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REVIEW OF CURRENT IN-VEHICLE SAFETY SYSTEMS AND RELATED DATA SOURCES

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Abstract

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, take into account as many design parameters as possible and consider previous evaluation work. The objective of this research is to provide an inventory of in-vehicle technological systems that are present on current production models, using a standard template. A catalogue listing details such as the aim of the system, the functions covered by the system, phase of the accident upon which the system is acting, the level of intervention, technical specifications and previous evaluations is developed for 31 active, passive and integrated safety systems and the example of the Adaptive Cruise Control system is presented in this paper. Moreover, a review of existing identification procedures related to safety systems is carried out, aiming to underline the available information sources that could be used to gather data on safety equipment using a common format, review the variable level of quality and the feasibility and length of time that it would take to collect the data.

Results revealed that although there are many different implementations of safety systems with different performance parameters, the development of a safety systems inventory can become a useful tool for analysts to establish a feel for a generic system, project the functionality of such a system onto available accident data and importantly to evaluate if the system really meets drivers' needs.

The use of an assembled standard template can further act as a central register, in which analysts can quickly acquire detailed information on the system along with web links to vehicle manufacturer, governmental, safety and research organisation websites.

Furthermore, two main safety systems data collection methods were identified through the review of different data sources, either using the make/model/ variant approach or the VIN number method, demonstrating the feasibility of recording all active, passive and integrated safety systems implemented within a vehicle to a European wide database.

This work has been undertaken in the EC funded DaCoTA project.

Key-words
Safety systems, data sources, system evaluation, adaptive cruise control

1. INTRODUCTION

In spite of countless amounts of research and development, road safety is still one of the main societal concerns today. It is not only a matter of concern for the European Commission and National Governments but also for several stakeholders such as the vehicle industry, insurance companies, non-governmental organisations and more generally for every single road user. Car manufacturers have made strong efforts towards the improvement of passive (and also active) safety of their vehicles for the past 20 years. However, current road safety research has shown that preventive (prevention of accidents) and active safety (recovery of an emergency situation) should now, particularly, be brought forward (TRACE, 2007).

There are two main objectives of this research: The first one is to develop a standard template to be used for the collection of all related information to in-vehicle technological systems that are present on current production models. A list of all currently available safety systems is provided and the standard template for information on Adaptive Cruise Control (ACC) is established as an example. Adaptive Cruise Control (ACC) systems have been actively developed and introduced into the consumer market by vehicle manufacturers in the past decade. They extend earlier systems (CCC – Conventional Cruise Control) to cases when driving at a fixed constant speed is not possible because of traffic conditions (Bifulco et.al., 2011).

The second objective 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. The aim is 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 information into a single database. 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.

A review of Welsh's previous work on the development of a fitment database (2009) is carried out, according to which governmental organisations, commercial organisations, research bodies, motor manufacturers and the insurance industry were contacted, together with a literature review with regards to the feasibility of a fitment database for the United Kingdom.

In summary two main methods of data collecting by the various sources were identified. Either collecting data according to a make/model/ variant approach or according to a Vehicle Identification Number (VIN). Regarding the first method, an outline of three possible approaches and a possible method that would combine these approaches is presented.

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).

2. LIST OF SAFETY SYSTEMS

The aim for presenting the list of 31 safety systems is to cover many types of road users and vehicles; cars, goods vehicles, buses, powered two wheelers and pedestrians, along with infrastructure technologies.

These technologies currently fall under four possible headings (DaCoTA, 2012):

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.

As expected with such a wide range of safety systems 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). According to the literature review, these are 31 safety relevant systems that are currently becoming established 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 regarding drivers' needs and system effectiveness evaluation (TRACE, 2007).

Table 1: Safety systems

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

3. STANDARD TEMPLATE FOR INFORMATION COLLECTION – ACC EXAMPLE

The aim of developing a standard template for each safety system is to give a good representation of generic system functions and parameters whilst also describing the functionality of current technologies fitted to vehicles.

The structure of this proposed standard template starts with the thorough description of each system examined. A thorough and complete description of the system's aim is presented, along with pictures or figures that describe the system operation. Then, the intentional and unintentional functions covered by the system, as well as the phases of the accident sequence upon which the system is acting, are described. Subsequently, in each template the different levels of intervention that the examined safety system can provide are described. Furthermore, technical specifications are provided aiming to give a good representation for generic system functions and parameters whilst also describing the functionally of current technologies fitted to vehicles, giving examples of particular vehicles. Finally, previous evaluations in terms of both methodology and results are provided as links, in order to recognize previous evaluations of safety systems.

The standard templates are developed for each of the 31 safety systems presented above to act as a central place in which analysts can quickly acquire the information needed to consider how safety systems fulfill driver's needs. For the purposes of this research, information collected through the proposed standard template is presented for the Adaptive Cruise Control (ACC) navigation system, as an example.

<u>Aim of the system</u>
If a leading vehicle is travelling at a lower speed than the user's vehicle, or is located within the preset time or distance headway, the ACC system intervenes via braking pressure or throttle/engine torque control so that the headway increases. The system only intervenes if the current preselected speed or headway would lead to a likely collision or the speed would reduce the set headway. ACC may employ radar, laser or machine vision to continuously monitor the leading vehicle. Auxiliary detectors also monitor the speed, yaw and cornering rate of the vehicle to maintain tracking of the leading vehicle in the same lane when cornering.

<u>Functions covered by the system</u>

- Keeps a set distance to vehicle in front
- Detecting a fixed obstacle on the road
- Predicting that another user will stop or slow down
- Predicting that another user will move off or fail to stop
- Improved traffic flow

Phases of the accident sequence upon which the system is acting

Table 2: Phases of the accident sequence

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	ACC may employ radar, laser or machine vision (camera) to continuously monitor the leading vehicle

Level of intervention

Table 3: Level of intervention

		Specifications
Perceptive Mode		ACC may employ radar, laser or machine vision to continuously monitor the leading vehicle
Mutual Control	Warning Mode	The system warns if the current preselected speed or headway would lead to a likely collision
	Limit Mode	The system intervenes if the current preselected speed or headway would lead to a likely collision
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		The system can decelerate or accelerate the vehicle if the current preselected speed or headway would lead to a likely collision. Or to maintain a safe headway.

Technical Specifications

In slow traffic or traffic jams, the automatic emergency braking function of Subaru's system aims to stop and hold one vehicle until the vehicle in front starts moving again, even if the driver is pressing the accelerator. In the case that the system, wiring, microprocessor or the code goes wrong, the worst that could happen could be almost entirely mitigated by good back-up procedures. (Moon et.al, 2009).

Previous evaluations

- ISO 15622:2002 Transport information and control systems – Adaptive Cruise Control Systems – Performance requirements and test procedures [15622]
- SAE J2399 Adaptive Cruise Control (ACC) Operating Characteristics and User Interface [J2399]
- FMCSA-MCRR-05-007 Concept of Operations and Voluntary Operational requirements for Forward Collision Warning Systems (CWS) and Adaptive Cruise Control (ACC) Systems On-Board Commercial Motor Vehicles [FMCSA05b]

- ISO/DIS 22178 Intelligent transport systems – Low speed following (LSF) systems – Performance requirements and test procedures
- ISO/DIS 22179 Intelligent transport systems – Full speed range adaptive cruise control (FSRA) systems – Performance requirements and test procedures

4. REVIEW OF EXISTING IDENTIFICATION PROCEDURES RELATED TO SAFETY SYSTEMS

The aims of this section are to underline the available materials that could be used with regards to understanding safety systems, 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 lead to a possibility of developing a standard recording system for every passenger vehicle that is introduced to the European market.

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.

<u>Make/model/ variant approach</u>
With regards to the make model approach three possibilities exist. A literature source addresses the availability of safety equipment fitted as standard. 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. JATO Dynamics is a research company that aims at delivering up to date and accurate automotive data for companies and the specification data cover 44 countries. 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.

<u>VIN based data sources</u>
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) (Welsh, 2009).

<u>Table 4:VIN data</u>

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

WMI: Managed by SAE and denotes the country of origin and the manufacturer.
VDS: For some manufacturers, e.g. Mercedes Benz, the VDS contains Model and Variant information, which could be cross referenced with manufacturer information to indicate the standard equipment fitted.

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.

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, to or by using the VIN as an identifier for a more detailed vehicle specification held by the manufacturer. Table 5 summarizes the findings found by Welsh (2009) with regards to methods for building a fitment database: Literature, JATO Net, VIN decoder, VIN link to manufacturer databases.

Table 5: Fitment data comparison from Welsh (2009)

	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 (quantifiable)	Accurate	Accurate	Accurate
Electronic source	No	Yes	No	No	Yes
Sufficient for research need	When combined with other method	Yes	Yes	No	When combined with other method
Update process	Manual	Provided by JATO Net	Manual	Manual	Upon request

5. CONCLUSION

This paper describes the development of safety systems descriptions to support work on drivers' needs and evaluations of safety benefit. For this purpose, a standard template was created for 31 safety systems including details such as the aim of the system, the functions covered by the system, phase of the accident upon which the system is acting, the level of intervention, technical specifications and previous evaluations. The example of the Adaptive Cruise Control system is presented.

The use of an assembled standard template can further act as a central register, in which analysts can quickly acquire detailed information on the system along with web links to vehicle manufacturer, governmental, safety and research organisation websites.

This paper 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. In summary, two main methods of source data were identified either a make/model/ variant approach or a VIN number method.

Make model approach does not require a large amount of resources but does require a labour intensive method due to the nature of the data procession. With regards to a VIN based approach the best results would be achieved by directly using manufacturer data. This data would be received directly from manufacturers and as such would require the support of the manufacturers. Furthermore, the equipment data for each VIN would be assembled within a database to be subsequently combined with accident data.

It is considered that the most reliable and effective method to assemble an equipment database within Europe would be to use a combined model. 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.

6. REFERENCES

1. Bifulco G. N., Pariota L., Simonelli F., Di Pace R. (2011). Development and testing of a fully Adaptive Cruise Control system, Transportation Research Part C: Emerging Technologies, In Press, Corrected Proof, Available online 4 November 2011)
2. COWI. (2006), Cost-benefit assessment and prioritisation of vehicle safety technologies. Final report. Contract TREN/A1/56-2004. European Commission, Brussels.
3. EC DacoTA. (2012), Deliverable 5.2, “Catalogue of current safety systems”, European Commission, Brussels.
4. EC TRACE (2007), Deliverable 5.1, “Analysing human functional failures in road accidents”, European Commission, Brussels.
5. EC TRACE (2007), Deliverable 6.1, “Common database of existing safety functions and existing and corresponding system platforms”, European Commission, Brussels.
6. European Commission DG TREN (2010) “Cost-benefit assessment and prioritisation of vehicle safety technologies”, European Commission, Brussels.
7. Kahane, C.J (2004) “ Lives saved by the Federal Motor Vehicle Safety Standards and Other Vehicle Safety Technologies, 1960-2002 – Passenger Cars and Light Trucks – With a Review of 19 FMVSS and their Effectiveness in Reducing Fatalities, Injuries and Crashes”
8. Kun, L., & Ioannou, P. (2004). Modeling of traffic flow of automated vehicles. IEEE Transaction on Intelligent Transportation Systems, 5, 99–113.
9. Moon S., Moon I., Yi K., 2009, “Design, tuning, and evaluation of a full-range adaptive cruise control system with collision avoidance”, Original Research Article Control Engineering Practice, Volume 17, Issue 4, Pages 442-455
10. Scully, J., Fildes, B., & Logan, D.(2005) “Use of Vehicle Identification Number for Safety Research” Undertaken for the SARAC project
11. Serafin, C. (1996). Driver preferences and usability of adjustable distance controls for an Adaptive Cruise Control (ACC) system. Ford Motor Company Systems Technology, Inc.
12. Welsh, R (2009) “Feasibility study for equipment database and exposure data evaluation” Undertaken for UK Department for Transport