Phases of the accident sequence upon which the system is acting
- Level of intervention
- Technical specifications
- Previous evaluations

Chapter 1, 'Safety System Descriptions to Support Benefit Evaluations', gives the background to the development of the Excel sheets, describing the principles for their selection, data/information collection and presentation in the proposed format. The collation of data for these Excel sheets forms a large part of the work of this sub-task.

Review of existing identification procedures related to safety systems

Chapter 2, 'Review of Existing Identification Procedures Related to Safety Systems' outlines the approach undertaken to understand the feasibility of recording all of the active, passive and integrated safety systems found within a vehicle to a European wide database. This data can be combined with a road accident database so that it can be used for statistical analysis of the performance of safety systems.

The aims of the present review are to underline the available information sources that could be used to gather data on safety equipment, to review the variable level of quality and the feasibility and length of time that it would take to incorporate these measures. This will in turn lead to a possibility of developing a standard recording system for every passenger vehicle that is introduced to the European market.

Moreover, a review of Welsh (2009) has been carried out, as the author contacted Government organisations, commercial organisations, research bodies, motor manufacturers and the insurance industry together with a literature review with regards to the feasibility of a fitment database for the United Kingdom.

In summary two main methods of source data were identified. Either collecting data according to a make/model/ variant approach or a VIN number method. An outline of these possible approaches and a possible method that would combine these approaches is highlighted in the discussion section of this chapter. Further contact with the organizations outlined in Section 2.3.1 would be required to quantify the applicability of the possible data collection methods.

TERMS AND DEFINITIONS

DfT	UK Department for Transport
EC	European Commission
ESC	Electronic Stability Control
EuroNCAP	European New Car Analysis Program
FCW	Forward Collision Warning
ISO	International Standardization Organization
LDW	Lane Departure Warning
NHTSA	National Highway Traffic Safety Administration
PTI	Periodical Technical Inspections
SAE	Society of Automobile Engineers
UNECE	United Nations economic Commission for Europe
USNCAP	United States New Car Analysis Program
VCA	Vehicle Certification Agency
VIN	Vehicle Identification Number

1. SAFETY SYSTEM DESCRIPTIONS TO SUPPORT BENEFIT EVALUATIONS

1.1. Introduction

Driving is a complex activity, road traffic crashes are proof of this. One of the main components of this complexity for the road user is the necessity to permanently share and control his/her limited attention resources at the right places and the right moments. This also involves keeping available a part of these resources in case of unexpected events, and to spare them in order to be able to function efficiently in the long term. Thus, every component of information added to the driving task is potentially able to consume attention capacity and maybe to lessen performance by leading to different forms of attention disturbances. For that reason, intelligent transport safety functions must not only be adapted to drivers' needs but also be restricted in order not to overload or disturb drivers' capacity.

Two steps of analysis are necessary to assess the potential effectiveness of a safety system:

- First, the capacity of the system to correctly address drivers' needs has to be estimated by comparing the functionalities of the system with the difficulties met by the driver in the accident situation. This asks for a clear and precise description of the way the system is acting.
- Then it must be taken into account the physical and operational constraints found in accident situations that the system shall be able to compensate for, in order to be fully efficient. This necessitates a thorough understanding of the specifications of the system functionality.

In Work Package 5 of the DaCoTA project analysts consider how safety systems fulfil drivers' needs, leading to evaluations of overall benefit. Information regarding each safety system is required to inform such work, to understand the overall functionality of the system, as many design parameters as possible and to consider previous evaluation work.

Therefore one of the activities of Task 5.2.3 was to collate into one place such information to be used as a tool for the analysts. For this reason, a set of Excel sheets has been created using a standard template which was created by the Task 5.2 leader, taking into account the requirements and objectives of the drivers' needs analysis. The collation of data for these Excel sheets forms a large part of the work of this sub-task. In support of this work an Excel sheet of weblinks to the safety areas of car manufacturers websites was also created, to give easy access to examples already on the market.

1.2. Selection of Safety Systems

The list of 21 safety systems assessed for drivers' needs in the EC 6th Framework TRACE (TRaffic Accident Causation in Europe) Project[1] was a starting point for selection (D4.1.5[2]). Considering the most promising and relevant technologies this list was revised with the Work Package and Task Leaders and additions made to create the list of 31 safety systems to be included (Table 1).

Table 1: Safety systems included

Name	Abb.	Category
Advanced Adaptive Front Light System	AAFS	Visibility
ABS (Antilock Braking System)	ABS	Dynamic Control Longitudinal
Adaptive Cruise Control	ACC	Dynamic Control Longitudinal
Airbag Pedestrian Protection	PedPro	Protection
Alcolock Keys	AK	Driver Behaviour
Anti Whiplash Seat	AW	Protection
Automated Headlights	AutoLights	Visibility
Blind Spot Detection	BS	Visibility
Brake Assist	BA	Dynamic Control Longitudinal
Collision Avoidance and Automatic Emergency Braking (not pedestrian)	CA (AEB)	Dynamic Control Longitudinal
Collision Warning	CW	Warning
Drowsy Driver Detection System	DDS	Driver Behaviour
eCall	eCall	Localization/Prevention
Electronic Stability Control	ESC	Dynamic Control lateral
Event Data Recorder	EDR	Driver Behaviour
Intelligent Speed Adaptation	ISA	Dynamic Control Longitudinal and Speed / Warning
Intersection Control	IC	Communication
Lane Changing Assistant	LCA	Warning
Lane Keeping Assistant	LKA	Dynamic Control Lateral
LDW (Lane Departure Warning)	LDW	Dynamic Control Lateral
Low Friction Detection	LoFrctD	Localization/Prevention
Night Vision	NV	Visibility
Precrash (Presafe)	PreSAFE	Protection
Predictive Assist Braking	PBA	Dynamic Control Longitudinal
Rollover Detection	RollD	Dynamic Control Lateral
Speed Cameras	SpdCam	Localization/Prevention
Traffic Sign Recognition	TSR	Communication
Tyre Pressure Monitoring and Warning	TPMS	Warning
Vulnerable Road Users Protection	VRU	Dynamic Control Longitudinal
Youth Driver Monitoring	DrvMon	Driver Behaviour
Youth Key	YK	Driver Behaviour

The aim was to include safety systems covering all types of road users and vehicles; cars, goods vehicles, buses, bicycles, powered two wheelers and pedestrians, along with infrastructure technologies. Safety systems for primary, secondary and tertiary safety were included. As expected with such a wide range of safety systems

[1] www.trace-project.org
[2] TRACE D4.1.5 Assessing drivers' needs and contextual constraints for safety functions: A human centred approach from in-depth accident analysis

different functional modes are present from systems that are completely automatic (for example, electronic stability control) to those requiring driver reaction (for example, lane departure warning). This diversity in the selection criteria was included as to not limit the potential of further evaluation work in WP5, as the road safety areas covered by ERSO are broad. On the other hand it would have been unmanageable to include too many safety systems. The list was considered by expert opinion to be a good balance of important safety systems that are currently on vehicles or are likely to be realised in the near future.

The category column in Table 1 was included to put the safety systems into generic descriptive categories that could be used in the further activities of WP5 regarding drivers' needs and system effectiveness evaluation. These categories are more descriptive, in line with the focused nature of the drivers' needs work, than the more general active, passive or integrated system categories sometimes used.

Furthermore, this list can easily be updated or more safety systems can be added as it acts as a reference list of available road safety systems that has both understandable and relevant information to eSafety research activities.

It has not been possible with the resources available in the sub-task to categorise all technologies by vehicle make and model. For the reasons discussed in Chapter 2 this would be a very large, resource intensive task. In particular it is very difficult to address the large selections of technologies available as optional fitment. Clearly the inclusion would be a next step in improving the catalogue.

1.3. Information Collated

An Excel template was provided by the Task 5.2 Leader (IFSTTAR) as guidance to the information that the analysts of drivers' needs and safety evaluation would find useful. The fields selected were based on many years of experience in the IFSTTAR team of examining drivers' needs. It was decided to use Excel due to the tab system allowing easy access to the different safety systems. Different sections with the descriptive headings given below were used.

System studied

In the area of eSafety, similar systems often have different names that differentiate the different vehicle manufacturers or OEMs. To move forward in research activities such as those in WP5 it is important to decide on names and abbreviations that are the best representation of the system, either in terms of the most commonly used or the best description. The name and abbreviation decided upon is stated here, along with guidance on other names and abbreviations that the description covers. For example, it is noted that Brake Assist (BA) also covers Emergency Brake Assist (EBA).

Aims of the system

A high level description of system aims along with pictures or figures that immediately describe the systems aims or operation. For example, for Advanced Adaptive Front Light System (AAFLS):

Predominantly AAFLS refers to headlights that turn relative to the vehicle to boost visibility through bends (in reaction to steering angle and sometimes yaw) although some systems can also adjust the light pattern for different road speeds and visibility (for example narrower beam on motorways).

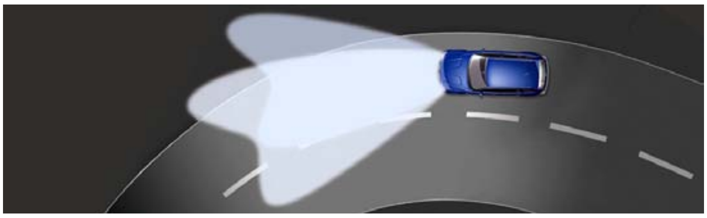

Figure 1: Advanced Adaptive Front Light System (AAFLS)

In this section other technologies or features that are associated with the main safety system are also mentioned: *Other technologies closely associated with AAFLS are Cornering Light Assist and Auto High Beam assist*

Functions covered by the system (intentional and unintentional)

The fundamental functions that the system provides. An example for Adaptive Cruise Control (ACC) would be *keeps a set distance to vehicle in front*. Unintentional functions are often more difficult to define and have been considered as functions away from the primary safety functions (safety or non-safety related). For example, *improved traffic flow* would be a function of ACC. Whilst this would not be necessarily unintentional, the designers would be aware of it, it is not a primary safety function.

Phases of the accident sequence upon which the system is acting

The accident sequence is split into 5 phases (stages) in a table (references: EC TRACE D5.1, Fleury (2001 and 1985), Brenac (1997), Ferrandez (1986)). At each phase the actions or potential actions that the safety system undertakes are recorded. There can be more than one action per phase. An example for ACC is given.

Table 2: Levels of intervention

Phases	Evaluation of actions
Driving Phase	ACC may employ radar, laser or machine vision (camera) to continuously monitor the leading vehicle
Rupture Phase	The system intervenes if the current preselected speed or headway would lead to a likely collision
Emergency Phase	The system decelerates the vehicle
Crash Phase	If a collision is inevitable the system may have been able to decrease speed and lower crash severity
Rescue Phase	-

- *Driving Phase*, during this phase no unexpected event or hazard has occurred or been detected.
- *Rupture Phase*, an unexpected event or hazard occurred which surprised the road user.
- *Emergency Phase* is defined as the distance and time between the rupture phase and crash phase.
- *Crash Phase*, when the impact is taking place.
- *Rescue Phase* is the period after the crash phase and then when passengers are being evacuated from the vehicle.

Level of intervention

Table 3 (EC TRACE D6.1) is included in each Excel sheet and describes the different levels of intervention that safety systems can provide. Table 4 is then completed.

Table 3: Levels of intervention

<table>
<tr><td>Perception</td><td colspan="2">The device only gives information to the user. The driver is free to take the information into account and keeps the capacity to decide to put forward or not an action.</td></tr>
<tr><td rowspan="4">Mutual control</td><td rowspan="4">Form of cooperation: the device takes over various control activities.</td><td>WARNING MODE: The device provides a judgement on driver performance under the form of a warning.</td></tr>
<tr><td>LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.</td></tr>
<tr><td>CORRECTIVE MODE: The driver requests the device to control by correcting his actions if they result in exceeding a predefined level.</td></tr>
<tr><td>ACTION SUGGESTION MODE: The device suggests an action to the driver.</td></tr>
<tr><td rowspan="3">Delegation of function</td><td rowspan="3">Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion</td><td>REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them</td></tr>
<tr><td>PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.</td></tr>
<tr><td>MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.</td></tr>
<tr><td>Automatic</td><td colspan="2">The device takes over the control without intervention or intention of the user.</td></tr>
</table>

Table 4: Levels of intervention (Lane Keeping Assist shown as example)

<table>
<tr><th colspan="2"></th><th>Specifications</th></tr>
<tr><td colspan="2">Perceptive Mode</td><td>-</td></tr>
<tr><td rowspan="4">Mutual Control</td><td>Warning Mode</td><td>Warns of lane departure or that system is not identifying road markings</td></tr>
<tr><td>Limit Mode</td><td>-</td></tr>
<tr><td>Corrective Mode</td><td>-</td></tr>
<tr><td>Action Suggestion Mode</td><td>Additional torque to the steering wheel will be an indication to driver that system is taking some control.</td></tr>
<tr><td rowspan="3">Delegation of a function</td><td>Regulated Mode</td><td>-</td></tr>
<tr><td>Prescriptive Mode</td><td>-</td></tr>
<tr><td>Mediatised Mode</td><td>-</td></tr>
<tr><td colspan="2">Automation</td><td>Provides additional torque to the steering wheel, which increases the resistance in the steering wheel or brakes one side of the vehicle.</td></tr>
</table>

Technical specifications

To understand whether a safety system can address drivers' needs, overall objectives and technical parameters need to be understood. On one hand, it can be difficult to find such information as many details are not included in the literature that manufacturers provide. On the other hand, the amount of information can be overwhelming if each manufacturer has a different implementation. The aim was to give a good representation of generic system functions and parameters whilst also describing the functionally of current technologies fitted to vehicles, giving examples on particular vehicles. It is then possible for the analyst evaluating such systems to establish a feel for a generic system and project the functionality of such a system onto available accident data and to evaluate if the system really meets drivers' needs. By including a particular vehicle implementation or system as an example no endorsement of that particular product is being given by the authors or the DaCoTA project, the publically available information is just presented as an example.

For many of the safety systems most information available regards their implementation in passenger cars but implementations in goods vehicles, powered two wheelers and buses have also been included when relevant.

Parameters considered are specific to the functionality of the system but general examples are; distance operates at, capacity to view (e.g. darkness, poor weather), deceleration capacity, speeds at which activated.

To use Night Vision as an example: *An active system or near-IR system illuminates the night with projected infrared light. Can see warmer living things just as clearly as it can spot colder, dead animals or non-living (inanimate) objects. Maximum effective range of less than 600 feet (183 meters). A passive system uses far-IR or FIR technology registering images based on body heat and produces images that resemble a photo negative. Therefore doesn't 'see' dead animals or objects in the carriageway such as fallen trees. It has a range of around 980 feet (299 meters).*

Previous evaluations

In terms of both methodology and results it is important to recognise previous evaluations of safety systems which are provided as links. Whilst all references available are considered, in particular the outputs of the EC TRACE[3] and eIMPACT[4] projects and references from the eSafety Support website are included, along with references from a large COWI report for the EC[5].

[3] www.trace-project.org/trace_template.html

[4] www.eimpact.info/results.html

[5] COWI. (2006) Cost-benefit assessment and prioritisation of vehicle safety technologies. Final report. Contract TREN/A1/56-2004. European Commission, Brussels. www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf

1.4. Summary / Discussion

The assembled Excel sheets have been created to act as a central place in which analysts can quickly acquire the information described above along with web links to vehicle manufacturer, OEM, governmental, safety and research organisation websites. Unless analysts are evaluating a specific vehicle, or a group of vehicles using exactly the same technology, for an estimation of real world effectiveness further expert judgement is needed for the particular evaluation being undertaken.

With so much information available the guides can never be complete and definitive with so many available technologies. The amount and quality of detailed technical information published is obviously a restriction to the completeness of the information collated. Sometimes this is due to a sensitivity to publishing the finer details of system parameters by manufacturers but it is also clear that for material aimed primarily at the buying public there is a limit to the amount of information that they want or require. It is enough to know the basic concept of the system, overall benefit and an assurance by the manufacturer that the system works. The information published through EuroNCAP (EuroNCAP Advanced) is particularly thorough in this respect, as the manufacturers are required to supply enough technical information to demonstrate the safety benefit to EuroNCAP[6].

The work undertaken here provides a template that can be used in the future to update the information held in the information sheets. Regular monitoring of key websites and manufacturers sales and marketing information could periodically update the information available to analysts.

[6] Explanation of EuroNCAP Advanced reward system
www.euroncap.com/rewards/explained.aspx

2. REVIEW OF EXISTING IDENTIFICATION PROCEDURES RELATED TO SAFETY SYSTEMS

2.1. Introduction

This activity outlines the approach undertaken to understand the feasibility of recording all of the active, passive and integrated safety systems found within a vehicle to a database. This will in turn allow existing or new accident databases to be used for statistical analysis of accident data with regards to said safety systems.

At present, accurate data in terms of the specific active, passive and integrated safety systems being fitted into vehicles are not readily available. This causes difficulties in using analytical methods to analyse the effectiveness of the specific technologies and also causes problems in a broader sense when doing accident research in that all vehicles are analysed under the assumption that they are similar depending on the vehicle type. The knowledge of the safety systems that are present in a vehicle would help clearer analytical methods to be developed for vehicle safety and allow for a more thorough analysis of vehicle crash data. This analysis will in turn allow a clearer link to be developed for before-after crash study statistics with regards to specific systems and also injury mitigation measures.

Examples of such studies are the Electronic Stability Control (ESC) effectiveness reviews carried out by Erke (2007), Page and Cuny (2006) and Thomas and Frampton (2006), highlighting the effectiveness of ESC in single vehicle, multi vehicle and head on accidents. The development of a fitment database throughout Europe would allow for a more conclusive statistical analysis to be conducted on all safety measures present, including ESC, for all vehicles.

Some of the challenges that need to be addressed before the launching of such a database are:

1. The optional nature of safety equipment fitted in vehicles. Vehicles are often not uniform with regards to safety system fitment even if they are the same make and model. Vehicle`s have a standard fit and then optional extras can be purchased, with levels of standard fit and the options available changing depending on the country.

2. Vehicles can be altered throughout their lifetime by either fitting newer safety equipment or removing/altering equipment that is already present in the vehicle, which is difficult to record.

3. The Vehicle Identification Number is not standard throughout Europe. Scully et al (2005) carried out a review of the VIN system throughout the world and discovered that other than the USA (where NHTSA mandate the collection and interpretation of VIN data), in all other countries some of the features of the VIN are consistent (such as build date, manufacturer) though other variables including safety features are not.

4. Information with regards to equipment fitted on vehicles is not provided to researchers by manufacturers. Accessing this data is only possible through commercial companies that charge for this service and also do not provide complete information so a number of companies would be required to obtain full data.

5. The name of a vehicle is sometimes different in different markets throughout Europe. So the same vehicle can have different names. Or the continuation of a name, such as VW Golf, can cause problems if the registration year is close to the release of a new version.

It is also necessary to highlight that with regards to data availability, the only current data that would be adequate for research purposes (with regards to fitment data) is macroscopic in-depth accident data. Aggregated data from national sources has limitations with regards to how much information can be provided for analysis as certain features of the crash cannot be recorded due to time/monetary limitations.

This report will review Welsh's (2009) work on the development of a fitment database for the Department for Transport within the United Kingdom. In that report, Welsh contacted government organisations, commercial organisations, research bodies, motor manufacturers and the insurance industry within the UK, reviewed available literature sources, with regards to the level of detail of data available to incorporate within a fitment database for the Department for Transport (DfT) in the UK, as well as the possibility of developing this data from the above stated sources.

The aims of this chapter are to underline the available materials that could be used with regards to understanding safety systems, and to review the variable level of quality, feasibility and length of time that it would take to incorporate these measures. This will then lead to a possibility of developing a standard recording system for every passenger vehicle that is introduced to the European market.

Welsh (2009) identified three possibilities for recording safety systems:

1. The recording for each vehicle model with regards to safety systems present as standard for that model.
2. The recording for each individual vehicle that is involved in a crash with regards to each standard and optional system that is present on this vehicle.
3. Combining the above stated methods.

The former considers the vehicle model core as a general basis for analysis and would take into account the core safety systems that are incorporated in the vehicle, recording the vehicle according to its make, model, variant and manufacture date (Welsh, 2009). This system would only report the extras that are available as optional extras, not identifying whether they are present or not within specific vehicles. This system is currently used in the USA by the National Highway Traffic Safety Administration (NHTSA). NHTSA evaluate all new vehicles that are sold in the USA and evaluate them according to specific criteria, they then record the findings of these tests as well as other specific safety measures that they require and record it within the New Car Analysis Program (US NCAP) database. An overview of this procedure can be found in Section 2.5.

The latter considers the possibility of getting data for specific vehicles by analyzing the Vehicle Identification Number (VIN) that are present in all vehicles. This data would provide all information on the optional extra's that are included in a specific vehicle. This data would be advantageous as it would be more in depth and provide data that is accurate. The level of data available from the VIN number currently varies depending on car companies, and this data is currently confidential.

For such a procedure to be incorporated, it would require some laws and guidelines to be put in place, with possibly a committee including representatives from vehicle producers, policy makers, road safety researchers and lawyers to decide what is appropriate to be shared and examined and what is not. Additional benefits to the reporting of safety equipment within each specific vehicle would be that owners would have documentation on all of the safety systems within the said vehicle (this may be especially valuable to second hand buyers of vehicles) and recall procedures could be simplified.

It is also necessary to take into consideration that there are currently a great variety of systems that are being integrated and used in vehicles that are not required by the United Nations Economic Commission for European (UNECE). The development of any database to record safety systems in vehicles needs to take into consideration all available technologies. These technologies currently fall under four possible headings:

1. Passive safety measures: reducing the consequences of an accident by managing the crash forces.
2. Active safety measures: reducing the possibility of accidents occurring by taking preventative measures.
3. Integrated safety measures: aiming at integrating active and passive safety systems within a vehicle to allow the vehicle to adapt to a pre-crash situation and either stop the crash from occurring or reducing the crash consequences by reacting to the crash appropriately.
4. Rescue safety measures: also known as tertiary technologies. Optimising the rescue phase by supplying information on crash severity and location to rescue services.

The list of equipment would of course have to stop at some point and the names and functional definitions standardised. This would need to be addressed by a decision making committee.

The development of said database would need to include all of the systems that fall into the four categories stated above as well as identifying the respective research questions, such as the specific variables that will be made available to analyse in the database. When considering the requirements of such a database it is necessary to consider at which level the available data will be analyzed: the vehicle level, driver level or driver behaviour level as all of these different data sources provide for different data compilation requirements. Naturalistic driving research is focusing on building up information on driver behaviour, observing driver decisions and actions taken whilst driving, with a view to provide information with regards to successful avoidance behaviours that drivers carry out when faced with possible crash situations. DaCoTA Work Package 6 is currently carrying out research into naturalistic driving behaviours and the mapping of this data and crash data including fitment information would allow for studies that are not currently possible.

The exposure data required needs to be taken into consideration as well. For an analysis of relative risk in relation to the different safety equipment fitted in vehicles, exposure data related to before and after accident statistics with regards to different car makes and models and fitted safety equipment would be a necessity. Information on the vehicle fleet would also be necessary to further proceed with a fitment database as the dynamic nature of the vehicle fleet would make it necessary for this information to be updated regularly (for example, accidents, destroyed at end of life). For a review of different possibilities with regards to data analyses for fitment data, please refer to Welsh (2009).

With the development of a European safety systems recording database, the possibility of collating databases that are already developed with this database is also necessary to be taken into consideration as this would allow for the analysis of past data or data that is currently being collected with regards to the safety systems that are present in vehicles.

2.2. Safety Systems in Road Safety

Within Europe, two systems of type approval have been in existence for over 20 years. One is based around EC Directives and provides for the approval of whole vehicles, vehicle systems, and separate components. The other is based around UNECE Regulations and provides for approval of vehicle systems and separate components, but not whole vehicles (Welsh, 2009).

Agreements over the requirements for vehicle type approval and the implementation of safety technologies within vehicles are now made within the United Nations Economic Commission for Europe (UNECE). The UNECE is tasked with creating a uniform set of vehicle designs for international trade purposes. The passive and active safety systems that are currently a legal requirement for vehicles are outlined in Table 5.

Safety System	**Active or passive**
Seat belts	Passive
Driver and Passenger airbags (side/head)	Passive
Head Restraints	Passive
Side Impact bars	Passive
Side and frontal impact protection	Passive
Energy absorbing steering system	Passive
Electronic Stability Control	Active
Anti-lock braking systems (ABS)	Active
Lane Departure warning systems (only for heavy vehicles)	Active
Advanced Emergency braking systems (only for heavy vehicles)	Active

Table 5: UNECE safety system requirements

In order to be able to understand what is necessary to build a database for analysis of safety systems within vehicles it is necessary to implement an analysis of all systems. These systems include:

1. Systems that are compulsory in Europe currently,
2. Systems that are in consideration to be implemented,
3. Systems that will be possibly implemented in the future.

Currently, a small number of available active and integrated systems are fitted to vehicles. The systems that are available in vehicles can be referred to in two categories - standard fit and optional extras. Standard fit are systems that are included in a vehicle that are part of the core model. Optional extras are equipment that is installed in the vehicle normally at extra cost to the consumer. Increasingly, vehicles are equipped with safety systems that are not required by European law as either standard fit or optional extras, often packaging them together or with other vehicle features. A number of optional extras can effectively become standard fit in time depending on how widespread the systems are implemented by different manufacturers. This makes it difficult in obtaining data for vehicle models as each individual vehicle has the potential to be fitted with different safety systems.

2.3. Fitment Data Sources

The created database would ideally list the vehicles according to the make, model and production year the safety systems were present from, with the possibility of more specific data in the case of the use of the VIN number. By using the make and model of the vehicle as an identifier, this would enable standard equipment details to be linked with other databases (Welsh, 2009). Welsh reported that upon consultation with some vehicle manufacturers the use of a VIN based database would be preferred and could also enable optional equipment to be identified. In order for the VIN data to be able to be used, European wide mandates would be a necessity and the recording for all models using the same VIN format. Adding a country identifier would be a key recommendation for the Commission and manufacturers to consider with regards to data acquisition for road safety research in the future due to differing safety system implementations in different markets. Both possibilities of sourcing the information are explored in this report.

Welsh (2009) considered the following organisations and resources for the fitment data assessment:

- Literature
    - Web sites
    - Brochures
    - Auto Magazines
    - Glass's Guide
- Dealers and Franchisers
    - Manufacturers
    - Volvo Car Corporation
    - Ford of Europe
    - Toyota
    - Renault
    - Vauxhall
- Thatcham Motor Insurance Repair Research Centre
- JATO - Automotive Intelligence on the Internet
- EuroNCAP
- Driver and Vehicle Licensing Agency (DVLA) (UK)
- Vehicle Certification Agency (VCA) (UK)

Welsh (2009) considered potentially available data in terms of the following points:

- Make, Model, Variant based data sources
- VIN decoders/ Manuals

Some of the sources and organisations above are focused on the UK. In other European countries there are likely to be similar sources and organisations.

2.3.1. Make, Model, Variant based data sources

Published literature review

This section addresses the availability of safety equipment fitted as standard. Basic information about the safety equipment of vehicles is published in a number of sources and it would be possible for it to be reviewed and entered into a dataset. The data could be incorporated from 4 possible sources:

1. Manufacturers web sites
2. Sales Brochures
3. Auto Magazines
4. Independent publications e.g. Glass's Guide

Manufacturer's websites provide information for each specific vehicle that the company develops. Sales brochures provide a similar level of detail to web sites but are more concentrated on including selling points of the vehicle. Auto magazines also provide information on vehicles. The most comprehensive and easily available source of these four in the UK is Glass's guide. Glass's guide is a vehicle catalogue that is available both in hard copy and online. Glass's guide provides a listing of each in-vehicle safety system that is available in the vehicle in the UK, with a listing of every vehicle that is sold in the UK. Similar guides will be available throughout Europe for individual countries.

If these data sources were to be used as a basis for the development of a fitment database then Glass's guide information would be inputted manually, using the other three information sources to cross check the data in terms of reliability. The Automotive Industry Branch of Glass's are also able to provide tailored analysis for specific projects. Glass's were contacted with regards to the possibility of sharing their database if available by Welsh (2009).

With regards to the implementation of this data source, the main obstacle would be the amount of person hours needed and the nature of the work. The resources required for this database are not expensive though the data could be open to inaccuracies and also difficult to implement new technological developments within the data. Each vehicle would be needed to be researched and inputted individually with cross checks for data inaccuracies being carried from 2-3 sources per vehicle. The Motor Repair Research Centre (Thatcham) have carried out an analysis of ESC systems using sales and marketing materials and they believe it to be reliable as they have cross checked it with additional data sources from manufacturers.

Car franchisers / dealers

Welsh (2009) visited car franchisers/dealers to establish the detail of information available. The level of information available was not any more significant than the show room brochures. No central electronic database is available for safety equipment listings and optional fitment data is also not available for specific vehicles. As such this resource was not explored any further as a potential data source.

Motor manufacturers

Welsh (2009) contacted five motor manufacturers:

1. Volvo Car Corporation
2. Ford of Europe
3. Toyota
4. Renault
5. Vauxhall

Responses were received from Ford, Toyota and Renault. These manufacturers also referred to web sites and brochures for fitment information and thus were not significantly different than the above approaches outlined for published literature and car franchisers/dealers. Ford particularly indicated that inaccuracies would be incurred using this method. Some manufacturers record safety features of the vehicles on the VIN label. If this was made a requirement in the future then it would be easier to acquire the needed information for a database.

JATO

JATO Dynamics is a research company that aims at delivering up to date and accurate automotive data for companies. The specification data cover 44 countries. Queries can be made by searching on vehicle make and model, by searching on vehicle features or by viewing recent changes to vehicles. The volumes data covers 50 countries giving sales and registration figures.

JATO gather data by using literature resources as outlined above. Information from the EuroNCAP is taken directly and new models are incorporated within the database as soon as they enter the market place. The variables included in the data set are reviewed annually; generally 20 or more new variables are added with none being removed. New variables can be considered according to the client's needs. Currently 1626 vehicle specifications are listed. The data automatically cover all manufacturers with a sales volume of 25 units / annum or more, but can be driven by clients requiring the data. Retrospective data are available for vehicles no longer in production. Optional fitment is coded for each make / model and option take up is collected as part of the sales figures (Welsh, 2009).

The JATO data base can be accessed on-line once a subscription has been taken. Typically access to the entire data available on-line requires a subscription of ~£30,000 per year (~€ 34,000). Alternatively, only parts of the data can be accessed at a reduced cost, or JATO is able to perform ad-hoc analyses on behalf of the client for a fixed cost (Welsh, 2009).

Quality checks are made of the data. A point system is used to rate the importance of each individual variable and a weighted error rate is calculated based upon which variables were in error. Thus, though inaccuracies can occur, these are to some extent quantifiable. The rates are available to clients for expert comment. Optional fitment uptake is accommodated by various links within the fitment and exposure elements of the JATO data (Welsh, 2009). The JATO data base offers a great deal of potential to supply fitment data sufficient for research needs. Since data are available relating to both standard fit and optional take up there is the potential to access a comprehensive data set.

On the JATO website, an analysis of two different car manufacture models are made to give an example of some of the data they collect. A list of active/ passive safety systems that are inputted from this analysis can be found in Table 6. On the website these are listed as Primary and Secondary safety options.

Safety System	**Active or passive**	**List of options**
ABS	Active	Selection
Electronic traction control	Active	Standard
Brake assist system	Active	Deleted by another option
Electronic brake distribution	Active	Added as another option
Stability control	Active	Required by another option
Disc brakes (ventilated)	Active	Excluded by another option
Parking distance sensors	Active	Not available
Halogen headlights	Active	Available as option
Bi-Xenon headlights	Active	Requires option
Headlight control: dusk sensor	Active	Included by another option
Indicator lights in door mirrors	Active	
Cornering lights/curb illumination	Active	
Driver front airbag / Intelligent	Passive	
Passenger front airbag / Intelligent	Passive	
Front side airbags	Passive	
Rear side airbags	Passive	
Front seat belt pre-tensioners	Passive	
Active Front head restraints	Passive	
Number of rear seat head restraints	Passive	
3-point centre rear seat belt	Passive	
Child safety seat	Passive	
Isofix preparation	Passive	
Hill holder	Passive	
NCAP adult occupant result	Passive	
NCAP pedestrian protection result	Passive	
NCAP child protection result	Passive	

Table 6: JATO website safety system list

JATO offers the possibility of a systematic source of data describing the availability of safety equipment as standard or as an option. The list of equipment considered could be developed further and JATO have indicated they can do this in response to consumer demand. However while the system will identify the equipment that is available as an option it will not specify the equipment that is available to a specific vehicle.

2.3.2. VIN based data sources

The Vehicle Identification Number (VIN) is a 17 digit alpha/numeric code that uniquely identifies all registered vehicles. It is a mix of manufacturer, SAE and ISO elements. These elements are broken down into: the World Manufacturer Identifier (WMI), the Vehicle Descriptor Section (VDS) and the Vehicle Identifier section (VIS).

Standard	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ISO 3779	WMI			VDS						VIS							

Table 7: VIN data

WMI: Managed by SAE and denotes the country of origin and the manufacturer (Welsh, 2009).

VDS: For some manufacturers, e.g. Mercedes Benz, the VDS contains Model and Variant information, which could be cross referenced with Glass's Guide/manufacturer information to indicate the standard equipment fitted (Welsh, 2009).

VIS: It may be possible to decode an option fitted to a single model, by a single manufacturer. E.g. for a 2006 Ford Focus the option of a handling pack may be indicated by the sequential number within the VIS. Unfortunately for the majority of manufacturers VIS is simply a sequential number in order to bring the VIN up to the required 17 digits (Welsh, 2009).

The VIN can be used either directly by decoding information contained within the VDS to identify the make/model and then refer to a literature source or by using the VIN as an identifier for a more detailed vehicle specification held by the manufacturer. Both approaches are discussed in this section.

VIN Decoders / Manuals

A VIN guidebook is researched and published yearly by the International Association of Auto Theft Investigators (IAATI). This book provides information on decoding Vehicle Identification Numbers. IAATI have confirmed that it is possible to decode safety technology fitted as an option to certain vehicles by limited manufacturers but not all manufacturers. The IAATI VIN guidebook is not available in any electronic format (Welsh, 2009).

As the 17 digit VIN number combined with national data can allow for fleet information this is a viable data source for a make/model approach. As only a select number of manufacturers provide safety fitment within the VIN there would not be any additional potential compared to the other data acquisition methods. This data would be accurate, though would be more labour intensive due to the nature of researching for safety fitment data.

Welsh (2009) consultation with Ford of Europe indicated that it is feasible for the manufacturer to provide listings of safety equipment by VIN. Ford keeps an in-house enhanced VIN database where the VIN has 80 digits rather than the 17 recorded on the vehicle. This enables considerable in-depth information for each vehicle to be stored, primarily for the purposes of product recall. Ford believes that other manufacturers would also have such databases available. This has been confirmed by Renault.

There is a current activity being undertaken by FSD (Fahrzeugsystemdaten GmbH) in Germany[7]. In Germany, as in all EU Member States, vehicles are required to undergo periodic roadworthiness testing and part of this concerns the continued performance of safety equipment installed on the vehicle. In order to properly test a vehicle the inspectors need to know the equipment that is fitted. A central database has been prepared by gathering information on both standard and optional safety equipment from manufacturers for each vehicle and coding it with the VIN. When a vehicle arrives for the periodic test the inspector is able to identify the exact equipment that must be examined. If the database is incomplete and the inspector identifies additional equipment this can be added to the database for subsequent inspections.

Consultation with FSD revealed that fitment data is purchased from a number of manufacturers including:

1. Ford
2. Volvo
3. BMW
4. Daimler
5. Toyota
6. Honda
7. General Motors
8. Volkswagen

The scope of the data base being co-ordinated by FSD covers the following technologies (Welsh, 2009):

- cornering light
- adaptive cruise control
- adaptive brake lights
- airbag / (seat) belt (pre-) tensioner
- hill hold assistant (hill launch assist)
- autonomous trailer stabilisation control
- auto hold
- anti-lock braking system
- emergency brake (currently for heavy vehicles)
- automatic headlight levelling
- automatic light / headlamp assist
- downhill assist
- brake assist
- bending light
- electric power steering
- electro-hydraulic controlled pusher and trailing axle (heavy vehicles)
- electro mechanic parking brake (EPB)
- electronically-controlled braking system
- electronic differential lock
- electronic stability program
- main beam assistant
- speed limiter

[7] http://www.tuev-sued.de/uploads/images/1238510125772606360501/TSJ-09-01-Electronictest.pdf

- cruise control
- trailer stabilisation control
- (bus) stop brake (brakes automatically while a door is open)
- tilt stabilisation control
- mechatronic wedge brake / electro hydraulic brake
- pre safe brake
- lane keeping assist
- lane departure warning system with break intervention
- lane changing assist
- traction control
- active steering
- roll-over protection (active)

Depending upon the level of co-operation within the industry / potential to collaborate with FSD, this data source has the potential to build an accurate data base but it is likely that it will need to be complimented by a make/model approach to build a fully comprehensive data base since it is unlikely that all manufacturers would contribute. The resulting data base would be sufficient for many research needs.

Since the information would be provided in an electronic format the data base would be easily established and maintained. Manual additions would be necessary for missing data. Follow up work is now required to determine further the potential for collaboration with FSD and the associated cost.

The system illustrates a good example of a mechanism whereby details of standard and optional equipment can be gathered and related to a single vehicle. The main purpose of the data gathering is for the periodic testing so the application to safety analysis is an added benefit. There may be obstacles in some countries when combining the equipment data with accident files owing to the privacy regulations in some countries resulting in the accident file not having a VIN field.

2.3.3. Other data sources

Vehicle Certification Agency (VCA)

The Vehicle Certification Agency (VCA) is the type approval authority within the UK for all type approvals to EC and UNECE regulations, although other certification organisations exist in other Member States. Type approval agencies conduct crash, braking and emissions tests to acquire such data. The reports that are produced are confidential, thus the ability to use this data is not currently possible.

EuroNCAP

The European New Car Assessment Programme (EuroNCAP) was established in 1997 and is composed of seven European governments as well as motoring and consumer organisations in every European country (EuroNCAP website). Welsh (2009) reported that EuroNCAP do not hold a suitable fitment base but are interested in contributing to a future database. The limitations in obtaining data from EuroNCAP are that they only crash one variant of the vehicle and not each individual model that is on the market.

Polk

Polk is a company that provides automotive market and vehicle data to the automotive industry. Polk can provide data with regards to both the automotive fleet throughout Europe and also detailed VIN data where available. Polk can decode vehicles VIN numbers from 1966 onwards. The data provided includes details on the make/model of the vehicle, the engine specifications, optional extras that are available for that model and the specification related to the price of the vehicle and other physical attributes. Though information is available for each vehicle model detailed information for each specific vehicle is not provided.

2.4. New European Policies

Numerous technical standard and requirements in vehicle safety have been adopted in Europe in recent years and more are under consideration. The European Commission aims at harmonising this data and reviewing the roadworthiness tests and technical roadside investigations that they currently undertake (European Commission Policy).

The German government put in place a pilot study to periodically test electronically controlled vehicle systems since the 1st April 2006. This test is included in the periodic testing of vehicles and encompasses all vehicle types and concentrates on 8 safety relevant system classes:

1. Braking system – Overall system
2. Steering system – Overall system
3. Headlights and lamps
4. Seat belts and restraining devices
5. Airbag
6. Roll-over protection features
7. Driving dynamic systems that intervene with the braking system
8. Speed limiters

Following the success of this study in Germany the European Commission is now planning to extend the Periodic Testing Directive to cover electronic safety equipment for which a similar database will become necessary. The proposals are still to be developed by the Commission but it is likely that there will be the need for a similar equipment database to the FSD system previously mentioned. The revision of the Periodical Technical Inspections (PTI) Directive opens up the possibility of a Pan-European vehicle safety equipment database at little additional cost beyond the PTI requirements.

2.5. United States System for Fitment Data

In the United States of America the National Highway Traffic Safety Administration (NHTSA) are charged with creating and maintaining data files with regards to both vehicle crash data and evaluating the passive, active and integrated safety systems that are fitted into passenger vehicles. The main data system, where the evaluated safety systems data is recorded, is the New Car Assessment Program (US NCAP) database. The data that is recorded in the US NCAP database are the ratings from six tests:

1. A frontal crash test,
2. A side barrier crash test,
3. A side pole crash test for the vehicle,
4. Electronic Stability Control (ESC),
5. Lane Departure Warning (LDW),
6. Forward Collision Warning (FCW).

Information on specific safety features that are a requirement in the US is also recorded. The ESC, LDW and FCW tests were introduced for the vehicle model year 2011. Table 8 has an overview of the data that is recorded in the US NCAP database. NHTSA have the legal authority to send requests to car companies asking them to provide data with information about each specific vehicle that they design. If not complied with, these requests can result in civil penalties.

The information that can and cannot be asked for is determined by a group of individuals including policy makers, the car companies' representatives and lawyers. Part of the information that is received can be made public but part of it is confidential. VIN data is collected by the individual states departments but NHTSA do not collect this data. VIN numbers are collected for each of the vehicles involved in crashes either by referring to the state the accident occurred in or the investigators record this number. NHTSA have certain programs which allow for an analysis of the different vehicle make, model and VIN numbers to allow for an analysis for these vehicles.

With regards to the data, three databases, the Fatality Analysis Reporting System (US FARS), National Automotive Sampling System (NASS) and General Estimates System (GES) use a matching system to match the specific data to the NCAP data which allows an analysis of the before-after affects of safety systems within a specific accident scenario. The accident types chosen to be used in the analysis are the scenarios that the safety systems aimed to prevent.

The systems that are selected to be evaluated and reported depend on multiple factors, which systems are evaluated as being effective, available from multiple manufacturers, or the public has a high interest in. This process involves evaluation of the particular systems and discussion with senior management and lawyers within NHTSA.

This data is then used to carry out comparisons between specific accident groupings and the vehicles before and after statistical results, basing the data on the immediate years after the safety measures are incorporated. NHTSA began to evaluate its Federal Motor Vehicle Safety Standards (FMVSS) in 1975 (Kahane, 2004). Kahane (2004) wrote a report evaluating the safety technologies introduced within passenger vehicles from 1960 to 2002 developing a model using FARS data and past effectiveness estimates to calculate how many lives were saved. Kahane (2004) reported that an estimated 328,551 lives were saved from 1960 through 2002 by the incorporation of safety measures through the FMVSS analysis.

The possibility of incorporating a European wide database for the application of data acquisition from vehicle manufacturers is a necessity for the forward movement of the ability to analyse European Crash data and accident statistics. Though European law provides certain hurdles with regards to data confidentiality, an analysis and integration of the procedures that are undertaken by the US government may aid the possibility of overcoming these hurdles.

Safety System	**Active, Passive or Integrated**
Frontal Airbag Driver	Passive
Frontal Airbag Passenger	Passive
Antilock Braking System	Active
Electronic Stability Control - ESC	Active
Brake Assist Safety Feature	Active
Traction Control Safety Feature	Active
Adjustable Upper Seat Belts (Front)	Passive
Rear Seat Head Restraint	Passive
Adjustable Upper-Belts -Rear	Passive
Pretensioner	Active
Advanced Frontal Air Bag Feature	Passive
Dynamic Head Restraint	Active
Frontal Airbag On/Off Switch	Passive
Roll Stability Control	Active
Lane Departure Warning	Active
Frontal Collision Warning	Active
Rear Collision Warning	Active

Table 8: Current fields for US NCAP database with regards to all safety systems

2.6. Summary / Discussion

This deliverable explores the possibility of creating a fitment database to record all of the safety systems that are available on the vehicle fleet throughout Europe. This was done by reviewing:

1. currently available data sources
2. proposed European policies with regards to fitment data acquisition
3. the United States system for fitment data

This report also identifies the advantages of setting up a database that contains safety equipment. This database would enable the analysis of current and future active, passive, integrated and rescue systems implemented in vehicles in conjunction with accident and naturalistic driving data, providing a better understanding of driving behaviour and safety system performance. It is important that this database provide adequate data for analysis with both microscopic and macroscopic accident data.

In summary, two main methods of source data were identified. Further contact with the organizations outlined in Section 2.3.1 may be required to quantify the applicability of the possible data collection methods. This report establishes the possibility of either collecting data according to a make/model/ variant approach or a VIN number method.

With regards to the make model approach three possibilities exist. Either a literature source such as Glass's guide or Polk.com could be used to build up the data with a cross check of other sources such as manufacturer websites, brochures and motoring magazines (Welsh, 2009). Though detailed information on each vehicle model is provided by these sources online, a detailed cross checking of this data with other sources would be required to guarantee that this data is accurate enough for use. This does not require a large amount of resources but does require a labour intensive method due to the nature of the data procession.

A second approach would be to use JATO as a private group to collect the data with an applicable data file. This file would then be incorporated within a database and used to collate with existing databases. After this procedure two approaches could be taken. Either JATO would be used as a subcontractor to collect annual data for upload into said database or the methods identified above with regards to literature sources could be used as a further development of the JATO data. This method has a higher cost compared with the literature source approach but would be easier to use, as the data would be given in a file that is ready for use within a fitment database.

With regards to a VIN based approach the best results would be achieved by directly using manufacturer data (Welsh, 2009). This data would be received directly from manufacturers and as such would require the support of all the manufacturers providing vehicles for sale throughout Europe. As in the German system the equipment data for each VIN would be assembled within a database to be subsequently combined with accident data.

Table 9 summarizes the findings found by Welsh (2009) with regards to 5 potential methods for building a fitment database: Literature, JATO Net, US NCAP, VIN decoder, VIN link to manufacturer databases.

	Make/Model sources			VIN sources	
	Literature	**JATO Net**	**US NCAP**	**VIN decoder**	**VIN link to manufacturer**
Fleet coverage	Full	Full	Full	Extremely Limited	Some manufacturers may not contribute
Optional fit	No	Yes	Yes	Extremely Limited	Yes
Readily available	Yes	Yes	No	No	No
Accuracy	Inaccuracies	Inaccuracies	Accurate	Accurate	Accurate
Electronic source	No	Yes	Yes	No	Yes
Sufficient for research need	When combined with other method	Yes	Yes	No	Yes
Update process	Manual	Provided by JATO Net	Manual	Manual	Upon request

Table 9: Fitment data comparison from Welsh (2009)

It is considered that the most reliable and effective method to assemble an equipment database within Europe would be to use a similar model to the German pilot study, following a process such as in Figure 2. As part of the data needed for a revised PTI process the VIN for each relevant vehicle would be included within a database together with the relevant safety equipment. This would include both standard equipment for that model of vehicle as well as the optional equipment installed. The database would be in a format that could be combined with the vehicle registration data at national level and subsequently with macroscopic and in-depth accident data.

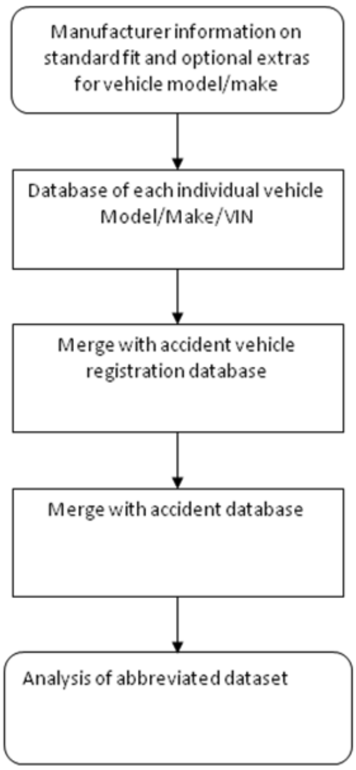

Figure 2: Development of Safety Equipment Database

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