Projet CACIAUP

***A**mélioration des **C**onnaissances sur les **AC**cidents **I**mpliquant un **AU**tomobiliste et un **P**iéton*

Rapport R4.2
Analyse des besoins des usagers

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Ce projet est financé par la Fondation Sécurité Routière (FSR) et le Laboratoire d'Accidentologie et de Biomécanique (LAB)

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Le projet ***CACIAUP*** - amélioration des ***C***onnaissances sur les ***AC***cidents ***I***mpliquant un ***AU***tomobiliste et un ***P***iéton – est un projet français financé par la Fondation Sécurité Routière (FSR) et le Laboratoire d'Accidentologie et de Biomécanique (LAB).

Il a débuté en juin 2009 et s'est terminé en juin 2012, soit une durée totale de 3 ans.

L'objectif principal du projet CACIAUP est d'améliorer les connaissances sur les causes d'accidents corporels impliquant au moins un piéton.

Afin d'atteindre l'objectif précédemment cité, il a été proposé de réaliser les tâches suivantes :

- La mise en place d'une étude détaillée d'accident spécifique pour les piétons en collaboration avec plusieurs services d'urgence. En particulier, l'idée est d'optimiser l'alerte, de disposer de bilans médicaux complets, de faire évoluer le recueil de données, et d'améliorer les techniques liées à la reconstruction. La cible est de disposer d'un échantillon de 90 cas sur 3 ans (Figure 1– Lot 1).

- La mise en place d'un suivi des personnes blessées au cours de l'accident. Ce suivi sera effectué jusqu'à consolidation des séquelles, dès lors qu'elle est médicalement constatée. (Figure 1 – Lot 3).

- L'actualisation des méthodologies et études permettant l'amélioration des connaissances, d'une part sur les aspects techniques liés à la reconstruction d'accident, et d'autre part sur l'adéquation des (futurs) systèmes de sécurité en fonction des besoins réels (Figure 1, Lot 2).

- Des études thématiques permettant un éclairage particulier sur les sujets suivants (Figure 1, Lot 4):

    - Identification des principales configurations d'accident et de leurs caractéristiques principales.

    - Une analyse basée sur les besoins des usagers qui sont confrontés à un piéton.

    - Une analyse globale des lésions observées avec un zoom spécifique sur les cas dont la vitesse au choc entre dans le cadre des tests réglementaires.

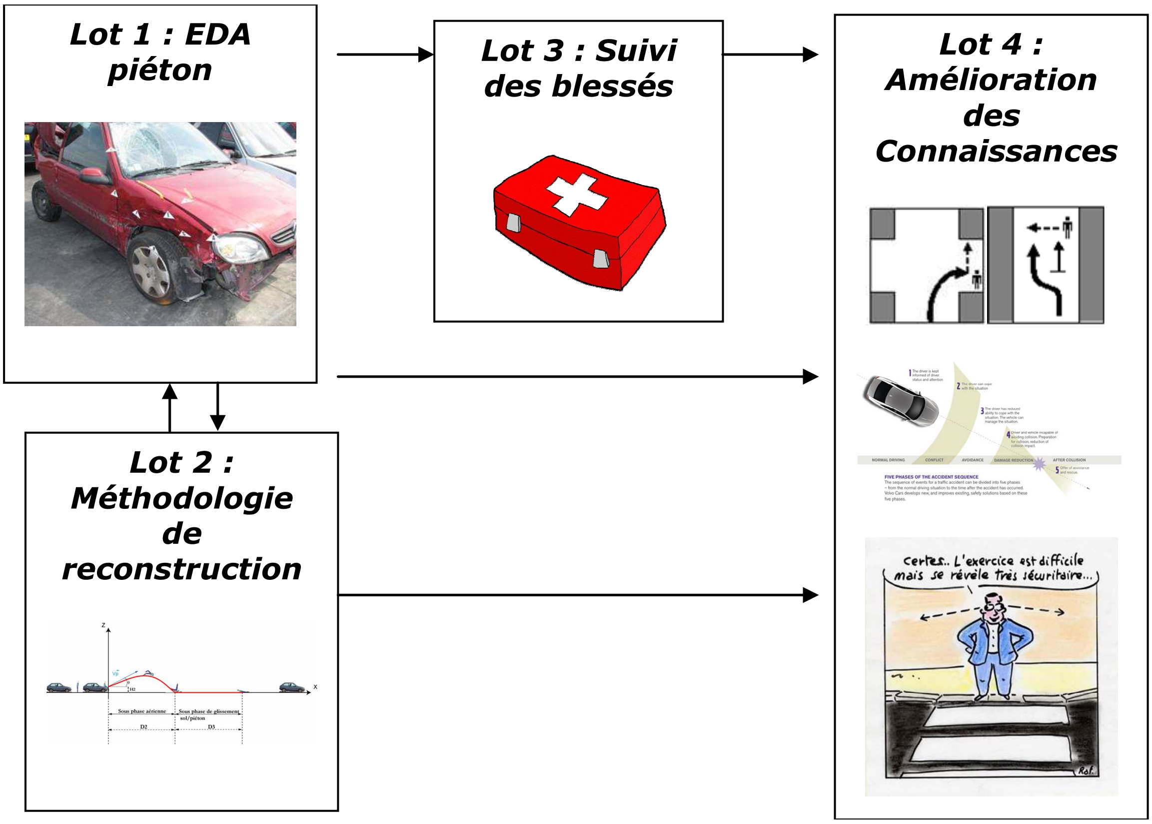

Figure 1: Organisation du projet CACIAUP

Le présent rapport s'inscrit dans le lot N°4 « Amélioration des connaissances » pour apporter un éclairage particulier d'un point de vue des usagers en proposant une analyse de leur(s) besoin(s) au cours du déroulement de l'accident.

1 Introduction

L'accidentalité des piétons constitue un enjeu important tant au niveau mondial qu'aux niveaux européen et français. Les différentes études sectorielles sur les accidents de piéton 2008 [3], 2009 [4] et 2010 [5] réalisées dans le cadre du projet CACIAUP, précisent ces enjeux :

- Dans le monde en 2007, on compte 270 000 piétons tués, soit 22% du total des tués annuellement sur les routes. L'enjeu est d'autant plus fort pour les pays en voie de développement ainsi, en République Démocratique du Congo 59% des victimes de la route sont des piétons.

- Dans l'Europe des 27, 7094 piétons ont été tués en 2009, soit 21% du total des tués dans un accident de la circulation.

- En France en 2011, on compte 519 piétons tués, 4593 blessés hospitalisés, 7318 blessés légers. Les piétons représentent 13% des tués dans un accident de la route.

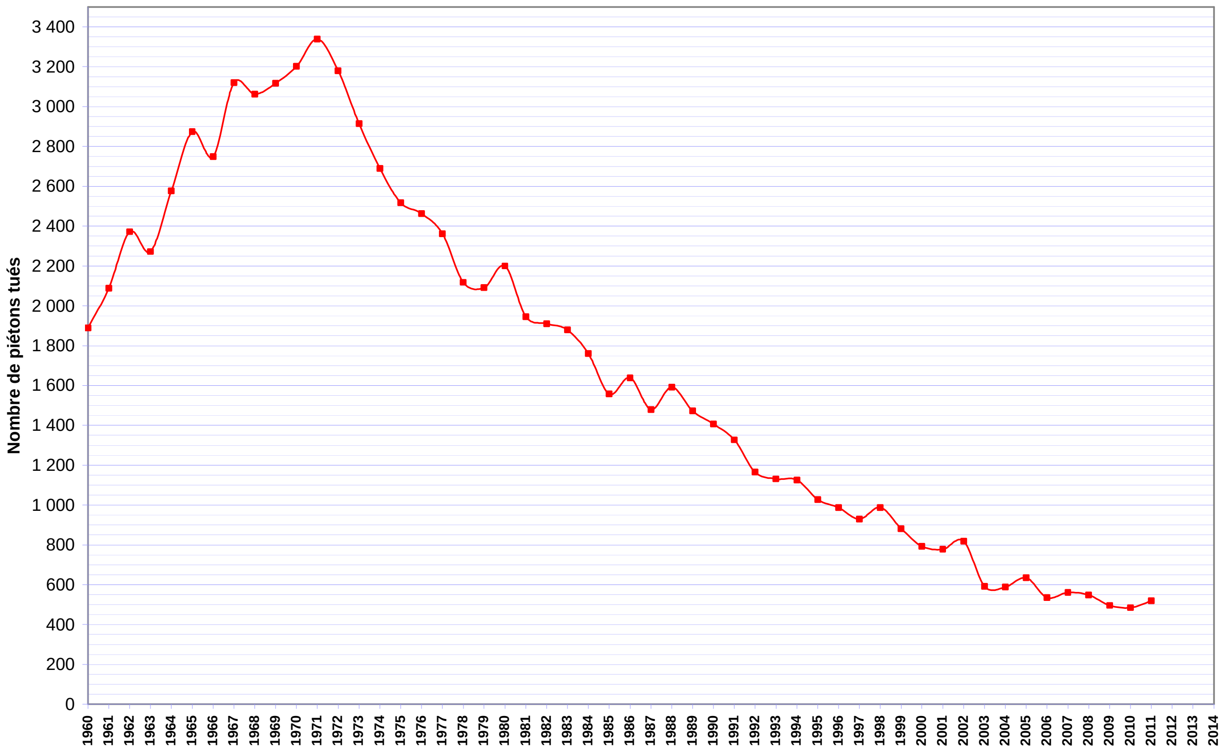

Figure 2 : Evolution de la mortalité chez les piétons en France depuis 1960 (Source ONISR)

Si les derniers chiffres de l'année 2011 montrent une baisse globale de 0,7% de la mortalité routière, seuls les piétons et les motocyclistes sont en augmentation avec une évolution respective de 7% et de 8% par rapport à l'année précédente.

Tués	2010 Nb	2010 %	2011 Nb	2011 %	Evolution 2011/2010	
Usagers de voitures de tourisme	2 117	53%	2 062	52%	▼	**-2,6%**
Motocyclistes	704	18%	760	19%	▲	**8,0%**
Piétons	485	12%	519	13%	▲	**7,0%**
Cyclomotoristes	248	6%	220	6%	▼	**-11,3%**
Cyclistes	147	4%	141	4%	▼	**-4,1%**
Usagers de véhicules utilitaires	146	4%	134	3%	▼	**-8,2%**
Autres	145	4%	127	3%	▼	**-12,4%**
Total	3 992	100%	3 963	100%	▼	**-0,7%**

Table 1 : Evolution de la mortalité en France entre 2010 et 2011 (Source ONISR)

Ces résultats montrent que rien n'est jamais acquis et que les efforts doivent être maintenus, que ce soit en termes de mesures de sécurité ou d'analyse et de recherches de solutions adaptées.

1.1 Objectif de l'étude

Ce rapport présente une analyse centrée sur le facteur humain (en tant que composante de l'accident) et basée sur les besoins des usagers impliqués dans un accident avec piéton. L'idée est d'identifier les besoins réels des usagers (conducteur ou piéton) à partir de l'analyse de leurs défaillances fonctionnelles survenues dans leur tâche de conduite et dont la conséquence est l'accident. Cette analyse permet de compléter les évaluations de l'efficacité des systèmes de sécurité. L'objectif ici n'est pas d'analyser l'accident pour trouver la contre mesure la plus efficace, mais plutôt d'analyser le besoin réel du conducteur pour d'une part identifier l'aide la plus utile pour gérer la difficulté qu'il a rencontrée et d'autre part pour connaître l'adéquation entre les aides proposées et les besoins analysés.

Les résultats de cette étude permettront :

- D'identifier les besoins du conducteur en terme d'aide ;
- D'évaluer la capacité des aides proposées à répondre à ces besoins ;
- D'identifier les limites potentielles de ces aides en fonction du contexte de façon à être capable de maximiser leur efficacité ;

La méthode proposée ici permet également de compléter les méthodes d'évaluations. La plupart du temps, les évaluations proposées sont orientées vers l'efficacité en termes de diminution de la gravité.
Ici les contre-mesures sélectionnées sont évaluées en fonction de leur efficacité à répondre aux besoins réels des conducteurs et compte tenu des limitations potentielles dues au contexte dans lequel se déroule l'accident.
La méthode repose donc sur une analyse approfondie au cas par cas afin premièrement d'identifier les défaillances fonctionnelles de chaque conducteur survenues au cours de l'accident, secondement pour chacune des défaillances de caractériser le besoin réel associé, puis pour chaque besoin de sélectionner le ou les systèmes de sécurité les plus adaptés et enfin d'identifier les limitations potentielles dans le contexte de l'accident.

Ce type d'analyse a déjà été initié dans le projet TRACE pour les conducteurs de véhicules légers.
On propose ici trois aspects nouveaux :

- D'étendre l'analyse aux usagers piétons

- D'identifier les besoins non plus seulement à la situation de rupture, mais à chaque séquence principale de l'accident
- Dans le cas de l'identification des limitations de l'efficacité d'un système de sécurité d'estimer le niveau de perturbation.

Le présent rapport s'articule comme ceci :

Une première partie concerne les aspects méthodologiques dans laquelle on explicite les concepts utilisés ainsi que différentes étapes pour la construction de l'analyse.

La seconde partie décrit les résultats obtenus. Nous commencerons par présenter notre échantillon de référence à partir de données générales descriptives, puis nous nous focaliserons sur l'analyse des défaillances pour le conducteur et pour le piéton.

Enfin la dernière partie sera consacrée à la conclusion et aux perspectives.

2 Méthodologie

L'objectif principal de cette étude est d'identifier les besoins des conducteurs en termes d'aide ou d'assistance à l'exécution de leur tâche de conduite pour éviter l'accident. Cette identification est réalisée à partir de l'analyse de leur(s) défaillance(s) fonctionnelle(s) survenue dans le déroulement de l'accident. Le besoin est ainsi identifié comme le miroir de la défaillance fonctionnelle observée.

L'identification des besoins permet de compléter l'analyse sur les causes d'accidents en développant le volet relatif à l'usager. Elle complète donc le diagnostic de sécurité. Elle permet :

- d'identifier les besoins en termes de prestation de sécurité qui seraient utiles à l'usager pour l'aider dans sa tâche de conduite
- de vérifier l'adéquation entre les besoins réels des usagers (demande) et les systèmes de sécurité proposés (offre)
- de mettre en évidence les limites en termes de performance de ces systèmes en prenant en compte le contexte dans lequel se déroule l'accident.

L'analyse des besoins a été développée par l'IFSTTAR-MA. Elle est principalement basée sur l'analyse des défaillances fonctionnelles humaines [10]. Elle utilise comme support les accidents corporels étudiés dans le cadre des EDA pour leur niveau de détail que l'on peut y trouver notamment au niveau facteur humain.

Cette analyse a été utilisée pour la première fois dans le cadre du projet Européen TRACE [14] principalement pour les accidents impliquant un véhicule léger.
Dans cette première version, les besoins étaient identifiés uniquement pour la phase de rupture, phase au cours de laquelle la situation de conduite normale bascule en situation d'accident.
Partant du constat que l'accident peut être décomposé de façon séquentielle, on pouvait imaginer que les besoins de l'usager pouvaient également évoluer, voire disparaître pour laisser place à de nouveaux. Ainsi les défaillances fonctionnelles et l'analyse du besoin ne sont plus uniquement identifiées pour la phase de rupture, mais sont proposées pour la phase en amont correspondante à la situation de conduite normale, et aux phases suivantes à savoir en situation d'urgence et de collision. Cette extension de la méthodologie a été initiée et utilisée pour la première fois simultanément dans le projet européen DaCoTA et pour le projet CACIAUP.

La valeur ajoutée de cette étude a été d'étendre l'analyse à la spécificité de l'accident avec piéton à savoir, identifier de nouveaux besoins ou la nécessité d'adapter des besoins existants que ce soit pour le conducteur ou l'usager piéton.

2.1 De l'analyse des défaillances fonctionnelles vers l'identification des besoins

L'étude proposée ici repose aussi bien théoriquement que méthodologiquement sur l'analyse des défaillances fonctionnelles humaines (HFF[1]) développée dans le cadre des EDA par l'IFSTTAR-MA. Cette analyse des défaillances repose sur l'identification des difficultés rencontrées par les conducteurs dans leur tâche de conduite lors de la survenue d'un accident.
La tâche de conduite reste une activité complexe faisant intervenir de multiples composantes elles-mêmes en permanente interaction (véhicule, infrastructure, environnement, l'humain, etc.). La méthode HFF propose donc de focaliser l'analyse sur une de ces composantes à savoir le facteur humain.

2.1.1 Le contexte

Il ne s'agit pas ici de reprendre le cadre scientifique lié à l'analyse des défaillances fonctionnelles ni d'en expliquer tous les rouages (nous renvoyons le lecteur aux excellents articles de son concepteur), mais simplement de donner les éléments indispensables pour une meilleure compréhension de la démarche effectuée dans cette étude.
Dans la recherche des causes d'accident, l'analyse des défaillances fonctionnelles permet d'identifier les causes d'un point de vue de l'usager. Elle propose un cadre méthodologique dans la recherche des erreurs humaines ayant initiées ou simplement contribuées à la survenue de l'accident.
L'erreur humaine peut être analysée de différentes façons, le plus souvent fondées sur certaines croyances.
Par exemple, dans un cadre juridique l'accident sera examiné en fonction du niveau de responsabilité des impliqués. Chaque erreur décelable chez un usager pourra alors être interprétée comme une faute. La solution consistera alors à définir un niveau de sanction (punition) adaptée en fonction de la « gravité » et/ou de l'intention donnée à l'infraction commise. Si ce point de vue trouve sa place auprès des forces de l'ordre et des tribunaux, ce raisonnement a cependant tendance à se répandre et à prendre le dessus en sécurité routière, et à se substituer à la recherche de solutions mieux adaptées et plus efficaces face aux difficultés rencontrées par les conducteurs.

Dans l'analyse des défaillances fonctionnelles, « l'erreur » n'est pas considérée comme une faute à blâmer mais plutôt comme le révélateur d'un problème de fonctionnement du système de conduite (le conducteur faisant partie intégrante de ce système). Ce symptôme est analysé comme le résultat indésirable dans les interactions entre un opérateur et une tâche, et de l'interaction entre des facteurs endogènes et exogènes. En d'autres termes, il serait plus judicieux de parler d'échec plutôt que d'erreur. La solution recherchée s'orientera donc vers une adaptation du système conformément au fonctionnement de ses utilisateurs, pour tenter de neutraliser les défaillances ayant produit de tels symptômes.

Pour pouvoir s'adapter avec succès aux difficultés liées à la tâche de conduite (variabilité des situations, complexité et défaillances propres du système de conduite), les conducteurs font appel à des combinaisons liant les fonctions perceptrices, cognitives et motrices. L'utilisation de ces fonctions permet aux conducteurs de surmonter la plupart des problèmes qu'ils rencontrent sur la route. En quelque sorte on pourrait considérer le conducteur comme un facteur de sécurité. Cependant, dans certains cas, les sollicitations sont trop nombreuses et/ou trop importantes (en termes de ressource) et dépassent voire annihilent les capacités du conducteur pour les surmonter. Vu sous l'angle ergonomique, on considérera l'erreur humaine comme l'échec d'une tentative et/ou d'une incapacité pour l'opérateur d'ajuster son activité.

[1] Human Functional Failure

L'analyse des défaillances fonctionnelles humaines ne peut pas être vue directement comme une cause d'accident mais plutôt comme le résultat d'une ou plusieurs défaillances du système de conduite provoquées par un défaut dans ses composantes (usager/environnement/véhicule) et/ou dans leurs interactions (inaptitude d'un élément avec un autre). Cette analyse permet donc de mieux comprendre non seulement les causes mais également les processus impliqués dans la production de l'accident. Le but est d'aller plus loin que l'établissement des faits, vers la fabrication d'un diagnostic permettant l'élaboration de contre-mesures adaptées.

Puisqu'un accident n'est pas intentionnel, il révèle une difficulté que le conducteur n'a pas pu (su) gérer. Cette difficulté - qui a mené le conducteur à l'accident, est considérée comme un symptôme d'une défaillance du système de conduite. Ce symptôme révèle un besoin en sécurité qui n'a pas été solutionné. Ainsi les besoins du conducteur peuvent être considérés comme le miroir d'un défaut survenu dans le système de conduite, défaut le plus souvent caché derrière une défaillance humaine.

Au départ, la défaillance fonctionnelle était uniquement définie pour la phase de rupture. En effet, dans l'analyse séquentielle de l'accident cette phase représente une étape cruciale : elle marque la transition entre une situation toujours sous contrôle (stable, même si quelques interférences en font partie) et une situation détériorée où le conducteur doit soudainement entreprendre une manœuvre d'urgence dans le but de revenir en situation contrôlée. Cette phase de rupture peut être interprétée d'un point de vue du facteur humain, comme un échec dans les fonctions activées lors de sa tâche de conduite et qui lui permettent habituellement de s'adapter aux difficultés rencontrées en situation de conduite normale.
Certes, le besoin est ici un point clé car s'il est solutionné de façon efficace et adaptée, la phase de rupture n'a pas lieu et la situation accidentelle peut être évitée.
Cependant, l'aide proposée (même la plus adaptée possible) peut ne pas suffire à rétablir une situation accidentelle. La présence d'autres facteurs externes ou internes au conducteur peuvent déjouer la contre-mesure (parade) mise en place. Par exemple:

- Atteinte des limites techniques (seuils) de fonctionnement de l'aide
- la présence potentielle de facteurs qui vont limiter ou dégrader le fonctionnement de l'aide
- le type de sollicitation demandé au conducteur (dans le cas d'une alerte il peut ne pas comprendre le message ou savoir ce qu'il doit faire, dans le cas d'une aide automatisée il peut aggraver la situation en exécutant une manœuvre inadaptée, etc.)
- etc.

Ainsi le besoin émis avant la rupture peut évoluer, se modifier, ne plus exister et/ou laisser place à de nouveaux besoins ou d'une autre nature. Une des manières pour identifier ces besoins est d'utiliser le découpage séquentiel de l'accident utilisé pour l'analyse des causes d'accidents [11]. A chaque phase, on peut ainsi identifier une défaillance fonctionnelle pour la situation courante et définir le ou les besoins associés.

L'analyse séquentielle consiste à diviser le déroulement de l'accident en différentes phases de nature différente (Figure 3) :

- ***La phase de conduite normale*** : c'est la période qui précède la situation accidentelle. Elle est dite « normale » par opposition aux évènements/enchainements/actions qui vont venir la dégrader. Le conducteur est dans sa tâche de conduite « habituelle ». C'est le domaine des aides dites de confort ;

- ***La phase de rupture*** : elle est déclenchée par l'apparition d'un évènement inattendu faisant basculer la situation de conduite normale en une situation accidentelle. Cette phase peut être vue comme le point ultime d'une alerte.
- ***La phase d'urgence*** : elle concerne toute la séquence pendant laquelle le conducteur doit réagir s'il veut éviter l'accident. C'est le domaine des systèmes de sécurité primaires semi-automatiques ou automatiques (exemple ESC, AFU, etc.)
- ***La phase de collision*** : c'est le domaine de la protection. L'accident n'a pu être évité et les usagers doivent être protégés.
- ***La phase de post-collision*** : l'accident est terminé, les usagers doivent être secourus le plus rapidement possible et recevoir les soins adaptés à leurs blessures. C'est le domaine de la sécurité tertiaire.

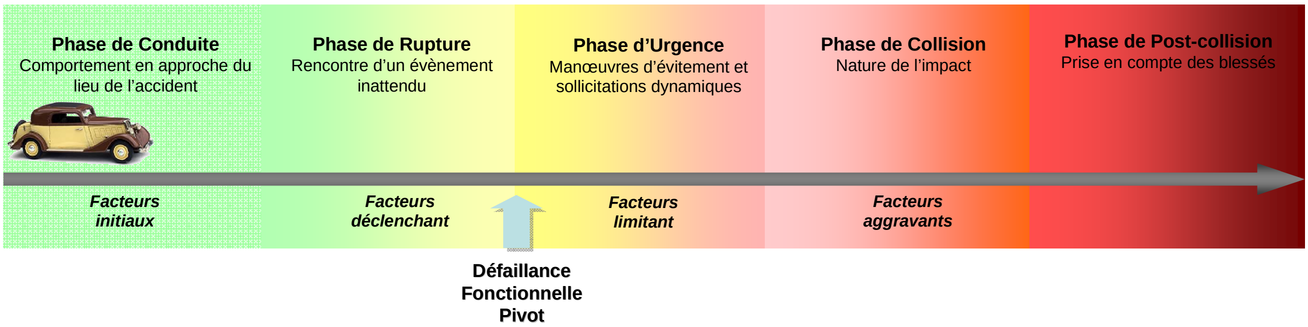

Figure 3 : Découpage du déroulement de l'accident en séquences.

A partir de ce découpage, on peut voir que le contexte d'un point de vue de la tâche de conduite évolue dans le temps et l'espace. Par exemple, en se plaçant dans le triptyque du modèle CVE[2] on pourrait observer les modifications suivantes :

- le conducteur doit en plus de gérer une situation à risque être capable d'intégrer d'autres éléments (de nouveaux facteurs ou des facteurs présents mais qui n'étaient pas prépondérants dans la phase antérieure) et ce d'autant plus rapidement que l'instant de la collision se rapproche.
- Le véhicule en cas de manœuvre d'urgence peut être fortement sollicité et doit répondre aux exigences souhaitées par le conducteur.
- Puisqu'il y a déplacement, l'environnement change également (nature du sol si le véhicule sort de la chaussée par exemple), les conditions de trafic évoluent (ex apparition d'un véhicule dans le sens opposé), les objets bordant la route peuvent devenir des obstacles potentiels, etc.

Il est donc important de pouvoir définir les besoins réels à chaque séquence pour être en mesure de proposer au conducteur l'aide voire la solution automatisée la plus appropriée pour lui permettre de se sortir de ce mauvais pas et éviter l'accident et ses conséquences.

2.1.2 Définition du besoin

Le besoin est principalement défini dans le dictionnaire comme un manque de ce qui est perçu comme nécessaire.
Dans le contexte de l'étude, le besoin est identifié comme quelque chose qui est essentiel pour la sécurité. Seul l'aspect sécuritaire nous intéresse. Les besoins plutôt liés au confort ou encore au style de conduite bien qu'intéressants ne sont pas concernés.

[2] Conducteur / Véhicule / Environnement

De la même façon, le besoin dont il est question ici n'est pas un souhait exprimé par le conducteur (à travers un questionnaire par exemple), mais le résultat d'une analyse inscrite dans un cadre méthodologique, conduite par un expert, révélant les difficultés manifestées par le conducteur dans sa tâche de conduite pour accomplir correctement sa tâche.

D'un point de vue systémique, le besoin du conducteur se réfère à un manque dans le fonctionnement du système de conduite. L'accident est le symptôme le plus évident de ce manque. La défaillance fonctionnelle quant à elle, est le signe particulier de ce qui manque au conducteur pour pallier à la difficulté rencontrée sur sa route.
Le besoin peut donc être vu comme le miroir d'une défaillance fonctionnelle du conducteur. Il représente ce qui aurait pu éviter l'échec (ici l'accident) s'il avait été comblé.
On peut donc penser que le fait de diagnostiquer ce besoin peut permettre d'aider plus efficacement ou de façon plus adaptée le conducteur dans les situations accidentelles.

2.2 Les besoins

L'étude proposée ici repose sur un échantillon de 100 accidents corporels impliquant au moins un piéton, collecté lors de la première phase du projet.
Ces 100 accidents ont été analysés de façon approfondie en respectant le cadre méthodologique des EDA (2).

Un des principaux intérêts de l'utilisation des données d'accident c'est que les informations utiles à l'identification des besoins se réfèrent indubitablement à la sécurité, contrairement à ceux que l'on pourrait extraire d'une expérimentation ou d'une observation qui ont plutôt tendance à souligner les difficultés exprimées par le conducteur que des problèmes de sécurité. Par conséquent les besoins déduits à partir de données d'accident seront des besoins en sécurité.

Un autre intérêt repose sur l'utilisation des EDA et du niveau de détail qu'elles contiennent.
Il existe plusieurs types de collecte de données d'accident :

- les données macro-accidentologiques, telles que le BAAC délivré par l'ONISR. Ce type de collecte présente l'avantage de pouvoir recenser l'ensemble des accidents corporels de la circulation dès lors qu'ils sont constatés par les forces de l'ordre. Les informations disponibles sont assez générales et permettent seulement de donner quelques enjeux. D'autres informations sont disponibles dans le procès-verbal, notamment les déclarations des usagers et autres témoins.
- Les données micro-accidentologiques, telles les EDA. L'avantage de ce type de collecte est le niveau d'informations offert avec beaucoup de détails mais par contre sur un nombre beaucoup plus restreint d'accidents. On retrouve généralement une analyse, des entretiens réalisés avec les conducteurs, la reconstruction cinématique et comportementale de l'accident, etc.

Avec le 1ier type de données, les informations provenant du conducteur sont obtenues par les forces de l'ordre lors de leur interrogatoire et sont plutôt orientées vers les circonstances de l'accident et les aspects judiciaires.
Dans la 2nde approche, les informations collectées sur le conducteur le sont sur la base de plusieurs entretiens (souvent 2) menés par un spécialiste suivant un cadre méthodologique bien défini dont le principal objectif repose sur la connaissance du mécanisme accidentel, des actions entreprises et des facteurs internes et externes dans l'objectif de rechercher des contre-mesures adaptées. Dans ce type d'étude le volet relatif au facteur humain est donc également pris en compte.

Reste à déterminer la façon d'identifier les besoins. Nous avons vu précédemment que les besoins peuvent être déduits à partir des difficultés que les conducteurs ont rencontré durant le déroulement de l'accident. Le conducteur étant un des facteurs principaux de la régulation du système de conduite, il est alors possible d'identifier ses erreurs ou ses défaillances dans sa tâche de conduite ou dans les actions entreprises.

Le modèle de la défaillance fonctionnelle humaine (HFF) est parfaitement adapté à l'identification des besoins. Basé sur des modèles classiques de la littérature [15], cette méthode propose une classification des défaillances fonctionnelles, et permet pour chaque conducteur impliqué dans un accident de connaître les difficultés auxquelles il a été confronté. Dans ce modèle, la défaillance fonctionnelle peut être attribuée suivant l'une des différentes étapes du processus du traitement de l'information par le conducteur que sont le niveau de détection, le niveau de traitement de l'information (diagnostic, pronostic), le niveau de décision (choix de la manœuvre), le niveau de l'exécution ou bien s'il s'agit d'une défaillance générale de ce dernier.

Ce modèle permet également de bien dissocier les défaillances et les facteurs (endogènes et/ou exogènes) qui sont intervenus. Par exemple, l'inattention est un facteur car elle peut provoquer plusieurs types de défaillances.
L'identification des besoins du conducteur peut alors être réalisée conformément aux hypothèses de ce modèle et seront donc le strict reflet des défaillances fonctionnelles rencontrées par le conducteur.

Plus simplement par exemple, une erreur de détection révèlera le besoin d'une aide au niveau du processus de détection pour le conducteur. Une erreur dans l'évaluation des contraintes liées au temps et/ou à l'espace révèlera le besoin pour le conducteur d'être aidé au niveau du processus d'évaluation, etc.

Dans le cas où un conducteur est sujet à plusieurs défaillances, cela signifie qu'il a probablement la nécessité de plusieurs besoins. En effet, même si un besoin peut être compensé, un autre besoin par exemple de nature différente peut ne pas l'être.
Il peut y avoir également une influence plus ou moins grande de telle ou telle défaillance dans le déroulement de l'accident. Le besoin correspondant devra aussi prendre en compte ce niveau d'importance.

Pour l'identification des besoins, une grille de codage spécifique a été établie sur la base des précédents travaux [14,[16]. Cette codification est réalisée à partir des données détaillées contenues dans les dossiers EDA, telles que les entretiens des conducteurs, la reconstruction cinématique, les caractéristiques environnementales, celles du véhicule et bien entendu de l'analyse du cas étudié.

Au total 28 besoins ont été listés reflétant les principales difficultés rencontrées soit par le conducteur soit par le piéton.
Cette liste des besoins est calquée sur les différentes fonctions mises en application par le conducteur et pour lesquelles une défaillance peut survenir, à laquelle ont été ajoutée deux catégories une dédiée à la phase d'urgence (besoin en correction) et une autre dédiée à la phase de collision (besoin en protection).

Les besoins sont donc classés en 8 catégories :
1. Besoins liés au diagnostic interne à l'usager
2. Besoins en détection
3. Besoins liés au diagnostic externe à l'usager
4. Besoins en pronostic
5. Besoins liés au contrôle du véhicule
6. Besoins en communication
7. Besoins en protection
8. Besoins en correction

2.2.1 Besoins liés au diagnostic interne à l'usager

Les besoins liés au diagnostic interne se réfèrent à la capacité du conducteur à évaluer et comprendre les informations liées à son état et à celui de son véhicule. Ces besoins touchent à la question globale de la capacité du conducteur et du véhicule à garder le cap.

2.2.1.a B01 - Besoins liés à l'état de l'usager

Les problèmes liés à l'état de l'usager s'appliquent lorsque les performances du conducteur sont diminuées soit par la fatigue, l'alcool, drogues ou encore certains médicaments.
Le besoin approprié consiste alors à aider le conducteur à être conscient de son niveau de vigilance ou d'attention. Il doit être codé à chaque fois que le conducteur montre une forte diminution de ces capacités à la conduite.

2.2.1.b B02 - Besoins liés à l'état du véhicule

Les problèmes liés à l'état du véhicule s'appliquent lorsqu'un défaut mécanique a soit contribué à la survenue de l'accident, soit a diminué l'efficacité de la manœuvre d'urgence (exemple pression des pneus, usure des pneus, systèmes de freinage, etc.) Le besoin approprié consiste en une aide qui alerte le conducteur (le plus tôt possible) d'un défaut sur son véhicule.
Dans le cas où le conducteur est au courant de l'existence d'un défaut sur son véhicule, ce besoin n'a pas lieu d'être identifié.

2.2.2 Besoins en détection

Ces besoins sont liés à un problème de perception ou de détection d'un obstacle gênant la progression.

2.2.2.a B03 – Détection d'une difficulté inattendue liée à la route

Ce besoin s'applique pour toutes les difficultés inattendues et liées à la route telles que :

- Un virage dangereux, en particulier avec un rayon qui se resserre
- Une intersection sans aucune indication
- Un problème lié à l'état de surface (verglas, route glissante, trous, travaux, etc.)
- Un problème de visibilité (brouillard soudain)
- Un problème de lisibilité (le conducteur ne sait plus où il doit aller ou la vitesse qu'il doit adopter)
- etc.

Ce besoin est identifié seulement en cas d'une difficulté soudaine rencontrée par le conducteur et pas seulement pour un problème intrinsèque de la route.

2.2.2.b B04 – Détection d'un obstacle fixe sur la route

Ce besoin s'applique lorsque le conducteur rencontre un obstacle fixe sur sa route qu'il n'avait pas vu ou perçu trop tard pour éviter l'accident.
Il ne doit pas être confondu avec un problème lié à la compréhension de la manœuvre d'un autre usager ou d'anticipation de ses intentions.
De plus, l'obstacle (objet, piéton, animal ou véhicule) doit être depuis suffisamment longtemps sur la route pour que le conducteur soit capable de le détecter et de prendre en compte cette information.

2.2.2.c B05 – Détection d'un obstacle se déplaçant lentement sur la route

Ce besoin est très proche du précédent mais avec la particularité que l'obstacle se déplace très lentement sur la route. De la même façon, l'obstacle doit se déplacer lentement et doit se trouver sur la route depuis suffisamment longtemps pour que le conducteur puisse le détecter et traiter l'information.

2.2.2.d B06 – Détection d'un usager se déplaçant dans sa voie de circulation

Ce besoin s'applique en particulier dans le cas de collision fronto-arrière, fronto-frontale ou pour certaines manœuvres de dépassement (les dépassements effectués avec une évaluation des possibilités trop rapide ou inexistante sont exclus).
Ce besoin peut s'appliquer dans les cas où le véhicule est masqué par la géométrie du virage, un sommet de côte, par un autre véhicule ou par une visibilité réduite (brouillard, pluie, éblouissement, etc.). Il peut également s'appliquer dans le cas où le conducteur ne fait pas assez attention à ce qui se passe devant lui.

2.2.2.e B07 – Détection d'un usager/animal qui traverse

Ce besoin ne s'applique que si l'obstacle (piéton, animal ou véhicule) a surgi soudainement devant le conducteur ou l'on est sûr qu'il a été perçu trop tardivement pour effectuer un évitement (par exemple les cas liés à un masque à la visibilité en particulier en zone urbaine).

2.2.2.f B08 – Détection d'un usager se trouvant hors du champ de vision

Ce besoin s'applique essentiellement lorsque un autre véhicule provenant de derrière ou roulant à côté dépasse ou change de voie et que cette manœuvre empêche celle entreprise par le conducteur (changement de voie ou dépassement). Ce besoin survient généralement après une défaillance attentionnelle.

2.2.2.g B09 – Détection d'un usager masqué

Ce besoin s'applique essentiellement lorsqu'un véhicule est masqué par la végétation, la signalisation ou par un autre véhicule et qu'il va empêcher la manœuvre entreprise par le conducteur (changement de direction, dépassement, etc.). Ce besoin est initié par un élément externe qui entraine un masque à la visibilité.

2.2.2.h B10 – Détection d'une sortie de voie

Ce besoin s'applique lorsque le conducteur ne détecte pas que son véhicule dévie de sa voie à cause d'un problème d'attention ou d'endormissement.

2.2.3 Besoins liés au diagnostic externe à l'usager

Le besoin en diagnostic externe se réfère à la capacité du conducteur à évaluer et comprendre les informations provenant de son environnement. Ce besoin traduit la capacité du conducteur à développer un comportement adapté en fonction de la route et des autres usagers.

2.2.3.a B11 – Adaptation de la vitesse par rapport aux conditions environnementales

Ce besoin s'applique dans le cas d'une vitesse excessive par rapport à la géométrie de la route ou des conditions d'adhérence (perte de contrôle en virage par exemple).

2.2.3.b B12 - Adaptation de la vitesse par rapport à la réglementation

Ce besoin s'applique lorsque la vitesse pratiquée n'est pas en adéquation avec la signalisation imposée par le type de route sur laquelle l'usager roule (violation du code de la route).

2.2.3.c B13 - Evaluation de la vitesse d'approche sur un usager ralentissant

Ce besoin s'applique lorsque le conducteur sous-estime la vitesse d'un véhicule devant lui qui ralentit ou s'arrête. Ce besoin est codé dans les 2 cas suivants :

- Lorsque sur une voie rapide le conducteur est confronté à un véhicule roulant lentement ou qui s'arrête à cause d'un embouteillage
- Lorsqu'un conducteur dans un trafic soutenu est surpris par le freinage soudain du véhicule devant lui.

2.2.3.d B14 - Evaluation d'une probabilité de collision avec un autre usager

Ce besoin s'applique aux intersections lorsque le conducteur évalue mal les mouvements relatifs entre lui et un autre véhicule se déplaçant transversalement. Il ne s'applique pas lorsque l'autre usager est perçu tardivement (besoin en détection)

2.2.3.e B15 - Evaluation de la possibilité d'effectuer un dépassement ou un changement de voie

Ce besoin s'applique correspond par exemple aux cas où l'estimation de la distance ou du temps requis pour effectuer la manœuvre a été réalisée de façon trop rapide.

2.2.3.f B16 - Evaluation de la possibilité pour traverser ou s'insérer dans le trafic

Ce besoin s'applique généralement aux usagers qui n'ont pas la priorité et qui doivent traverser (couper) ou s'insérer dans un flux rapide de circulation. Ceci correspond le plus souvent au démarrage à partir d'un stop ou une ré-accélération suite à un changement de direction.

2.2.4 Besoins liés au pronostic

Les besoins liés au pronostic se réfèrent à la capacité du conducteur à prévoir :

- D'adapter son comportement au fonctionnement du site
- Le comportement des autres usagers.

2.2.4.a B17 - Prévision du démarrage ou d'un non arrêt de l'autre usager

Ce besoin s'applique principalement aux intersections où le conducteur qui a la priorité pense jusqu'au dernier moment que l'autre usager le laissera passer. Ce besoin est relié au fait de pouvoir prédire les intentions des autres.

2.2.4.b B18 - Prévision du ralentissement ou de l'arrêt de l'autre usager

Ce besoin s'applique principalement en section courante lorsqu'un conducteur est surpris par le ralentissement soudain ou l'arrêt du véhicule dans les cas non couverts par le besoin B13.

2.2.4.c B19 - Prévision de la manœuvre de l'autre usager

Ce besoin s'applique lorsque le conducteur fait une mauvaise interprétation des intentions de l'autre usager.

2.2.4.d B20 - Prévision de la manœuvre à effectuer relative au fonctionnement du site

Ce besoin permet d'anticiper l'adéquation entre une action (manœuvre) et l'infrastructure et son fonctionnement. Par exemple un conducteur peut avoir détecté une intersection mais ne comprend pas ce qu'il doit faire (absence de marquage, intersection complexe, signalisation insuffisante, absente ou hors fonction, etc.)

2.2.5 Besoins liés au contrôle du véhicule

Le besoin lié au contrôle du véhicule se réfère à la capacité du conducteur à effectuer des actions sur son véhicule en fonction du trafic, du tracé ou des sollicitations dynamiques que peut supporter son véhicule.

2.2.5.a B21 – Contrôle du véhicule

Il y a plusieurs causes à l'origine d'un mauvais contrôle ou d'une perte de contrôle d'un véhicule, en particulier la non-perception d'une difficulté. Ici, le besoin se réfère à l'évaluation correcte par le conducteur des capacités du véhicule ainsi que des connaissances appropriées pour la manœuvre envisagée, en particulier pour les mouvements du volant.

2.2.6 Besoins en communication

Les besoins en communication s'applique lorsqu'un usager à la nécessité de montrer sa présence (dans le cas d'un masque à la visibilité par exemple) ou de montrer ses intentions aux autres (par exemple ralentir pour tourner à gauche). Ce besoin s'adresse en particulier aux aides liées à la communication véhicule/véhicule ou véhicule/infrastructure.

2.2.6.a B22 - Besoin de montrer sa présence / son intention

Ici l'usager n'est pas visible ou n'a pas la visibilité suffisante et doit s'avancer donc empiéter sur la voie de circulation pour prendre l'information avant d'entreprendre sa manœuvre.

2.2.7 Besoins en protection

Les besoins en protection s'appliquent à la phase de collision. Ils ne sont codés que lorsque les blessures de l'usager sont jugées graves et que le niveau de violence reste dans des proportions que l'on peut maitriser.

2.2.7.a B30 – Besoin en protection

Ce besoin se réfère à la protection de l'usager (occupant, piéton) en cas de blessures graves (M.AIS3+) et si les énergies mises en jeu pendant l'accident ne sont pas trop importantes. La protection souhaitée peut également s'appliquer à l'autre véhicule (cas piéton par exemple).

2.2.8 Besoins en correction

Les besoins en correction ne concernent que la phase d'urgence. Ils s'appliquent lorsque le conducteur doit entreprendre une manœuvre d'urgence pour se sortir de la mauvaise situation dans laquelle il se trouve.

2.2.8.a NE1 - Besoin en aide au contrôle de trajectoire

Ce besoin s'applique lorsque le conducteur entreprend une manœuvre d'urgence qui conduit à la perte de contrôle du véhicule, par exemple en cas d'un coup de volant trop brutal ou sur dosé.

2.2.8.b NE2 - Besoin en freinage /régulation du freinage

Ce besoin s'applique lorsque le conducteur effectue un freinage d'urgence sous ou sur dosée. Il ne concerne pas un défaut de freinage sur le véhicule.

2.2.8.c NE3 - Besoin au niveau de l'infrastructure

Ce besoin s'applique lorsque le conducteur effectue une manœuvre d'urgence mais que l'infrastructure n'offre pas la place suffisante pour pouvoir effectuer un rattrapage (exemple sur-largeur pas suffisamment dimensionnée)

2.2.8.d NE4 - Besoin en aide à la décision / à la prise de décision

Ce besoin s'applique lorsque le conducteur n'a pas pris ou est incapable de prendre la décision la plus adaptée pour se sortir de la situation dans laquelle il se trouve. Ici le conducteur à conscience qu'il se trouve en situation de danger.

2.2.8.e NE5 - Besoin en diagnostic de situation d'urgence

Ce besoin s'applique lorsque le conducteur n'a pas perçu la situation comme dangereuse et n'a donc pas réagi.

2.2.9 Les besoins pivot, en amont, en correction et en protection

Comme il a été dit auparavant, l'accident est un processus qui peut être décomposé en plusieurs phases. Cette décomposition si elle n'est pas bien utilisée peut compliquer l'analyse des problèmes survenus dans le déroulement de l'accident et peut amener des erreurs dans la définition de solutions. Il est donc important de bien connaître le problème auquel on s'adresse ainsi que la séquence à laquelle il se produit si l'on veut mettre en place une solution adaptée.

Au cours de l'accident le conducteur doit adapter en permanence ses fonctions opérationnelles aux différents évènements intervenant dans les phases successives de l'accident. Dans le cas contraire, il peut avoir besoin de plusieurs aides successives.
Lorsqu'un conducteur est confronté à plusieurs défaillances fonctionnelles qui s'enchainent, l'analyse séquentielle de l'accident permet d'identifier pour chaque phase, les défaillances en cours des autres.
La défaillance la plus significative est celle qui se produit lors de la phase de rupture. C'est elle qui va faire basculer la situation de conduite en une situation accidentelle. Le besoin associé sera dit « pivot » ou « central » car s'il est comblé l'accident peut ne pas se produire à condition que le conducteur ne soit pas complètement passif.
Bien entendu, les conducteurs pour lesquels aucune défaillance n'a pu être identifiée (en particulier les conducteurs passifs), aucun besoin ne pourra être défini.
Lorsque plusieurs défaillances fonctionnelles sont identifiables, plusieurs besoins peuvent être définis.
Il suffit dans ce cas de bien mettre en correspondance le moment où se produit la défaillance avec les séquences prédéfinies de l'accident.

Durant la phase de conduite les besoins diagnostiqués permettront de devancer la défaillance rencontrée lors de la phase de rupture. Les besoins identifiés à cette étape seront appelés « ***besoins en amont*** ».

Durant la phase de rupture, les besoins diagnostiqués seront appelés « ***besoins pivot*** » car ils représentent l'aide nécessaire (mais pas forcément suffisante) pour l'évitement de l'accident.

Durant la phase d'urgence, les besoins diagnostiqués permettent au conducteur de reprendre le contrôle de la situation mal engagée à partir de la rupture, en prenant en compte les contraintes spatio-temporelles et dynamiques. Les besoins identifiés à cette étape seront appelés « ***besoins en correction*** ». Ils s'appliquent aux processus de décision et d'exécution.

Durant la phase de collision, les besoins diagnostiqués doivent permettre de diminuer voir d'éviter l'apparition de blessures graves chez les usagers (conducteur, occupant, piéton). Les besoins identifiés à cette étape seront appelés « ***besoins en protection*** ».

Les besoins en amont, pivot et en correction concernent le domaine de la sécurité active, c'est-à-dire que les aides associées doivent permettre l'évitement de l'accident ou dans le cas où l'évitement à échoué d'en diminuer les conséquences.
Les besoins en protection concernent le domaine de la sécurité passive c'est-à-dire tous les systèmes destinés à la protection des usagers sachant que le choc a lieu.

2.3 Les contre-mesures utilisées

Puisque nous avons identifié des besoins, il devenait intéressant d'analyser l'adéquation entre ces besoins réels et un ensemble de contre-mesures sélectionnées.
Bien sûr, cette adéquation reste très dépendante de la sélection. C'est pourquoi nous avons choisi des systèmes de sécurité qui sont soit déjà commercialisés ou sur le point de l'être, soit déjà à l'étude mais non encore finalisés.
De la même façon, nous ne nous sommes pas contentés de sélectionner uniquement des contre-mesures liées aux véhicules, mais avons également essayé de regarder du côté de l'infrastructure.
Si l'on veut être capable de juger de l'adaptation entre un besoin identifié et un système de sécurité ainsi que de pouvoir analyser ses éventuelles limitations dans son

fonctionnement due aux contraintes environnementales entourant l'accident, il faut pouvoir disposer de certaines caractéristiques techniques du système.
La difficulté principale lorsque l'on veut appréhender les caractéristiques de fonctionnement d'une contre-mesure de sécurité c'est que pour une même prestation, il peut exister différents systèmes qui peuvent eux-mêmes différer entre eux de par les technologies utilisées ou de par ses fonctionnalités.
Ici nous voyons apparaître plusieurs concepts qu'il nous faut définir.

Prestation de sécurité : Une prestation est un service fourni dans le but de répondre à une problématique d'ordre général d'insécurité (exemple amélioration de la visibilité, amélioration de la tenue de route en situation d'urgence, détection de la collision, etc.).

Un système de sécurité est une composante d'une prestation, un outil d'application permettant de répondre à un problème spécifique. Par exemple, le système de détection de l'angle mort est un système permettant d'améliorer la visibilité pour le conducteur (prestation). Un système peut également faire partie de plusieurs prestations (exemple, l'AEBS est un système répondant aux prestations de détection d'une collision ou encore d'amélioration de la tenue de route en situation d'urgence par l'apport d'un freinage automatique).

Une ***technologie*** est une composante du système de sécurité qui assure une fonction bien précise (acquisition, traitement, exécution). Elle se réfère à l'aspect technique. Une même technologie peut être utilisée par différents systèmes de sécurité.

Prenons un exemple : amélioration de l'efficacité du freinage.
La prestation requise est d'apporter une solution qui permette d'améliorer les performances d'un freinage en situation d'urgence.
Aujourd'hui, il existe différent systèmes de sécurité répondant à cette prestation (la liste suivante n'est pas exhaustive) :

- L'ABS (Anti-Blocking System) qui équipe tous les nouveaux véhicules et qui évite le blocage des roues (perte de l'efficacité de la friction) lors d'une forte sollicitation du freinage par le conducteur.
- L'AFU (Assistance au Freinage d'Urgence) qui déclenche un freinage optimal (type ABS) dès que le conducteur sollicite un freinage d'urgence. En fait le système se base soit à partir d'un effort sur la pédale de frein, soit d'une attaque rapide de la pédale de frein.
- L'AEBS (Automatic Emergency Braking System) qui déclenche un freinage automatique dès qu'un obstacle est identifié dans la trajectoire du véhicule.

Prenons maintenant l'exemple du système AEBS et principalement celui dédié au piéton. Dans ce cas le système doit être capable de détecter un piéton dans la trajectoire du véhicule. Aujourd'hui, il existe plusieurs technologies permettant de détecter un piéton :

- Le RADAR : le système détecte la présence d'un piéton à partir de l'émission et de la réception d'une onde radio. Ce type de système permet également de déterminer la distance et la vitesse à laquelle se déplace l'objet.
- Détecteur infrarouge : il s'agit d'un système permettant de détecter la présence d'un piéton à partir du rayonnement thermique de l'objet.
- La caméra : la scène avant est filmée par une caméra le plus généralement placée derrière le rétroviseur et un programme est chargé d'identifier les piéton(s) mais également de pouvoir prévoir si ce piéton deviendra un obstacle potentiel.

Dans l'analyse proposée dans cette étude, pour répondre à un besoin identifié, le niveau de documentation défini par la prestation peut suffire. Cependant, nous voulons aussi évaluer les limites de cette prestation à partir des contraintes contextuelles liées à l'accident. Pour cela, la définition générique ne suffit plus et il nous est donc nécessaire d'avoir un niveau de granularité supérieur et donc d'introduire les systèmes mais également dans certains cas la technologie.

Descendre jusqu'au niveau de la technologie, implique d'avoir une bonne connaissance du fonctionnement de chaque système. Si pour chaque constructeur et équipementier nous sommes capables d'identifier les systèmes de sécurité qu'ils proposent (systèmes mis sur le marché ou sur le point d'être commercialisés) les technologies utilisées ne sont (pour certains) pas très bien documentées quant aux spécifications techniques (autre que celles du domaine d'utilisation qui sont accessibles au grand public) elles font partie du savoir faire de l'entreprise et sont donc confidentielles.
Pour la sélection des aides, nous nous sommes arrêtés au niveau du système en essayant de donner (lorsque cela a été possible) des informations techniques sur son fonctionnement.

2.3.1 Les systèmes de sécurité sur le véhicule

30 systèmes de sécurité ont été sélectionnés pour le véhicule. La sélection est identique à celle utilisée pour le projet DaCoTA.
Pour chaque système, nous avons créé une fiche spécifique sur laquelle on retrouve les informations suivantes :

- Sa dénomination
- Les problématiques auxquelles la prestation répond
- Les fonctionnalités couvertes
- L'identification des phases de l'accident où la prestation peut intervenir
- Ses différents modes opératoires (Informatif, Alerte, Coopératif ou Automatique)
- La liste des systèmes de sécurité et leurs caractéristiques techniques principales
- Les évaluations d'efficacité associées qui ont été publiées.

Les fiches réalisées pour le projet DaCoTA sont données dans l'annexe. Une synthèse est présentée dans le tableau ci-dessous :

Système de sécurité	Prestation	Sigle	Phase de l'accident concernée				
			Conduite	Rupture	Urgence	Collision	Post-Collision
Advanced Adaptive Front Light System	Amélioration de la visibilité	AAFLS	x	x			
Adaptive Cruise Control	Contrôle dynamique longitudinal	ACC	x	x	x	x	
Alcolock Keys	Surveillance du conducteur	AK	x				
Brake Assist	Contrôle dynamique longitudinal	BA	x	x	x	x	
Blind Spot Detection	Amélioration de la visibilité	BS	x	x			
Automatic Emergency Braking System	Contrôle dynamique longitudinal	AEBS	x	x	x	x	
Collision Warning	Détection	CW	x	x	x	x	
Drowsy Driver Detection System	Surveillance du conducteur	DDS	x	x			
Electronic Stability Control	Contrôle dynamique latéral	ESC	x	x			
Intersection Control	Détection / Communication	IC	x	x			
Intelligent Speed Adaptation	Gestion de la vitesse	ISA	x	x	x	x	
Lane Changing Assistant	Surveillance du conducteur	LCA	x	x			
Lane Keeping Assistant	Contrôle dynamique latéral	LKA	x	x			
Night Vision	Amélioration de la visibilité	NV	x	x			
Predictive Assist Braking	Contrôle dynamique longitudinal	PBA	x	x	x	x	
Vulnerable Road Users Protection	Contrôle dynamique longitudinal	VRU	x	x	x	x	
Tyre Pressure Monitoring and Warning	Détection	TPMS	x	x	x		
Traffic Sign Recognition	Détection / Communication	TSR	x	x	x	x	
ABS (Antilock Braking System)	Contrôle dynamique longitudinal	ABS	x	x	x	x	
LDW (Lane Departure Warning)	Contrôle dynamique latéral	LDW	x	x			
Rollover detection	Contrôle dynamique latéral	RollD	x	x			
Automated headlights	Amélioration de la visibilité	AutoLights	x	x			
eCall	Détection / Communication / Protection	eCall				x	x
Event Data Recorder	Surveillance du conducteur	EDR			x	x	x
Low friction detection	Détection	LoFrctD	x	x	x	x	
Airbag Pedestrian protection	Protection	PedPro	x	x	x	x	
Anti Whiplash seat	Protection	AW				x	
Precrash (Presafe – Mercedes)	Protection	PreSAFE			x	x	
Youth Key	Surveillance du conducteur	YK	x	x	x	x	
Youth driver monitoring	Surveillance du conducteur	DrvMon	x				

Table 2 : Liste des systèmes de sécurité associés aux véhicules

2.3.2 Les contre-mesures à partir de l'infrastructure

Pour l'infrastructure 5 mesures ont été sélectionnées. Elles sont identiques à celles utilisées dans le projet DaCoTA.
Pour chacune des mesures sont données les informations suivantes :

- Une description de son fonctionnement
- Une partie technique renseignant :
    - les situations accidentelles concernées par le système
    - les spécifications liées au déclenchement (partie distance d'alerte)
    - les véhicules concernés
    - les situations défavorables.

Les fiches réalisées pour le projet DaCoTA sont données dans l'annexe.
Une synthèse est présentée dans le tableau ci-dessous :

Systèmes de sécurité	Sigle	Phase de l'accident concernée				
		Conduite	Rupture	Urgence	Collision	Post-collision
Bandes de rives sonores	INFRA AS 1	x	x			
Sur largeur praticable	INFRA AS 2		x	x	x	
Alerte Virage	INFRA AS 3	x	x			
Alerte intersection	INFRA AS 4	x	x			
Contrôle automatique de la Vitesse (Radar)	SPDCAM	x	x	x		

Table 3 : Liste des systèmes de sécurité associés à l'infrastructure

2.4 Prise en compte des contraintes contextuelles de l'accident

Une des valeurs ajoutées liées à l'association de mesures de sécurité répondant aux besoins réels identifiés pour chaque conducteur, est de pouvoir tenir compte du contexte particulier de l'accident pour en déduire des limites de fonctionnement pouvant engendrer une diminution plus ou moins grande voire totale de son efficacité.
Puisque nous réalisons une analyse au cas par cas, il était opportun de pouvoir également identifier les limitations dans le fonctionnement d'un système de sécurité en fonction des éléments externes ou interne au conducteur, autre que par une sélection de paramètres et de valeurs associées permettant d'exclure certaines situations.
Les limitations sont recensées par jugement d'expert en tenant compte de l'ensemble des éléments du dossier y compris des entretiens et de la reconstruction (informations difficilement transposable en codification).
Dans le cas où une limitation a été identifiée nous avons également essayé de juger son rôle dans la perturbation qu'elle pouvait créer d'un point de vue du fonctionnement du système de sécurité et de ce fait en limiter son efficacité.

2.4.1 Les limitations

Le terme limitation désigne ici le caractère d'un facteur lié au contexte de l'accident à restreindre le fonctionnement d'un système d'aide si celui-ci avait été disponible sur le véhicule. Cette restriction entraine donc une diminution de l'efficacité du système pour le cas considéré.
Les limitations recensées ont été listées en deux catégories les facteurs exogènes et les facteurs endogènes.
Les facteurs exogènes désignent les éléments qui sont externes au conducteur, présents lors de l'accident et qui peuvent avoir une influence plus ou moins grande sur son déroulement. Ce sont par exemple des facteurs liés aux conditions météorologiques, au trafic ou au véhicule.
Les facteurs endogènes désignent les éléments qui sont internes au conducteur, présents lors de l'accident et qui peuvent avoir une influence plus ou moins grande sur son déroulement. Ce sont par exemple des facteurs liés à l'état de santé du conducteur, liés à son niveau attentionnel ou encore à son état psychologique.

2.4.1.a Les facteurs endogènes

Ces facteurs sont liés au conducteur.
38 limitations ont été listées et regroupées en 5 catégories :

- Les rejets : ce sont les facteurs pouvant entrainer une volonté chez le conducteur à ne pas prendre en compte les alertes données par le système voire à le déconnecter.
- Les facteurs psychologiques : ce sont des facteurs liés à la baisse de vigilance ou aux effets liés à la consommation d'alcool, de drogues ou de médicaments.
- Les problèmes attentionnels : ce sont les facteurs liés à l'attention, à la distraction, au dépassement des capacités cognitives ou aux trop fortes émotions.
- Les problèmes liés à l'attente d'une action par l'autre : ces facteurs sont liés aux interactions (ou de non interaction) avec les autres usagers ou de négligence de prise d'information.
- Les problèmes d'exécution : ce sont les facteurs entrainant une mauvaise exécution de la manœuvre liés à la panique, réaction incontrôlée, etc.

Ces limitations sont données dans l'annexe 1.

2.4.1.b Les facteurs exogènes

Ce sont des facteurs externes au conducteur. 39 limitations ont été listées. Elles concernent essentiellement les facteurs environnementaux (adhérence, conditions de luminosité, état de l'infrastructure, limitation géométrique, etc.) mais aussi des limitations techniques liées au fonctionnement de l'aide comme par exemple l'angle ou la distance de détection.
L'ensemble de ces limitations sont données dans l'annexe 1.

2.4.2 Le niveau d'interférence

Lorsqu'au moins une limitation a été identifiée, il nous a paru nécessaire de pouvoir estimer son degré de perturbation, c'est-à-dire d'introduire un indice permettant d'évaluer le niveau d'inefficacité engendré par sa présence.
Ce paramètre reste une valeur subjective donnée par l'expert qui réalise l'analyse.
Nous aurions pu nous attacher à essayer de quantifier de façon numérique cette diminution de l'efficacité mais cette question reste complexe et nécessite des connaissances techniques auxquelles nous n'avons pas accès (par exemple sur le fonctionnement précis de telle ou telle technologie, ou des spécifications techniques du domaine de fonctionnement de l'aide donnée par le constructeur, etc.) ou des connaissances sur des domaines de recherche encore en exploration notamment dans le domaine du comportement humain.
L'objectif principal de cette étude n'est pas d'évaluer l'efficacité réelle de tel ou tel système de sécurité. A partir de cette hypothèse, il n'était donc pas nécessaire de faire appel à de savants calculs pour tenir compte d'une potentielle limitation, voire de plusieurs limitations. Pour éviter tous problèmes liés à l'hétérogénéité des valeurs attribuées par dire d'experts ou encore sur la mise en place de formules mathématiques tenant compte d'une multitude de cas particuliers, nous nous sommes attachés à une estimation beaucoup plus simple basée sur 3 niveaux de perturbation, laissant le soin aux statisticiens de nous trouver (un jour) le secret de la formule miracle.
Pour la codification, le choix s'effectue donc entre les 3 propositions suivantes :

- ***Niveau 1*** : Aucune limitation visant à diminuer l'efficacité de l'aide n'a pu être mise en évidence.
- ***Niveau 2*** : Des facteurs limitant ont pu être identifiés mais leur impact sur l'efficacité de l'aide est jugé mineur.
- ***Niveau 3*** : Des facteurs limitant ont pu être identifiés et ont un réel impact sur le fonctionnement de l'aide sélectionnée, avec une forte probabilité de la rendre inefficace, voir de ne pas permettre de répondre au besoin.

2.5 Les étapes de l'analyse

Il s'agit d'une analyse au cas par cas, c'est-à-dire que chaque cas doit être étudié indépendamment en fonction de l'objectif recherché. Le type d'information ici requis nécessite le retour au dossier et une analyse réalisée par un spécialiste et ne peut pas être automatisé.

La démarche utilisée dans cette étude repose sur les étapes principales suivantes pour chaque séquence de l'accident et pour chaque impliqué :

- Identification de la défaillance fonctionnelle
- Identification des facteurs exogènes ou endogènes associés
- Caractérisation du besoin associé
- Sélection des contre-mesures répondant à ce besoin
- Identification des limitations dues au contexte quant à la performance de chaque contre-mesure sélectionnée
- Estimation du niveau de perturbation

En tout, la codification complète d'un cas d'accident repose sur 22 étapes (Figure 4). Chaque étape fait appel à une grille de codage qui est donnée en annexe.

Les différentes étapes de la codification sont les suivantes pour chaque usager (conducteur ou piéton) impliqué dans l'accident:

- Etape 1 : Il s'agit de décrire la situation dans laquelle se trouve le conducteur juste avant l'accident.
- Etape 2 : Il s'agit d'établir la liste des facteurs initiaux présents avant la phase de rupture
- Etape 3 : Identification de la défaillance fonctionnelle à l'origine de l'accident
- Etape 4 : Caractérisation de l'ensemble des facteurs déclenchant
- Etape 5 : Identification du scénario relatif à l'analyse HFF
- Etape 6 : Caractérisation du degré d'implication du conducteur
- Etape 7 : Identification de la défaillance fonctionnelle en phase d'urgence
- Etape 8 : Caractérisation de l'ensemble des facteurs limitant l'exécution de la manœuvre d'urgence
- Etape 9 : Identification de la configuration de la collision
- Etape 10 : Caractérisation des facteurs aggravants
- Etape 11 : Sélection des besoins en amont conformément à la situation identifiée à l'étape 1 et des facteurs initiaux (étape 2)
- Etape 12 : Sélection des contre-mesures appropriées en fonction des besoins caractérisés dans l'étape 11
- Etape 13 : Identification des limitations potentielles de l'efficacité des contre-mesures sélectionnées lors de l'étape 12 en fonction du contexte, et estimation du degré de limitation
- Etape 14 : Sélection des besoins pivot conformément à la défaillance fonctionnelle identifiée à l'étape 3
- Etape 15 : Sélection des contre-mesures appropriées en fonction des besoins caractérisés dans l'étape 14
- Etape 16 : Identification des limitations potentielles de l'efficacité des contre-mesures sélectionnées lors de l'étape 14 en fonction du contexte, et estimation du degré de limitation
- Etape 17 : Sélection des besoins en correction conformément à la défaillance fonctionnelle identifiée à l'étape 7
- Etape 18 : Sélection des contre-mesures appropriées en fonction des besoins caractérisés dans l'étape 17
- Etape 19 : Identification des limitations potentielles de l'efficacité des contre-mesures sélectionnées lors de l'étape 18 en fonction du contexte, et estimation du degré de limitation
- Etape 20 : Sélection des besoins en protection conformément à la configuration de la collision identifiée à l'étape 9 et des facteurs aggravants (étape 10)

- Etape 21 : Sélection des contre-mesures appropriées en fonction des besoins caractérisés dans l'étape 20
- Etape 22 : Identification des limitations potentielles de l'efficacité des contre-mesures sélectionnées lors de l'étape 21 en fonction du contexte, et estimation du degré de limitation

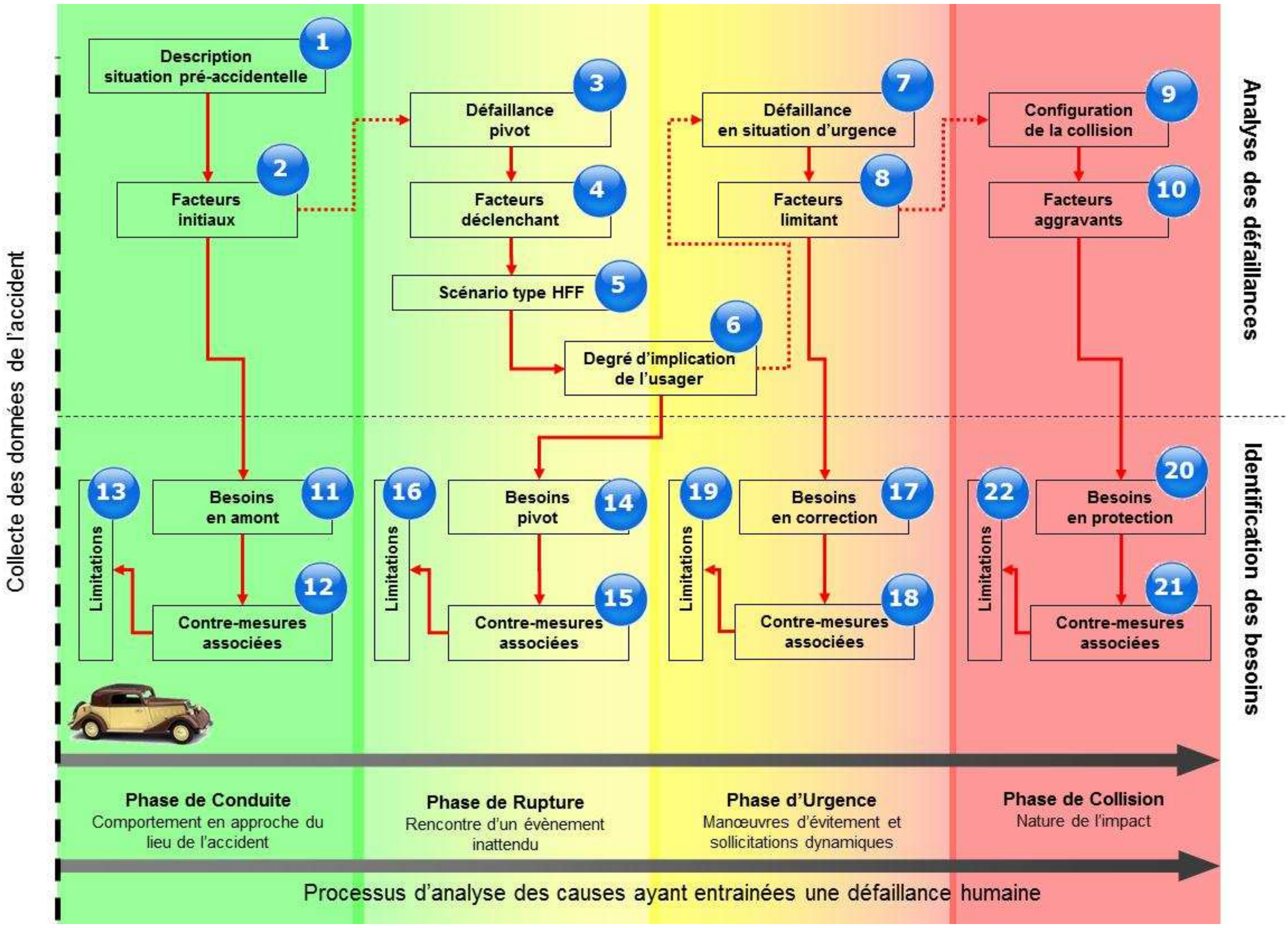

Figure 4 : Etapes de codification pour l'identification des besoins du conducteur

Ces 22 étapes sont à répéter pour chaque accident et chaque conducteur et piéton impliqués dans l'accident.
L'échantillon contenant 100 accidents impliquant dans la plupart des cas un conducteur et un piéton, c'est un total de 440 étapes qui ont été réalisées pour cette étude.

3 L'analyse des besoins

Cette partie est dédiée aux principaux résultats de l'analyse.
Dans un premier temps nous allons donner quelques caractéristiques principales de l'échantillon utilisé, puis dans un second temps nous présenterons les résultats obtenus pour chaque séquence de l'accident.

3.1 L'échantillon CACIAUP

L'étude repose sur 100 cas d'accidents corporels piéton analysés entre 2009 et 2012 dans le cadre du projet. 110 piétons ont été impliqués dans ces accidents. La base de données ainsi constituée contient des accidents étudiés en temps réels et d'autres en différé [2]. Nous présentons ici quelques informations descriptives de la base de données. Cette description reste succincte car elle est développée plus précisément dans d'autres rapports du projet CACIAUP, en particulier dans l'analyse sectorielle.

La plupart des accidents ont eu lieu en agglomération (95%). Dans 56 cas, on note la présence d'une intersection, à l'endroit du choc ou à proximité immédiate, mais celle-ci joue un rôle dans la genèse de l'accident dans un peu moins de la moitié des cas (25 cas soit 45% des cas en intersection).

On rencontre principalement des intersections en Y et en T (10 et 9 cas respectivement). Ces intersections sont régies par des feux (11 cas), un stop ou une priorité à droite (5 cas chacun).

Le choc a lieu sur un passage piéton pour 50 piétons sur les 110 soit dans à peu près la moitié des cas.

Parmi les piétons, on trouve 55% de femmes et 45% d'hommes.
Les conducteurs se répartissent entre 67% d'hommes et 33% de femmes. La Figure 5 présente les distributions de l'âge du piéton et du conducteur par classe de 5 années.

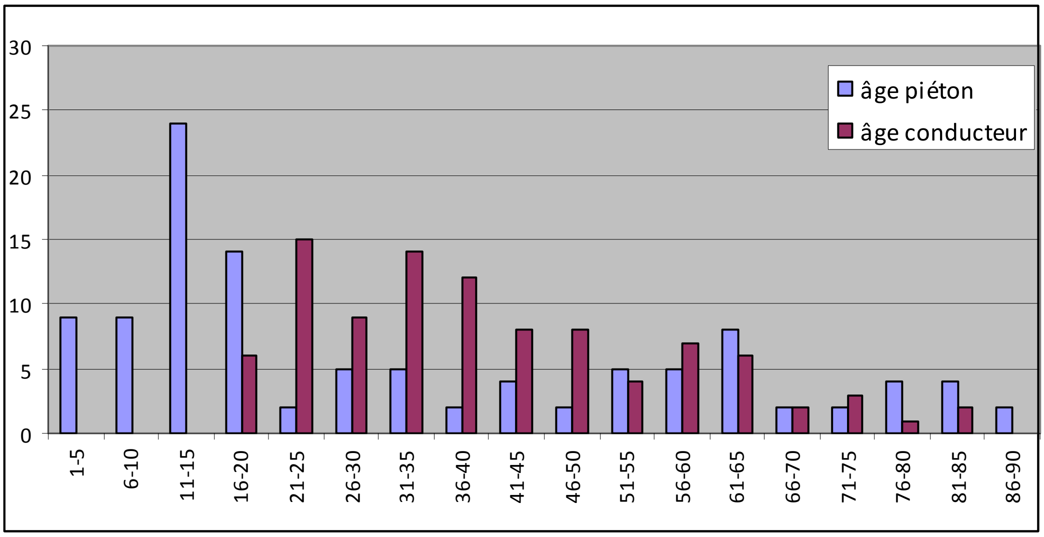

Figure 5: Distribution de l'âge des piétons et des conducteurs.

L'âge moyen des conducteurs est de 40 ans avec une médiane à 38 ans.

Pour les piétons, l'âge moyen est de 32 ans mais la médiane se situe à 18 ans, ce qui indique une distribution décalée vers les âges les plus jeunes malgré une moyenne assez élevée.

Le tableau suivant présente l'âge moyen des piétons et conducteurs en fonction du sexe : les piétons sont caractérisés par une forte différence d'âge selon le sexe, avec une forte proportion de jeunes chez les hommes.

	Sexe	Age moyen	Valeur médiane
Piéton	**Masculin**	26 ans	15 ans
	Féminin	37 ans	31 ans
Conducteur	**Masculin**	39 ans	35 ans
	Féminin	44 ans	43 ans

Table 4: Caractéristiques de l'âge des piétons et des conducteurs en fonction du sexe.

Le choc frontal est le plus représenté (82%), puis le choc latéral (10%). On compte 5 chocs arrière et 3 cas d'inclassable.

Le Table 5 présente la position du choc entre le véhicule et le piéton.

Position du choc	n	%
Sur l'accotement ou le trottoir	8	7,3%
Sur la chaussée en bordure de l'accotement ou du trottoir	13	11,8%
En début de traversée	33	30%
En milieu de traversé hors refuge	22	20%
En milieu de traversée sur le refuge	5	4,6%
En fin de traversée	23	21%
Autres et inconnu	6	5,3%
Total du nombre de piéton	110	100%

Table 5: Répartition de la localisation du choc piéton-véhicule.

Les chocs en début de traversée sont prépondérants, avec plus de 40% des piétons, si on considère que les piétons sur la chaussée ou en bordure du trottoir démarraient leur traversée.

La plupart des piétons marchaient au moment du choc (60 piétons), 31 couraient, 6 étaient immobiles. Il y a un cas où le piéton tombait, et 11 cas d'autres et inconnus.

3.2 La situation pré-accidentelle

La situation pré-accidentelle comme son nom l'indique est l'étape en amont de l'accident juste avant la phase de rupture.

3.2.1 Les situations pré-accidentelles

Les situations pré-accidentelles établissent les circonstances dans laquelle se trouvaient les usagers avant la situation accidentelle. Elles caractérisent les actions qui étaient en cours juste avant la phase de rupture et ne prennent pas en compte le fait que ces actions étaient ou non autorisées.

Ces situations sont classées en 4 typologies :

- ***Les situations stabilisées*** décrivent les situations de conduite usuelles durant lesquelles le conducteur suit sa route sans changement de cap ou de voie avec une vitesse stabilisée. Ces situations sont hors intersection et ne concernent pas le cas des manœuvres particulières.
- ***Les situations en intersection*** décrivent les situations lorsqu'un usager arrive sur une intersection. On distinguera les situations suivant que l'axe emprunté par l'usager est prioritaire ou pas (au sens des règles du code de la route) mais également sur ses intentions de direction (pour tourner à droite, à gauche, aller tout droit, etc.)
- ***Les manœuvres*** décrivent les situations hors intersection au cours de laquelle l'usager effectue une manœuvre particulière telle qu'un dépassement, un changement de voie, ralentit, démarre, tourne (hors intersection), fait demi-tour ou recule. Les usagers circulant à contre-sens sont aussi inclus dans cette typologie.
- ***Les autres situations*** regroupent toutes les situations qui ne sont pas décrites dans les 3 classes précédentes (en stationnement, embouteillage, passage à niveau, etc.). On y retrouve également les manœuvres associées à l'usager piéton.

Sur la Figure 6 sont donnés les résultats relatifs à la distribution des situations pré-accidentelles dans lesquelles se trouvaient les conducteurs avant la situation accidentelle.
La situation dite stabilisée est de loin la plus fréquente puisqu'elle apparait dans 48%.
Viennent ensuite les situations en intersection (39%) dont la moitié concerne des manœuvres de « tourne à gauche » ou dans une moindre mesure des « tourne à droite ».
Les situations dans lesquelles le conducteur effectue une manœuvre représentent 11% de l'ensemble des situations pré-accidentelles dont presque la moitié sont des manœuvres de marche arrière.

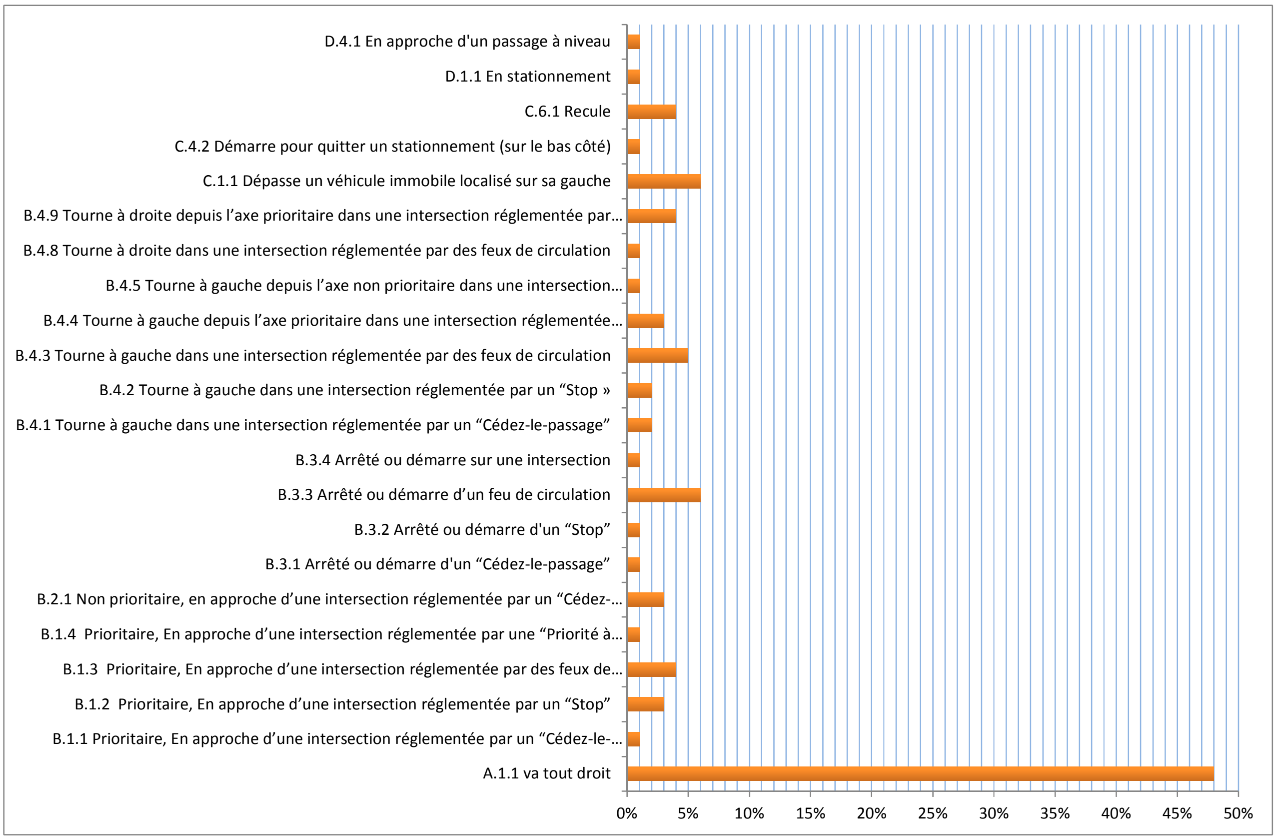

Figure 6 : Répartition des situations pré-accidentelles chez les conducteurs (n=100)

Pour les piétons, dans 51% des cas, l'usager se trouvait sur ou proche d'un passage piéton (dont 60% d'entre eux étaient en train ou s'apprêtaient à traverser), 23% traversaient hors passage piéton, 22% marchaient ou couraient sur le trottoir ou le bas-côté de la route et 4% été arrêtés au bord de la route.
Ces résultats montrent que la détection simultanée d'un passage piéton et d'un individu proche de ce dernier pourrait être une condition de pré-alerte pour un système tel que le VRU (Vulnérable Road User Protection)

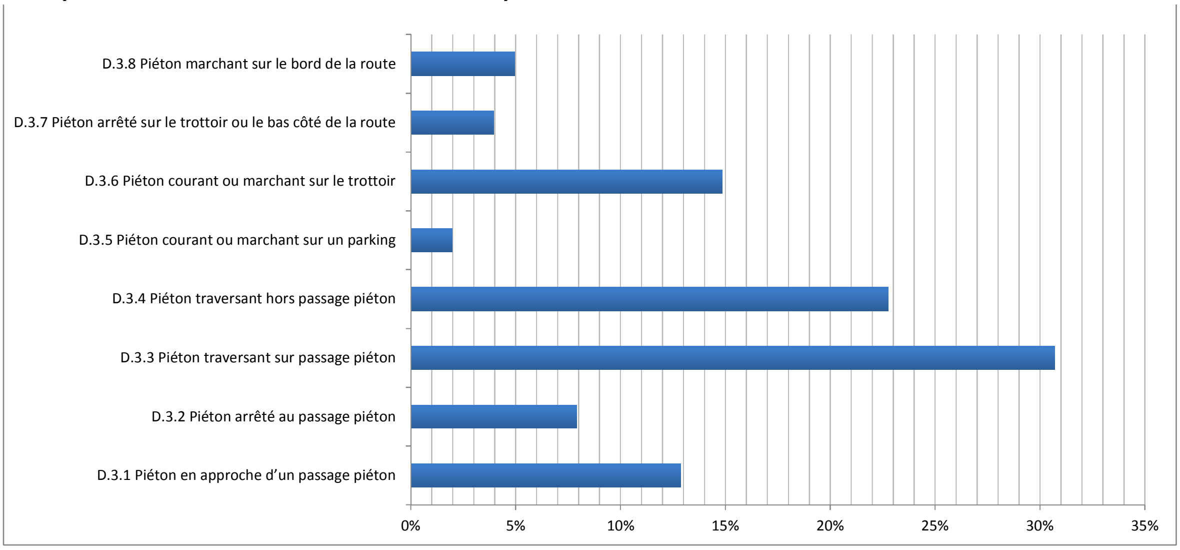

Figure 7 : Répartition des situations pré-accidentelles chez les piétons (n=101)

Lorsque l'on croise les situations entre les conducteurs et les piétons le top 5 des combinaisons les plus représentées (63% des cas) est le suivant (Figure 8) :

- Le conducteur est en intersection et le piéton traverse sur un passage protégé (19%)
- Le conducteur est en situation stabilisée et le piéton traverse hors passage protégé (14%)
- Le conducteur est en situation stabilisée et le piéton traverse sur un passage protégé (11%)
- Le conducteur est en situation stabilisée et le piéton court ou marche sur le trottoir (11%)
- Le conducteur est en intersection et le piéton est en approche d'un passage protégé (8%)

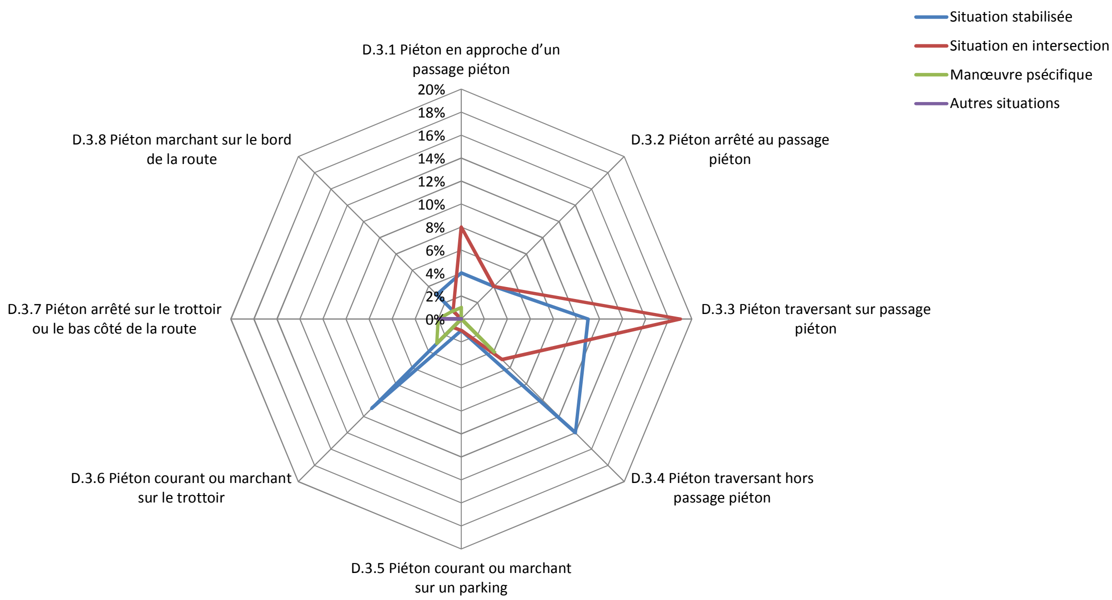

Figure 8 : Croisement des situations pré-accidentelles conducteurs/piétons (n=100)

3.2.2 Les facteurs initiaux

Les facteurs initiaux sont les facteurs présents avant la situation accidentelle. Ce ne sont pas pour la plupart les facteurs qui vont déclencher l'accident mais ils vont contribuer au dysfonctionnement.
La liste des facteurs initiaux est similaire pour les 3 séquences à savoir la situation de conduite normale, la phase de rupture et la phase d'urgence.

Chez les 100 conducteurs, il n'a pas été trouvé de facteurs initiaux pour 31 d'entre eux. Sur les 69 conducteurs restant, 103 facteurs ont été identifiés soit un 1,5 facteur en moyenne par conducteur.
5 facteurs ont été trouvés pour un conducteur, 4 facteurs pour 10 d'entre eux, 2 facteurs dans 12 cas et un seul facteur pour 46 usagers.
Les facteurs les plus fréquents chez les conducteurs sont les facteurs endogènes (45%), plus particulièrement liés :

- à l'état de l'usager (26%), avec une majorité d'identification d'un risque potentiel mais sur une partie seulement de la situation ou encore à des attachements rigides du statut prioritaire ou bien des prises de risque (vitesse excessive).
- à des problèmes attentionnels (10%) avec comme principale cause la distraction.
- à des problèmes de sur-expérience (9%) principalement liés à la banalité du tracé de la route.

On retrouve ensuite les facteurs liés à l'environnement (25%) avec majoritairement des gênes à la visibilité.
Des facteurs associés au véhicule apparaissent dans 6% dont majoritairement des problèmes liés à la visibilité à travers le pare-brise (sale, embué, etc.).

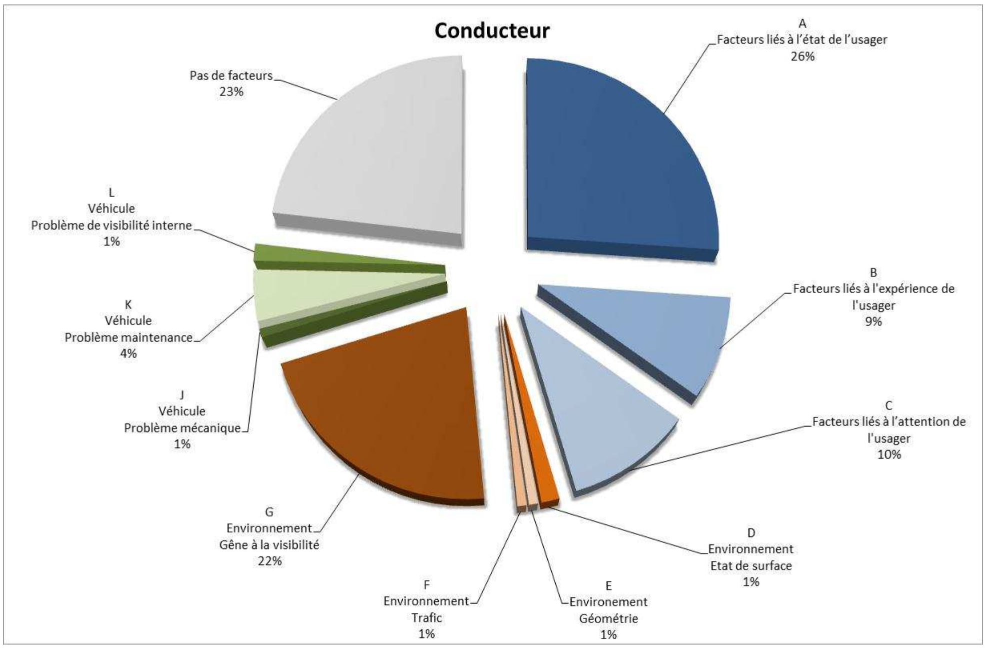

Figure 9 : Distribution des facteurs initiaux présents en situation pré-accidentelle pour les conducteurs (n=134)

Chez les piétons, on retrouve ici aussi en première position les facteurs associés à l'usager (53%) avec une très forte majorité. Parmi ces facteurs on a :

- Dans 33% des facteurs relatifs à l'état de l'usager dont principalement des problèmes liés à une prise de risque avec une traversée en contradiction avec la signalisation en cours ou des problèmes liés à la fatigue.
- Dans 15% des problèmes attentionnels dus soit à de la distraction soit à des préoccupations internes.
- Dans 9% des facteurs liés à l'expérience dont principalement la banalité de la situation.

Les problèmes environnementaux interviennent pour 11% avec principalement des facteurs liés à une gêne à la visibilité (véhicule en stationnement, bâti, végétation, etc.).
Enfin on retrouve des facteurs spécifiques aux piétons (15%) avec le plus souvent des personnes en train de courir ou des enfants échappant à la vigilance des parents.

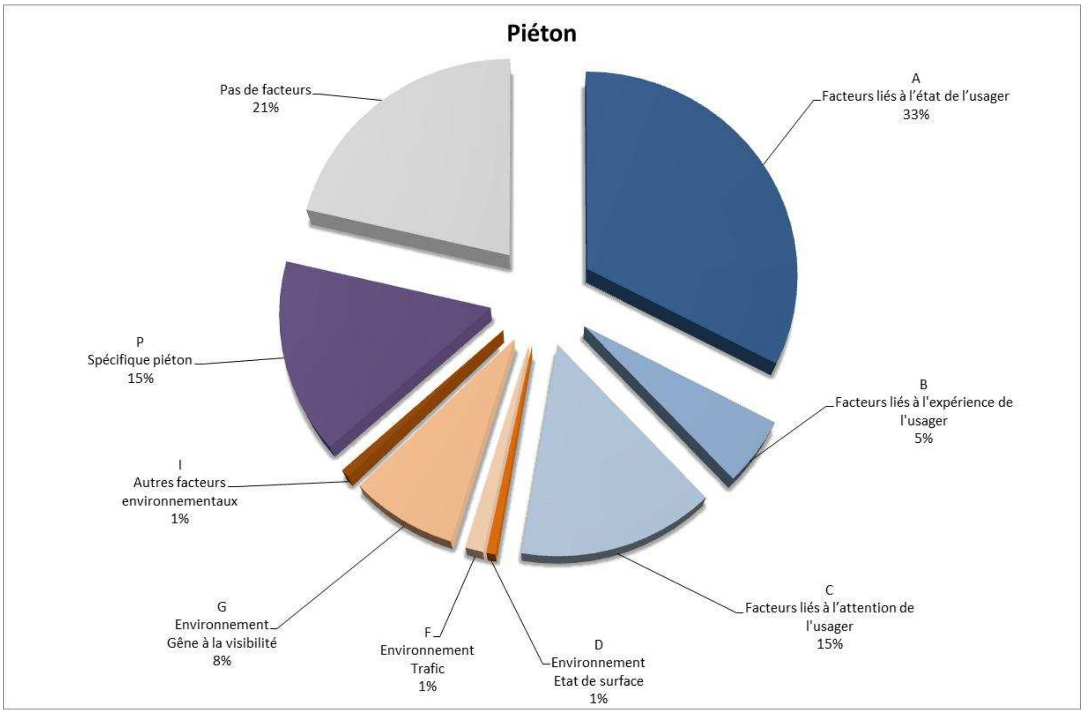

Figure 10 : Distribution des facteurs initiaux présents en situation pré-accidentelle pour les piétons (n=150)

3.2.3 Les besoins en amont

Comme nous l'avons mentionné auparavant, les besoins sont identifiés à partir de la situation pré-accidentelle et des facteurs associés. Cependant lors de l'analyse des accidents il est difficile de bien faire la part des choses entre les besoins avant l'accident et ceux associés à la défaillance fonctionnelle qui va conduire à l'accident.
Sur la Figure 11 est donnée la répartition des besoins amont identifiés pour les 100 cas d'accidents analysés.

Les besoins en détection sont ceux qui dans la phase pré-accidentelle ressortent le plus (72%) et notamment la détection d'un usager qui traverse.
On retrouve ensuite les besoins en prédiction (14%) avec principalement celle de la traversée du piéton, puis des besoins relatifs à l'adaptation de la vitesse par rapport à la réglementation (7%) et enfin les besoins qui vont anticiper des problèmes de perte de contrôle ou de réaction inadaptée comme l'alcool ou l'état des pneumatiques.

Ces résultats montrent une forte dépendance avec les circonstances de l'accident et qu'il est difficile pour la personne qui réalise l'analyse de se détacher des faits de l'accident.

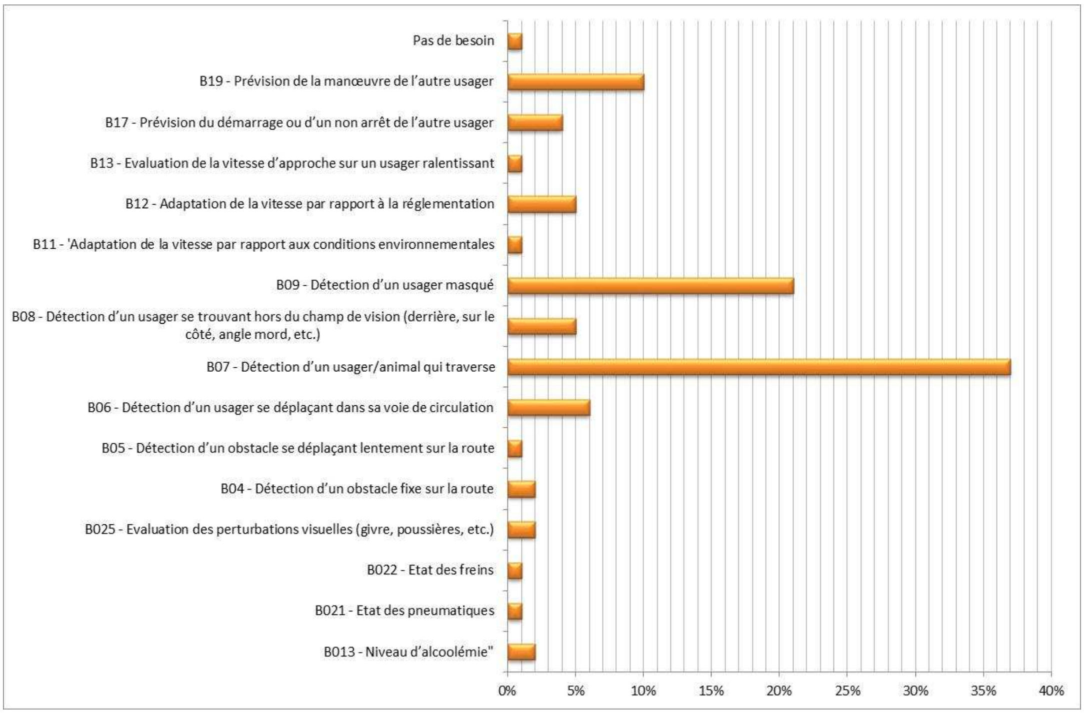

Figure 11 : Distribution des besoins en amont (n=100)

3.2.4 Les contre-mesures associées et leur(s) limitation(s)

Les contre-mesures sont sélectionnées pour répondre aux besoins amont identifiés auparavant. Le choix est réalisé à partir d'une liste de systèmes préétablie. Pour chaque système sélectionné, nous avons également essayé d'identifier parmi les divers éléments du contexte liés à l'accident ceux qui pouvaient en limiter son efficacité.

Sur les 100 cas d'accidents, 99 besoins ont été trouvés pour les conducteurs. Pour 35 de ces besoins il n'a pas été possible de sélectionner un système permettant de résoudre le problème. Il s'agit principalement de besoins liés à la prédiction de la manœuvre du piéton ou de sa détection alors qu'il est totalement masqué. Cette proportion devrait être selon nous plus importante car le fait de connaître les circonstances des accidents lors de l'analyse nous influence dans le choix de solutions. Cette remarque est également applicable lors de l'identification des besoins.

Pour les 64 besoins restants, 79 systèmes ont été identifiés. Pour un cas d'accident, il a été déterminé la possibilité de 3 aides et dans 12 cas la possibilité d'avoir 2 aides.
Parmi les systèmes sélectionnés on trouve :

- Détection dans l'angle mort (BS)
- L'Alcolock (AK)
- Evitement de la collision (CA)
- Adaptation intelligente de la vitesse (ISA)
- Vision de nuit (NV)
- Protection des Usagers Vulnérables (VRU)
- Contrôle en intersection (IC)
- Surveillance des pneumatiques (TPMS)
- Radar de recul (non listé dans la présélection mais utile pour les cas avec le véhicule en manœuvre de marche arrière)

La distribution de ces systèmes est donnée dans la Figure 12.

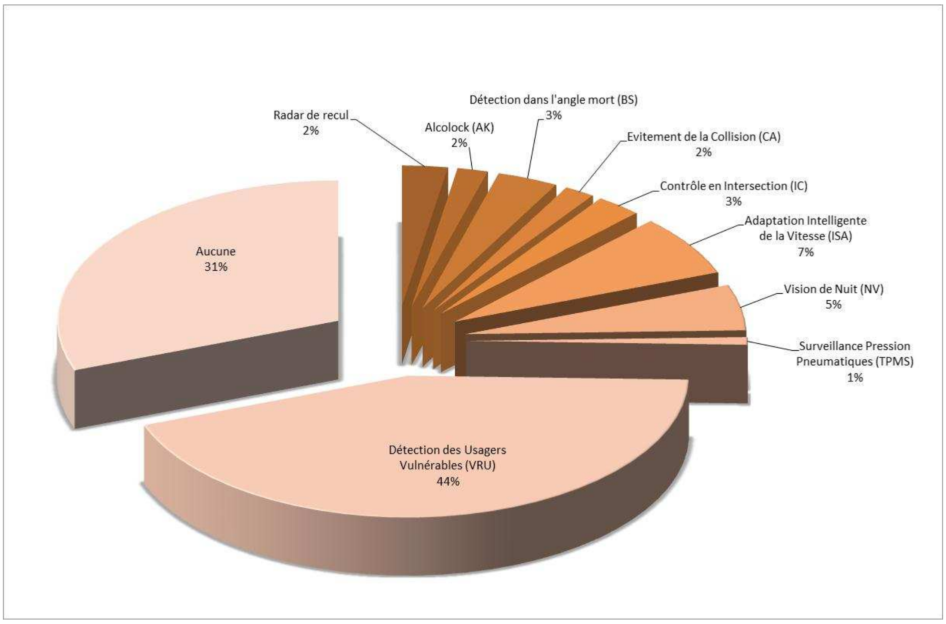

Figure 12 : Distribution des systèmes de sécurité répondant aux besoins amont identifiés (n=114)

Pour les 79 systèmes identifiés, 77% trouvent au moins une limitation dans leur fonctionnement. Ces limitations se regroupent en 7 typologies :

- Visibilité limitée (23%)
- Problèmes liés aux seuils de déclenchement (21%)
- Problème attentionnel (19%)
- Rejet intentionnel par le conducteur (10%)
- Faible conditions de luminosité (3%)
- Conditions météorologiques (1%)
- Etat psychophysiologique (1%)

La liste exhaustive des limitations déterminées en fonction du contexte des accidents ainsi que son degré d'interaction associé est donnée dans le graphique ci-dessous.

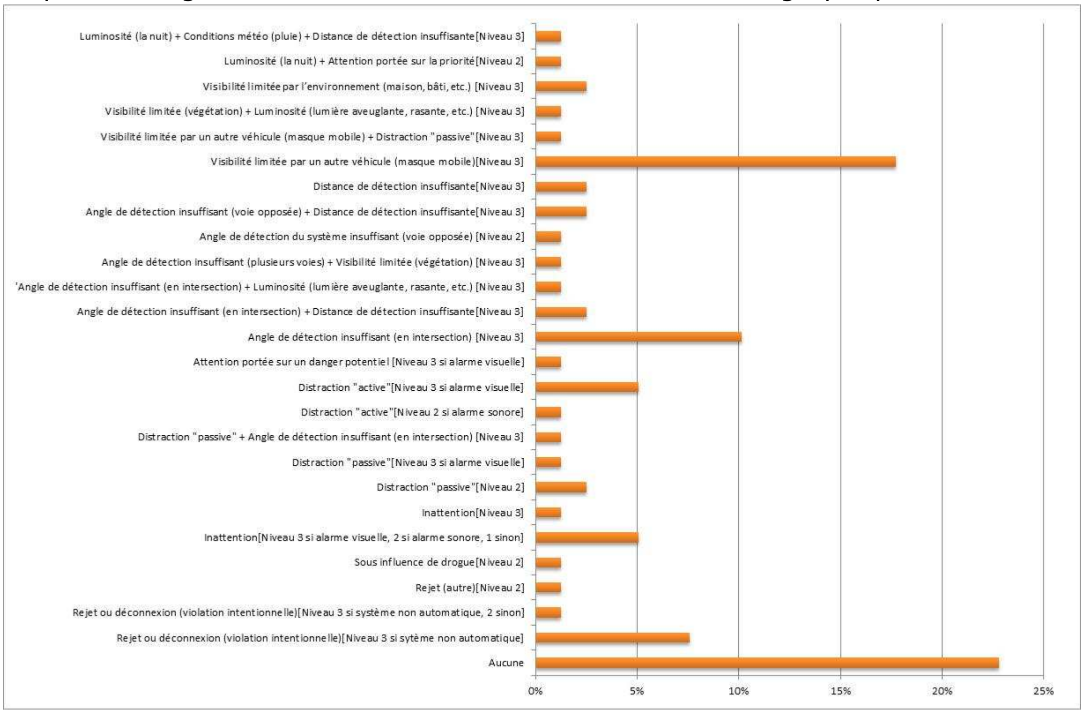

Figure 13 : Distribution des limitations identifiées en situation pré-accidentelle en fonction du contexte (n=79)

Pour chaque limitation identifiée nous avons essayé de donner une estimation du degré d'interaction que cette limitation pourrait avoir sur l'efficacité du système de sécurité associé. Si l'on analyse de façon globale ces degrés d'interférence on s'aperçoit que les systèmes proposés pourraient être rendus totalement inefficace (Niveau 3) dans 54% des cas, d'une inefficacité conditionnelle (c'est-à-dire un Niveau 3 dépendant de la technologie utilisée) dans 14%, une diminution de cette efficacité (Niveau 2) dans 8%, et une diminution conditionnelle (Niveau 2 dépendant de la technologie utilisé) dans 1%.

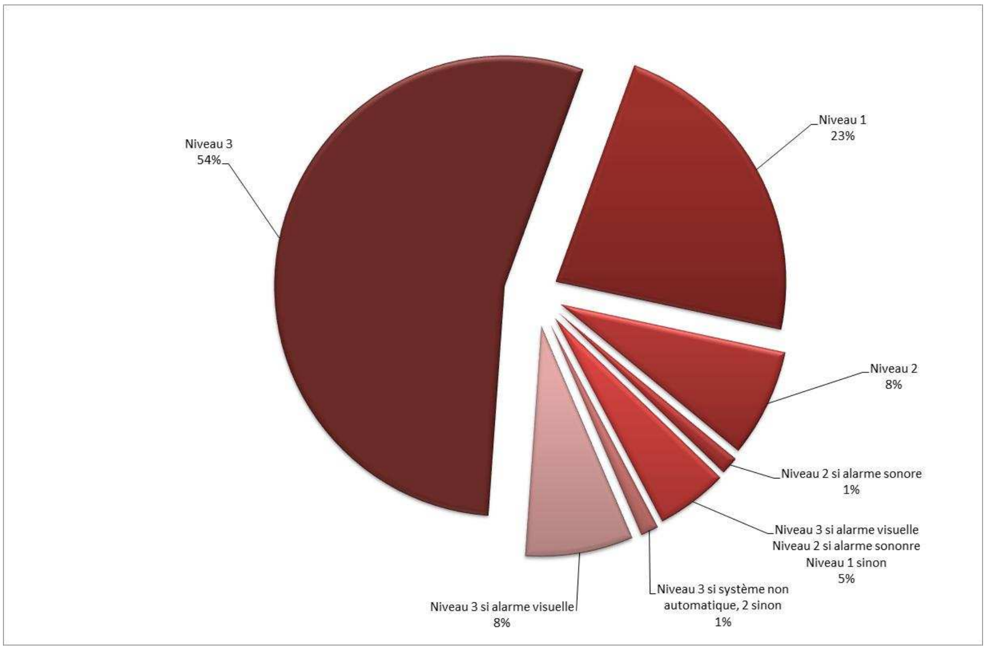

Figure 14 : Distribution des degrés de limitation pour les contre-mesures sélectionnées pour la situation pré-accidentelle (n=79)

3.2.5 Ce qu'il faut retenir

L'analyse des besoins dans la phase pré-accidentelle ainsi que l'identification des contre-mesures associées est délicate à mener car elle est en partie biaisée par la connaissance des circonstances de l'accident. Le cas le plus représentatif est celui d'un piéton masqué par un bâtiment et qui va traverser. Si l'on s'en tient uniquement aux éléments factuels, d'un point de vue du véhicule il n'y a aucun moyen de savoir si derrière le bâtiment se trouve un piéton. Or comme nous savons qu'il s'agit d'un accident et qu'en plus il implique un piéton, la tendance sera d'indiquer un besoin de détection d'un usager masqué. Un autre problème qui trouve son sens ici, ce sont tous les éléments du contexte qui sont intervenus à ce moment-là. A partir des enquêtes EDA seulement une petite partie de ces éléments peuvent être appréhendée, en particulier ceux qui resteront présents lors de l'accident. Or certains « second rôle » à un instant donné peuvent être des « premier rôle » à un autre moment.
Pour en revenir aux résultats relatifs à cette phase de l'accident, ce que l'on peut retenir c'est que dans 19% des cas le véhicule est en situation stabilisée et le piéton traverse sur un passage protégé et dans 14% la traversée se fait hors d'un passage protégé. Les situations où le véhicule se trouve en intersection (rond-point compris) sont également nombreuse avec pour la moitié d'entre elles des situations de tourne à gauche.
D'un point de vue des besoins, on remarque que dans la plupart des cas c'est la détection du piéton qui est mise en avant (72%).
Parmi les systèmes sélectionnés, on retrouve essentiellement le système de détection d'un usager vulnérable (VRU) et concerne toujours la fonction détection. Cependant si l'on tient compte des éléments du contexte (uniquement ceux qui ont été relevés) on observe alors un nombre important de limitations (principalement de visibilité limitée ou un champ de détection trop éloigné) et qui vont avoir une grande influence sur l'efficacité

du système. Ici on reste dans le domaine de l'alerte, le problème est donc de détecter le plus tôt possible dans une forêt d'éléments (trafic, mobilier urbain, végétation, bâti, piétons, etc.) LE piéton qui va traverser et de transmettre la bonne information au conducteur sous une forme qu'il soit capable d'interpréter.

3.3 La phase de rupture

Comme nous l'avons définie auparavant, la phase de rupture est la séquence durant laquelle la situation de conduite bascule en une situation accidentelle par la survenue d'un évènement inattendu. A partir de cet instant, le conducteur entre dans la phase d'urgence, séquence dans laquelle il doit impérativement réagir et engager une manœuvre s'il veut éviter l'accident.

Comme nous le voyons, la rupture est un point clé dans le processus de l'accident. Si l'on parvient à résoudre le problème qui a créé ce dysfonctionnement dans le système de conduite, alors on peut supposer que l'accident n'aura pas lieu. Le conducteur étant le principal régulateur de ce système, on peut d'un point de vue du facteur humain identifier pour chaque problème rencontré une défaillance fonctionnelle. Il ne s'agit pas d'une faute de conduite mais plutôt d'un défaut survenant dans le système de conduite mis en avant par le conducteur lorsqu'il tente de s'adapter à ce dysfonctionnement.

La défaillance fonctionnelle identifiée au niveau de la phase de rupture est dite critique car c'est elle qui initie la situation accidentelle, de sorte que le besoin qu'elle engendre chez l'usager (besoin pivot) peut être considéré comme la pièce maîtresse de l'accident. Si ce besoin est pallié par une aide adaptée au conducteur, l'accident peut être évité. Bien sûr, d'autres besoins peuvent également être identifiés tout au long du processus de l'accident, comme en phase d'urgence ou en amont de la phase de rupture comme nous l'avons vu auparavant.

3.3.1 Les défaillances fonctionnelles critiques

Dans le cadre des études d'accident, la tâche de conduite peut être modélisée de façon dynamique à partir des séquences fonctionnelles suivantes :

- ***Etape de Perception*** : la première activité nécessaire à la tâche de conduite est de percevoir les informations, et ce le plus tôt possible pour qu'elles puissent être traitées en temps voulu.
- ***Etape d'Evaluation (diagnostic)*** : une fois les informations perçues, il faut commencer à les traiter. Le premier traitement est d'établir un diagnostic de ce qui a été perçu. Il concerne d'une part la compréhension des informations recueillies (c'est quoi, l'information est-elle pertinente ?, etc.) et d'autre part l'évaluation des paramètres physiques associés (par exemple le déplacement, la vitesse).
- ***Etape d'Interprétation (pronostic)*** : La seconde étape du traitement consiste à prévoir les évolutions probables des informations pertinentes collectées. C'est l'étape du pronostic. Cette étape conditionne la décision sur les actions que l'usager va entreprendre.
- ***Etape de Décision*** : Face aux informations pertinentes collectées et analysées, l'usager est confronté à un choix parmi les différentes stratégies qu'il pourra mettre en œuvre. Il doit donc sélectionner celle qui lui parait la plus adaptée en fonction de la situation rencontrée.
- ***Etape d'Action*** : c'est le dernier maillon de la chaine dans la modélisation proposée. Le conducteur doit exercer une action pour assurer le guidage de la trajectoire poursuivie.

Suivant la classification utilisée par la méthode HFF développée par l'IFSTTAR, les défaillances fonctionnelles humaines sont réparties conformément aux séquences fonctionnelles précédemment énoncées. S'agissant de défaillances fonctionnelles, on retrouve donc les 5 catégories afférentes aux étapes plus une catégorie spécifique :

- ***Problème de détection*** : cette catégorie est associée à l'étape de perception des informations. Pour éviter les situations à risque la première étape à réaliser est de pouvoir détecter le plus précocement possible l'ensemble des données pertinentes du système routier afin que l'usager puisse mettre en œuvre les autres séquences fonctionnelles. Sont regroupés ici les problèmes liés à la non détection ou la détection tardive d'une des composantes de l'accident. Les usagers impliqués dans cette catégorie ont donc principalement non détecté (ou détecté très tardivement) des paramètres essentiels de la situation Comme par exemple la présence d'un autre usager sur une trajectoire conflictuelle, la modification du fonctionnement d'un site.
- ***Problème de diagnostic*** : Cette catégorie est associée à l'étape d'évaluation des informations recueillies. Les problèmes rencontrés dans cette étape sont par exemple liés à l'évaluation de l'importance d'une difficulté associée à l'infrastructure (virage, travaux, etc.) ou à l'évaluation des inter-distances ou encore à la compréhension de la manœuvre de l'autre. Un problème de diagnostic ne peut être codé que si ce problème est à l'origine du déclenchement de l'accident et que l'étape de détection a été correctement menée.
- ***Problème de pronostic*** : Cette catégorie de défaillances fonctionnelles est associée à l'étape d'interprétation. Les problèmes rencontrés à cette étape, sont par exemple liés à une mauvaise anticipation de la manœuvre de l'autre, ou encore à une prévision d'absence d'un autre usager ou d'un obstacle. Un problème de pronostic ne peut être codé que si il est à l'origine de la phase de rupture et que les précédentes étapes ont été effectuées correctement.
- ***Problème de décision*** : Cette catégorie est associée à l'étape de décision de l'action que l'usager va entreprendre. Les problèmes répertoriés ici sont associés à la notion de « violation » c'est-à-dire à une déviation plus ou moins délibérée des pratiques nécessaires pour assurer le fonctionnement sécuritaire d'un système potentiellement dangereux. Les violations que l'on retrouve ici sont classées suivant le degré d'intention : violation contrainte par les caractéristiques de la situation, la violation intentionnelle d'une règle de sécurité ou la violation involontaire (automatisme ou effet d'entrainement). Un problème de décision ne peut être codé que si d'une part il est à l'origine de la situation accidentelle et d'autre part les autres séquences antérieures ont été correctement effectuées.
- ***Problème d'exécution*** : Cette catégorie est associée à l'étape d'action. Le conducteur a décidé (ou pas) d'une manœuvre à engager et les problèmes recensés ici sont liés à la mauvaise réalisation de cette manœuvre dans le sens où la régulation poursuivie ne sera pas atteinte. On ne retrouve dans cette classe que les problèmes dont le contrôle du véhicule est à l'origine du basculement de la situation de conduite normale à une situation accidentelle sachant que toutes les séquences précédentes ont été correctement effectuées.
- **Problème d'ordre global** : Cette catégorie permet de référencer les défaillances d'ordre global, c'est-à-dire à une incapacité totale de l'usager à maîtriser la situation rencontrée. C'est le cas par exemple des problèmes liés au dépassement des capacités cognitives, psychologiques ou des capacités sensori-motrices.

Ces 6 catégories sont celles habituellement utilisées pour les conducteurs.

Dans le cadre de l'élargissement de la méthodologie aux cas d'accidents avec piéton nous sommes effectivement partis de cette grille et avons essayé dans la mesure du possible d'utiliser les défaillances existantes en apportant parfois quelques extensions pour le piéton. Cependant, il est des cas où la méthodologie ne peut pas être appliquée. C'est le cas des jeunes enfants qui ayant échappé à la surveillance des parents se retrouvent seuls à traverser une route. En effet, pour ces jeunes enfants les capacités de leur système cognitif n'est pas encore finalisé et opérant. De plus les connaissances de ce qu'il faut faire pour traverser en toute sécurité ne sont pas encore acquises. D'un point de vue de la méthode, ces enfants ne rentrent donc pas dans un schéma habituel comme les adultes. Pour ces cas particuliers, nous avons donc défini une catégorie supplémentaire que nous avons appelée « inadapté ». Dans cette catégorie on retrouve donc les enfants de moins de 7 ans traversant seul la route. Le choix de la limite d'âge a été défini en s'appuyant sur la théorie de Piaget, âge correspondant au début du stade opératoire concret, stade à partir duquel l'enfant devient capable d'envisager des événements qui surviennent en dehors de sa propre vie [17].

Dans les autres cas avec enfants (donc ceux avec la présence d'un adulte), nous avons choisi de coder la défaillance fonctionnelle de l'adulte même dans le cas où seul l'enfant a été blessé. En effet, un des objectifs de cette étude est aussi de mieux diagnostiquer les problèmes rencontrés par les impliqués, il était plus intéressant de ce point de vue là d'analyser la défaillance fonctionnelle de la personne « responsable » (au sens de celui qui a la charge de et pas au niveau de celui à qui incombe la faute). C'est le cas également lorsqu'une personne handicapée est accompagnée, la défaillance est codée pour l'usager blessé mais elle est déterminée à partir de celui ou celle qui à la « maîtrise » du déplacement.

Les principaux problèmes rencontrés au niveau de la défaillance fonctionnelle critique pour l'ensemble des usagers (n=201) sont majoritairement des problèmes liés à la détection (54%), puis à l'interprétation (pronostic, 25%) et enfin dans une moindre importance les problèmes affectés à l'étape de l'évaluation (diagnostic, 7%).
Sur la Figure 15 sont donnés les résultats suivant la distribution globale des défaillances fonctionnelles identifiées par type d'usager (conducteur, piéton).

Chez les conducteurs (n=100), les problèmes de détection représentent à eux seuls 67% de l'ensemble des défaillances. S'en suivent les problèmes d'interprétation (24%), puis avec quasiment le même niveau, les problèmes d'exécution (4%) et les problèmes d'évaluation (3%). On peut donc en déduire que le principal problème pour le conducteur est de détecter le piéton. Si ce dernier est détecté les conducteurs semblent avoir des difficultés à savoir ce que le piéton va faire.

Chez les piétons (n=101), la répartition de la distribution des défaillances est quasi identique. Ici aussi, les problèmes de détection sont les plus nombreux (42%), ainsi que les problèmes d'interprétation (26%). On retrouve ensuite les problèmes d'évaluation (12%) et les problèmes de décision (9%), problème qui n'a pas été identifié chez les conducteurs.
Pour les piétons, on note une violation intentionnelle d'une règle de sécurité (89% des problèmes de décision). Elle consiste soit à une traversée du piéton hors emplacement prévu ou bien sur passage protégé régulé par des feux tricolores avec le feu rouge pour le piéton.
Dans l'ensemble les piétons semblent mieux détecter les véhicules que l'inverse. Par contre, ils ont du mal (comme les conducteurs) à anticiper correctement les manœuvres de l'autre.

Pour les problèmes de détection, chez les conducteurs (67%), ils consistent principalement pour 57% d'entre eux à une difficulté d'accès à l'information (i.e. le conducteur ne découvre le piéton que très tardivement, ce dernier étant le plus souvent masqué soit par des véhicules en stationnement, un bus à l'arrêt ou de la végétation), viennent ensuite les problèmes liés à une mauvaise organisation dans la recherche d'informations (le conducteur focalise son attention sur un autre élément du trafic) pour 24%.
Chez les piétons les défaillances au niveau de la détection ne sont pas les mêmes. En effet, 74% des erreurs identifiées à l'étape de détection sont un problème lié à la

recherche d'informations, soit celle-ci est totalement négligée (43%) ou très sommaire (31%).

Pour les problèmes liés au diagnostic (représentant seulement 3% chez les conducteurs et 12% chez les piétons de l'ensemble des défaillances), le classement des principales défaillances identifiées à ce niveau (la perception est une étape acquise) sont les mêmes chez les conducteurs et les piétons mais pas dans les mêmes proportions. Ainsi chez les conducteurs, 67% des cas présentent une mauvaise compréhension de la manœuvre de l'autre (par exemple le fait qu'un piéton – ou que le véhicule - ralentisse avant de s'engager) alors qu'elle n'est que de 50% chez les piétons et dans 33% des cas une mauvaise évaluation d'un créneau d'insertion par rapport au trafic (respectivement 42% chez les piétons).

Pour les problèmes liés à l'étape du pronostic :
Chez le conducteur la défaillance la plus fréquemment identifiée est celle où le conducteur s'attend à ce que le piéton qui est arrêté au bord de la chaussée ne traverse pas (58%), à ne pas trouver d'interférence sur sa trajectoire (21%) ou à ce que le piéton s'arrête (21%).
Chez les piétons, on retrouve principalement les piétons en attente active d'une régulation de la part du véhicule (58%) ou à une absence totale d'interférence sur leur voie (38%).

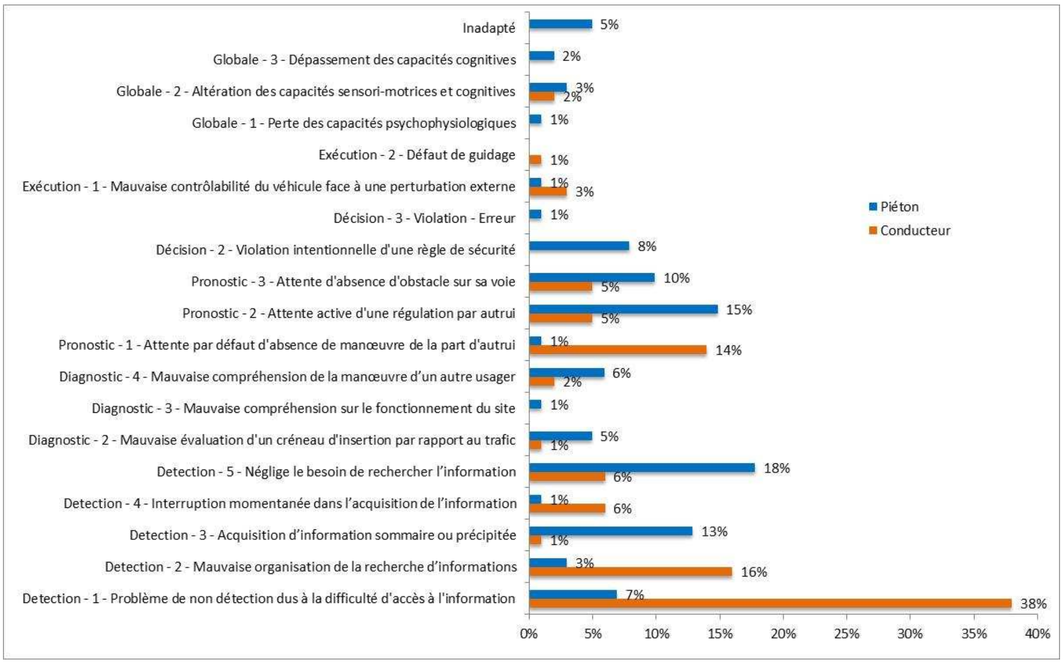

Figure 15 : Répartition des défaillances fonctionnelles globales identifiées chez les conducteurs (n=100) et les piétons (n=101)

3.3.2 Les facteurs déclenchant

Les facteurs déclenchant sont les éléments qui peuvent être considérés comme ayant une forte influence sur la défaillance fonctionnelle, et qui vont favoriser le basculement depuis la situation de conduite normale vers la situation accidentelle. Ces facteurs sont identifiés pour chaque usager. Bien évidemment dans certains cas plusieurs facteurs peuvent avoir un rôle. Pour chaque usager, 5 facteurs pouvaient être définis.

Parmi les facteurs déclenchant identifiés chez les conducteurs on retrouve principalement des facteurs associés à l'environnement (59%) ou à l'usager (30%).

Les facteurs environnementaux sont soit liés au trafic (non respect de la signalisation par le piéton) soit des masques à la visibilité (le piéton est masqué par des véhicules en stationnement ou arrêtés en circulation).
On distingue également quelques facteurs associés au véhicule (6%) dont principalement des problèmes de maintenance des pneumatiques.

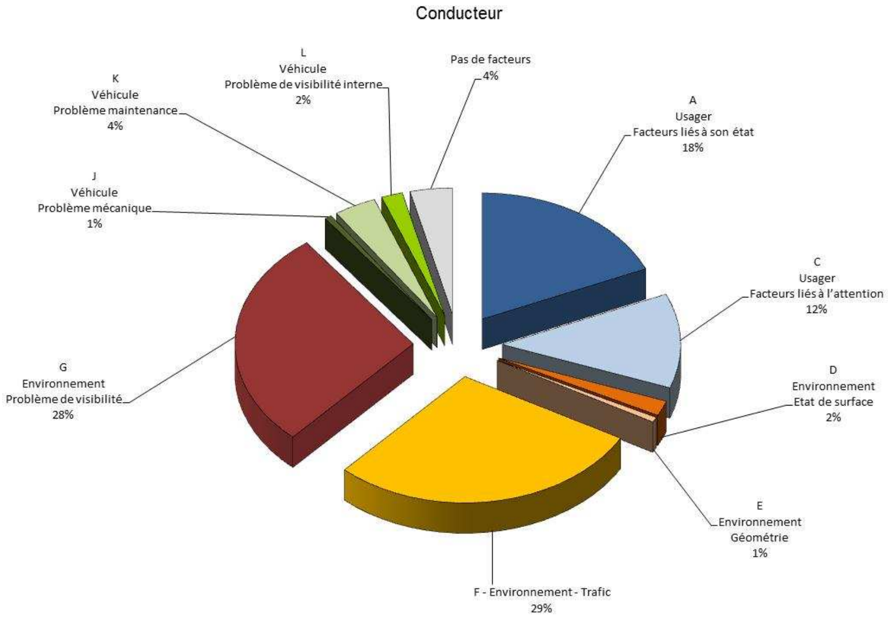

Figure 16 : Répartition des facteurs déclenchant identifiés chez les conducteurs (n=157)

Parmi les facteurs déclenchant identifiés chez les piétons on retrouve principalement des facteurs associés à l'usager (73%) et quelques facteurs liés à l'environnement (12%).
Pour ces facteurs attachés à l'usager, on retrouve des attachements rigides à la notion de priorité (le piéton se croit dans son bon droit et traverse), soit des prises de risque intentionnelle (principalement des traversées alors que le feu piéton est au rouge), soit encore des enfants qui échappent à la vigilance de leurs parents. Quant aux facteurs liés à l'environnement, comme pour les conducteurs on retrouve principalement des problèmes de visibilité ou lié au trafic.

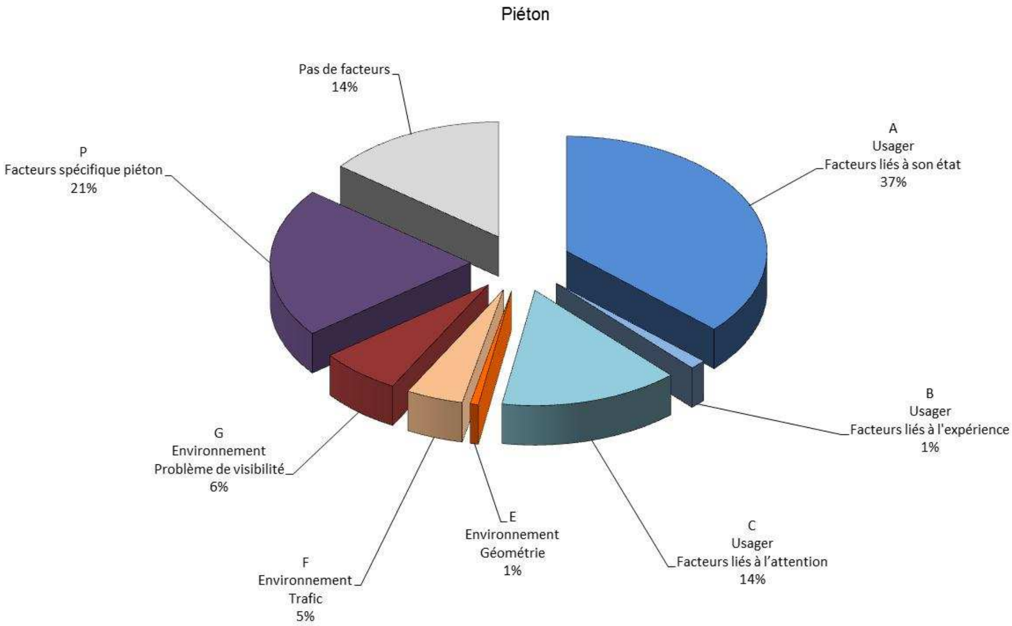

Figure 17 : Répartition des facteurs déclenchant identifiés chez les piétons (n=152)

3.3.3 Le degré d'implication

Le degré d'implication permet d'indiquer le rôle de chaque usager dans la survenue de l'accident. Ce paramètre permet d'identifier le degré de responsabilité de chaque usager d'un point de vue de son comportement dans la genèse du conflit. L'objectif n'est pas de juger de la faute commise (au sens de l'infraction au code de la route) comme le font les assurances ou la justice. Notre rôle n'est pas de punir mais de prévenir. Le degré d'implication n'a pas pour but de déclarer tel ou tel usager « coupable » ou « responsable » mais plutôt de jauger son degré de participation dans la dégradation de la situation. Cette notion peut permettre d'aider à prioriser les aides dans la mesure où on peut penser que plus le degré d'implication est élevé, plus le besoin qui a été identifié doit être pourvu.

4 degrés d'implication ont été définis :

- ***Actif primaire*** : c'est l'usager qui va provoquer la perturbation qui va conduire à l'accident
- ***Actif secondaire*** : l'usager n'est pas à l'origine de la perturbation mais il contribue à la genèse de l'accident
- ***Non actif*** : l'usager est confronté à une manœuvre atypique d'autrui difficilement prévisible, qu'elle soit ou non en contradiction avec la législation
- ***Passif*** : usager dont le seul rôle est d'être présent sur la scène de l'accident sans prendre part à la perturbation.

Sur le graphique ci-dessous nous observons que la contribution dans la genèse de l'accident est équivalente chez les conducteurs (86%) et les piétons (87%). Si chez le conducteur il semble y avoir une répartition plus équilibrée entre une contribution active ou secondaire, chez les piétons la majorité sont plutôt à l'initiative de la perturbation (59%).

Comme on peut le remarquer, il existe un cas où le conducteur est juste présent. C'est le cas par exemple lorsque le piéton tombe sur la chaussée suite à un malaise que le conducteur ne peut pas prévoir.
Il est tout aussi surprenant de trouver quelques cas où le conducteur est jugé comme « non actif » (13%). Ici aussi il s'agit de cas de traversée soudaine et non prévisible du piéton.

Du côté des piétons, leur rôle passif est beaucoup plus important (9%) comparé à celui des conducteurs. Ces cas correspondent principalement à un piéton heurté par un véhicule en perte de contrôle le plus souvent sur le trottoir.
Il existe aussi des typologies pour lesquelles les 2 usagers sont à l'origine de l'accident. Dans l'échantillon CACIAUP, ces accidents comptent pour 2%. Il s'agit le plus souvent d'un conducteur qui entame une manœuvre sans apercevoir un piéton qui lui-même n'a pas vu (ou pris le temps de voir) le véhicule.

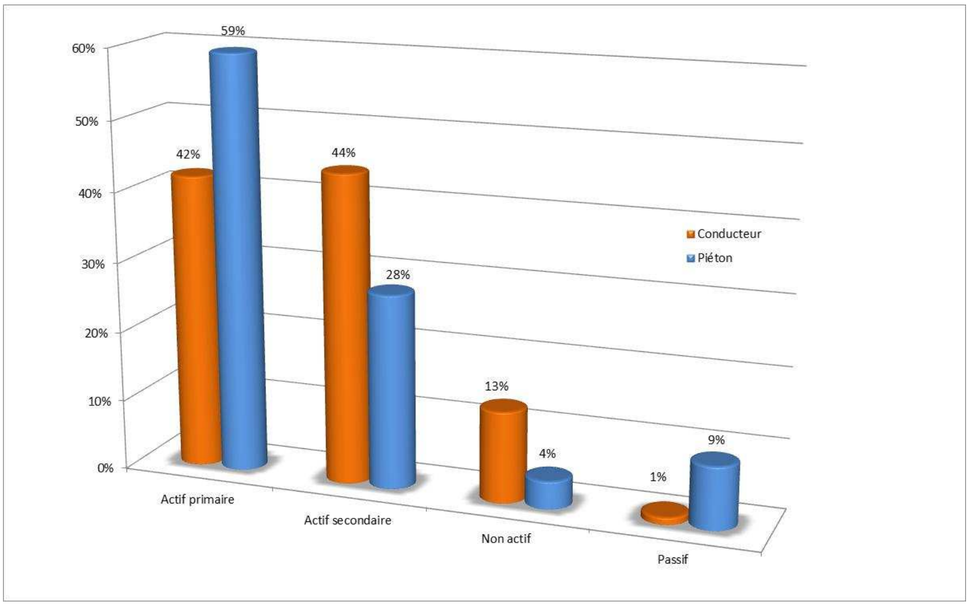

Figure 18 : Distribution du degré d'implication chez les conducteurs (n=100) et chez les piétons (n=101)

3.3.4 Les besoins

S'agissant de déterminer les besoins réels des usagers afin de pouvoir identifier l'aide la plus adaptée (un système de sécurité), les besoins pivots n'ont pas été codés pour les piétons lors de la phase de rupture.
Les résultats relatifs aux besoins pivots qui ont été identifiés pour les conducteurs impliqués dans un accident avec piéton sont donnés sur la figure ci-après.
Les besoins en détection sont de loin les plus fréquents (66%) et parmi eux ceux relatif à la détection d'un piéton qui traverse (36%) et ce que le conducteur soit à l'origine de l'accident (actif primaire) ou simple contributeur (actif secondaire).

Pour les conducteurs identifiés comme « actif primaire » représentant 42% des conducteurs, le top 3 des besoins pivots est le suivant :

- Besoin en détection d'un usager qui traverse (48%)
- Besoin en contrôle du véhicule (12%)
- Besoin de détection d'un usager se déplaçant dans sa voie de circulation (10%)
- Besoin de prévoir la manœuvre du piéton (10%)

Pour les conducteurs identifiés comme « actif secondaire » représentant 44% des conducteurs, le top 3 des besoins pivots est le suivant :

- Besoin en détection d'un usager qui traverse (31%)
- Besoin de prévoir la manœuvre du piéton (29%)
- Besoin de détecter un usager masqué (24%)

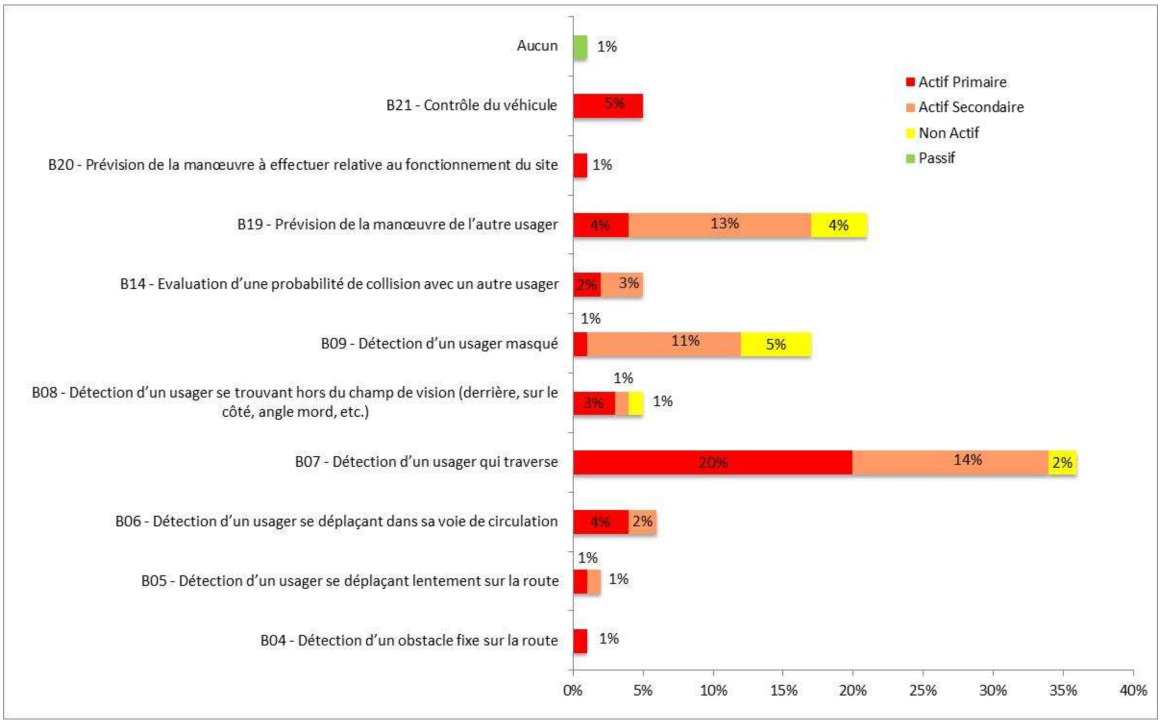

Figure 19 : Distribution des besoins pivots identifiés chez les conducteurs lors de la phase de rupture en fonction du degré d'implication (n=100)

3.3.5 Les contre-mesures associées et leur(s) limitation(s)

Comme nous venons de le voir précédemment, sur les 100 conducteurs impliqués dans un accident avec piéton nous avons déterminé 99 besoins pivots c'est-à-dire déterminant pour la situation accidentelle.
Après avoir identifié les besoins l'idée était de pouvoir sélectionner les systèmes de sécurité adaptés à chaque besoin (parmi la liste des systèmes proposés) puis d'en évaluer les limites en fonction du contexte de l'accident.
Pour les 99 besoins trouvés, 106 systèmes de sécurité ont été sélectionnés.
Dans la plupart des cas le besoin est couvert par un seul système. Dans un seul cas le choix de 3 systèmes a été rendu possible et dans 6 cas le choix de 2.

Sur les 35 systèmes de sécurité définis, seulement 9 ont été identifiés comme les plus utiles pour répondre aux besoins des conducteurs. Il s'agit (Figure 20) :

- Détection dans l'angle mort (BS)
- Evitement de la collision (CA)
- Adaptation intelligente de la vitesse (ISA)
- Vision de nuit (NV)
- Protection des Usagers Vulnérables (VRU)
- Contrôle en intersection (IC)
- Surveillance des pneumatiques (TPMS)
- Détection faible adhérence (LoFrctD)
- Radar de recul (non listé dans la présélection mais utile pour les cas avec le véhicule en manœuvre de marche arrière)

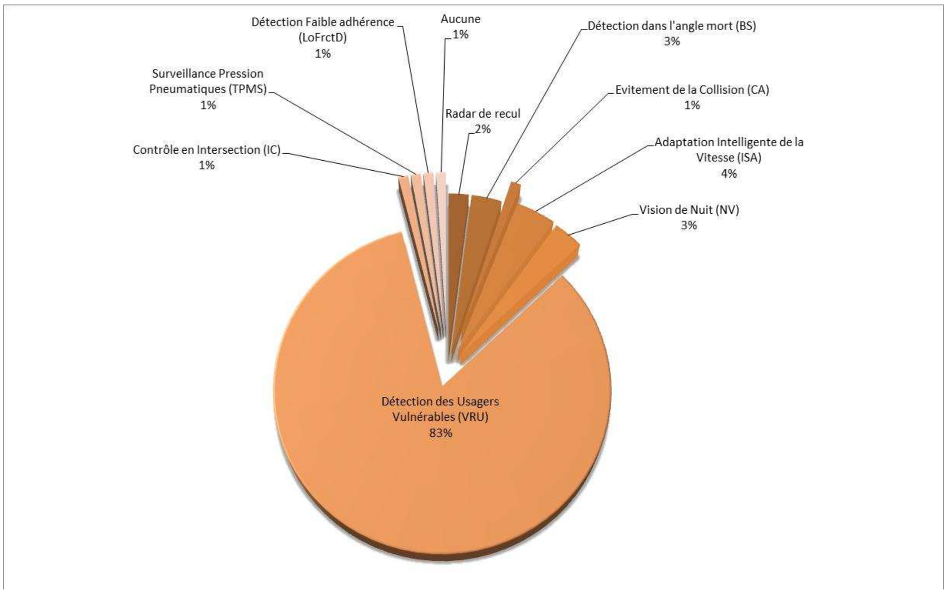

Figure 20 : Distribution des systèmes de sécurité répondant aux besoins pivots identifiés (n=106)

Pour les 105 systèmes identifiés, 65% trouvent au moins une limitation dans leur fonctionnement. Ces limitations se regroupent en 8 typologies :

- Visibilité limitée (25%)
- Problème attentionnel (21%)
- Problèmes liés aux seuils de déclenchement (7%)
- Conditions spatio-temporelles trop réduites (4%)
- Attente d'une régulation par l'autre (4%)
- Faible conditions de luminosité (3%)
- Rejet intentionnel par le conducteur (2%)
- Etat psychophysiologique (1%)

La liste exhaustive des limitations déterminées en fonction du contexte des accidents ainsi que son degré d'interaction associé est donnée dans le graphique ci-dessous.

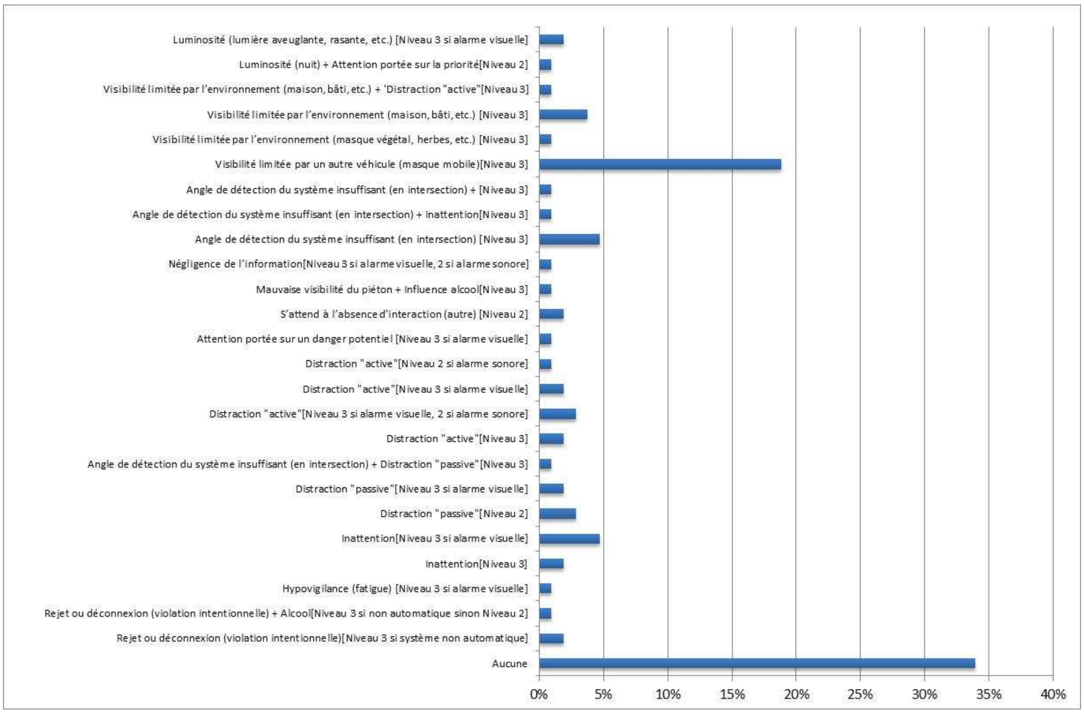

Figure 21 : Distribution des limitations identifiées en phase de rupture en fonction du contexte (n=106)

Pour chaque limitation identifiée nous avons essayé de donner une estimation du degré d'interaction que cette limitation pourrait avoir sur l'efficacité du système de sécurité associé. Si l'on analyse de façon globale ces degrés d'interférence on s'aperçoit que les systèmes proposés pourraient être rendus totalement inefficace (Niveau 3) dans 39% des cas, d'une inefficacité conditionnelle (c'est-à-dire un Niveau 3 dépendant de la technologie utilisée) dans 17%, une diminution de cette efficacité (Niveau 2) dans 7%, et une diminution conditionnelle (Niveau 2 dépendant de la technologie utilisé) dans 2%.

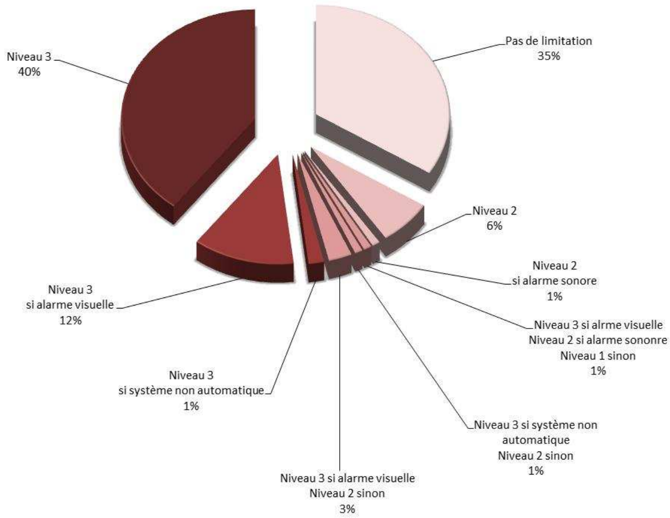

Figure 22 : Distribution des degrés de limitation (n=106)

3.3.5.a Protection des Usagers Vulnérables (VRU)

Dans la phase de rupture le système de sécurité le plus souvent mentionné est le système relatif à la Protection des Usagers Vulnérables (VRU). Ce système apparait dans 83% de la sélection totale. Dans cette séquence c'est surtout l'aspect détection du piéton qui est mis en avant par les besoins.

Sur le graphique ci-dessous nous observons que sur les 89 cas où le système a été sélectionné, 58 ont au moins une limitation dans leur fonctionnement. Ces limitations avec leur degré d'interaction se répartissent sur 20 typologies (Figure 23).

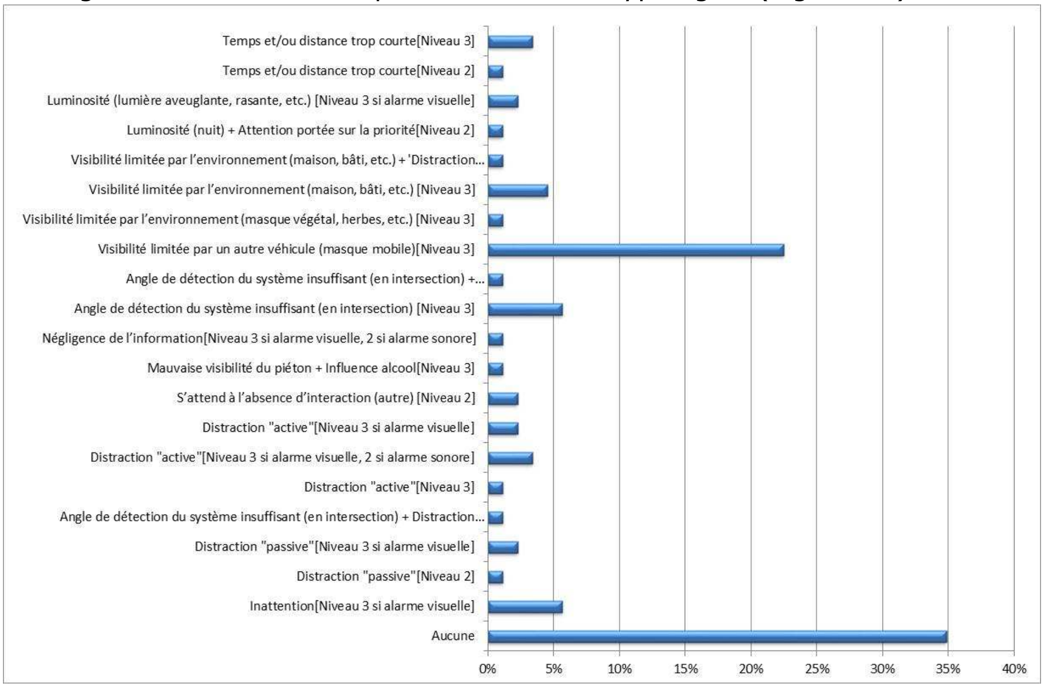

Figure 23 : Distribution des limitations identifiées pour le système VRU (n=89)

Sur ce graphique, on observe que l'efficacité du système n'est pas altérée dans 35% des cas. Les altérations observées par ordre décroissant sont les suivantes :

- Problème de visibilité limitée (29%)
- Problème attentionnel du conducteur (17%). Ici le conducteur n'est pas attentif.
- Problème identifié au niveau des seuils de déclenchement, ici angle et distance (7%)
- Problème spatio-temporel temps ou distance trop court (5%)
- Attente d'une régulation par l'autre (5%)
- Problème lié à la luminosité (3%)

Au niveau des degrés d'interaction sur l'efficacité du système de sécurité sur les 89 cas pour lesquels le système peut aider le conducteur, on observe :

- Dans 43% des cas le système pourra être totalement inefficace, la plupart du temps pour des problèmes liés à une visibilité très limitée ou des évènements très soudains.
- Dans 34% des cas l'efficacité du système ne devrait pas être altérée
- Dans 16% des cas il existe des conditions pour lesquelles le système pourra être inefficace (c'est-à-dire un Niveau 3 dépendant de la technologie utilisée). On retrouve ici les problèmes de distraction (active) ou d'inattention du conducteur.
- Dans 7% des cas l'efficacité serait altérée à cause de problèmes de distraction (passive) du conducteur ou d'attente d'une régulation de la situation par le piéton.

3.3.5.b Détection dans l'angle mort (BS) et Radar de recul

Nous avons traité ces 2 systèmes ensemble car ils concernent les cas dans lesquels le véhicule est en manœuvre de recul et que le piéton se trouvant dans la trajectoire du véhicule n'est pas visible par le conducteur.

Le radar de recul est à l'origine un système dédié à l'aide au stationnement. Cependant, dans les manœuvres de marche arrière il peut s'avérer très utile pour détecter la présence d'un piéton dans la trajectoire proche du véhicule. Malgré qu'il ne soit pas dans la liste des aides initiales, ce système a donc été sélectionné dans les cas où le véhicule recule.

Puisque les 2 systèmes ont été sélectionnés dans les cas de marche arrière par le véhicule, comment avons-nous fait la répartition entre les 2 systèmes ?
Nous avons considéré que lorsqu'au moment de la rupture le piéton était dans la trajectoire du véhicule (c'est-à-dire la zone que va utiliser le véhicule pour exécuter sa marche arrière compte tenu de l'angle volant zone verte sur la figure ci-après) l'aide la plus adaptée était le radar de recul, sinon (piéton dans la zone orangée) la détection dans l'angle mort était sélectionnée.

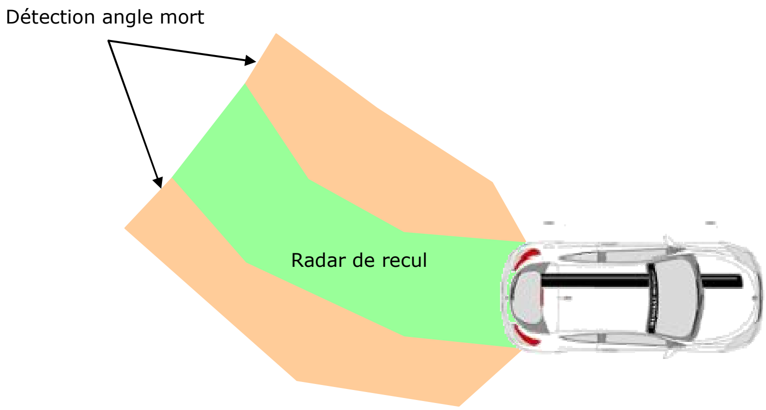

Figure 24 : Différentiation dans la sélection entre du Radar de recul et de la détection dans l'angle mort (BS).

Le radar de recul a été sélectionné dans 2 cas avec aucune limitation identifiée. Ces cas correspondent à des véhicules utilitaires tôlés c'est-à-dire sans fenêtre à l'arrière.

La détection dans l'angle mort a été sélectionnée dans 3 cas avec à chaque fois des limitations pouvant rendre totalement le système inefficace. Ces limitations sont le plus souvent liées à l'attention du conducteur cumulées à l'utilisation d'une alarme visuelle.

3.3.5.c Adaptation Intelligente de la Vitesse (ISA)

Ce système a été sélectionné dans 4 cas, dont 2 cas avec perte de contrôle avec à chaque fois un piéton fauché sur le trottoir.
Les 2 autres cas sont des cas avec traversée du piéton et un véhicule en excès de vitesse. Dans ces 2 cas, le système ne vient seulement qu'en complément d'un système de détection.
Dans tous les cas où ce système a été identifié il y a une limitation due soit à un rejet intentionnel du conducteur (en particulier si le système n'est pas automatique, c'est-à-dire que c'est le conducteur qui gère sa vitesse le système n'étant qu'informatif), soit à l'inattention du conducteur, ces limitations ayant un fort risque d'annihiler l'efficacité du système.

3.3.5.d Vision de nuit (NV)

Le système a été identifié dans seulement 3 cas. Dans 2 cas, une limitation de niveau 3 c'est-à-dire pouvant rendre le système totalement inefficace a été trouvée, limitation due à l'inattention du conducteur.

3.3.5.e Les autres systèmes

Parmi les autres systèmes identifiés on retrouve l'évitement de la collision, la détection d'une faible adhérence, la surveillance de la pression des pneumatiques et le contrôle en intersection. Tous ces systèmes ne sont pas en fait directement corrélés avec la traversée d'un piéton, mais s'occupe principalement de gérer un autre conflit de trafic (problème en intersection, perte de contrôle, sur-accident).

3.3.6 Ce qu'il faut retenir

Les besoins pivots sont essentiels car ils sont les principaux acteurs de la situation accidentelle comparés aux besoins amont dont la probabilité de conduire à l'accident est beaucoup moins certaine.
Le besoin le plus fréquent chez les conducteurs est celui de la détection (65%) avec majoritairement une difficulté dans la recherche de l'information due notamment à des masques à la visibilité. La prédiction de la manœuvre du piéton apparait également (21%).
Le piéton est le plus souvent à l'origine de la perturbation, soit parce qu'il néglige la recherche d'information soit parce qu'il s'attend à ce que le véhicule ralentisse.
Parmi les systèmes de sécurité les plus souvent sélectionnés on retrouve le système de Protection des Usagers Vulnérables essentiellement pour sa fonction de détection.
Cependant de nombreuses limitations sont à prendre en compte au niveau des masques à la visibilité (véhicule en stationnement, bâti, végétation, etc.) qui peuvent rendre le système totalement inefficace.

3.4 La situation d'urgence

La phase d'urgence est la séquence située entre la phase de rupture et le choc. C'est durant cette période que le conducteur doit impérativement réagir s'il veut éviter l'accident par l'intermédiaire de manœuvres qu'il va plus ou moins bien mener.

De la même façon que pour la phase de rupture, on identifie également dans cette séquence particulière des défaillances fonctionnelles qui seront étroitement associées aux manœuvres d'urgence engagées.

3.4.1 Les défaillances fonctionnelles en situation d'urgence

Les défaillances fonctionnelles définies pour la situation d'urgence sont étroitement associées aux manœuvres entreprises par les usagers.

Ainsi le dysfonctionnement est ici identifié à partir de 5 catégories :

- ***Aucune manœuvre*** : Aucune manœuvre corrective n'a été entreprise ;
- ***Manœuvre inappropriée*** : L'usager a détecté la situation d'urgence mais le choix de la manœuvre entreprise n'est pas la bonne en fonction des conditions et du contexte liés à l'accident ;
- ***Manœuvre mal réalisée*** : L'usager a détecté la situation d'urgence et a entrepris une manœuvre appropriée aux circonstances mais cette manœuvre n'a pas été correctement exécutée (exemple d'un freinage en dessous des capacités optimales permises par le véhicule) ;
- ***Collision inévitable*** : ici l'usager a bien détecté la situation d'urgence et a entrepris une manœuvre appropriée mais les conditions de temps et/ou d'espace sont trop courtes pour permettre l'évitement de l'accident.

Ce que l'on remarque c'est que dans 60% des cas la situation est inévitable pour le conducteur, dans 37% des cas ce dernier n'a pas détecté la situation de danger.

Pour les piétons, aucune correction dans la trajectoire ou dans l'allure n'a été réalisée dans 84% des cas.

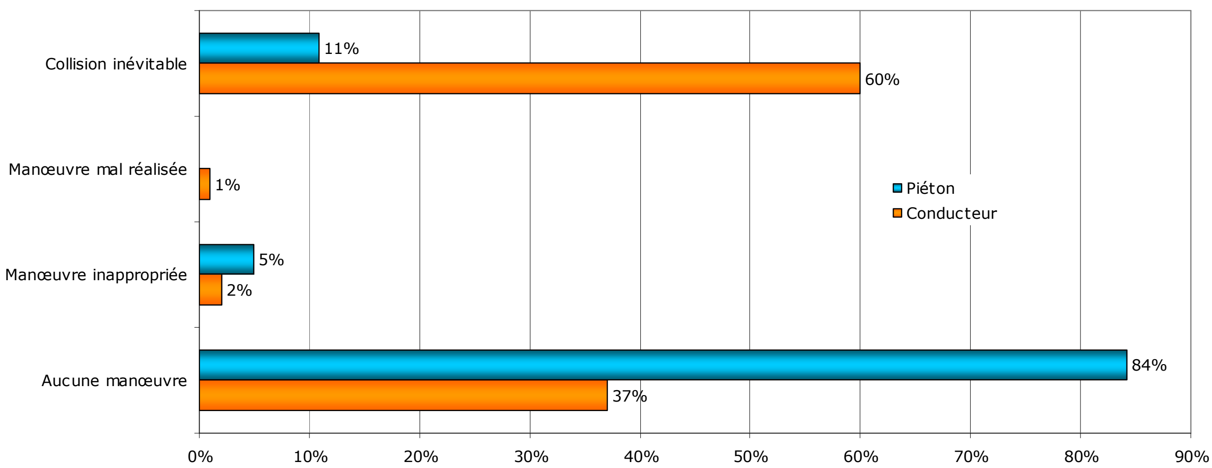

Figure 25 : Distribution des défaillances en situation d'urgence chez les conducteurs (n=100) et chez les piétons (n=101)

3.4.2 Les facteurs limitant

La liste des facteurs limitant utilisée dans cette phase est identique à celle de la phase de rupture. Ces facteurs limitant vont permettre d'expliquer en partie la défaillance observée dans la phase d'urgence.

Pour les conducteurs, un total de 126 facteurs a été identifié. Sur les 100 cas d'accidents traités, on trouve 1 cas avec 4 facteurs, un cas avec 3 facteurs, 21 cas avec deux facteurs, 55 cas avec un seul facteur limitant et 22 cas sans aucun facteur.

Parmi ces facteurs, 24% sont liés à l'usager lui-même, 50% à l'environnement (essentiellement des problèmes associés au trafic environnant ou à l'espace disponible pour réaliser la manœuvre) et au véhicule dans 9%.

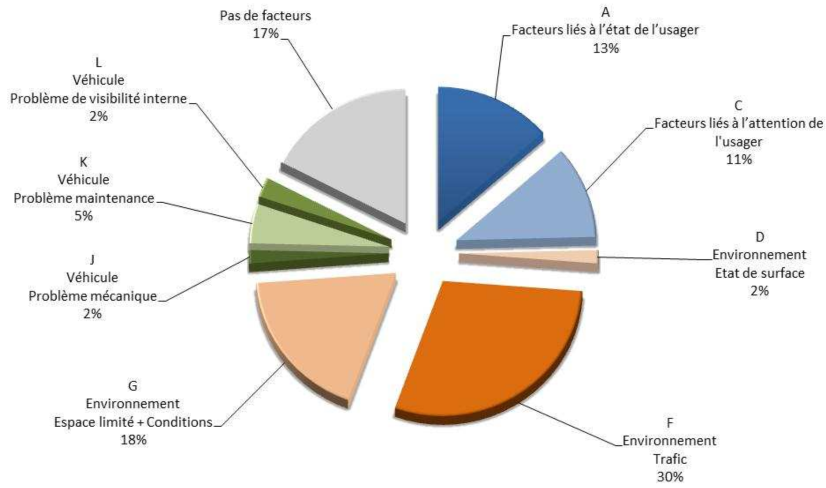

Figure 26 : Répartition des facteurs limitant identifiés chez les conducteurs (n=126)

Les facteurs limitant associés à une collision inévitable montrent que les problèmes principaux sont essentiellement des facteurs liés au trafic (39%), à un espace limité pour effectuer la manœuvre (12%), à des facteurs associés à l'état de l'usager (12%) ou encore à son attention (11%).

Dans les cas où aucune manœuvre n'a été entreprise par le conducteur, les facteurs semblent mieux répartis, même si les principaux restent liés au manque d'espace pour la réalisation de la manœuvre (29%) ou des problèmes de trafic (16%) ou encore à l'état de l'usager (16%).

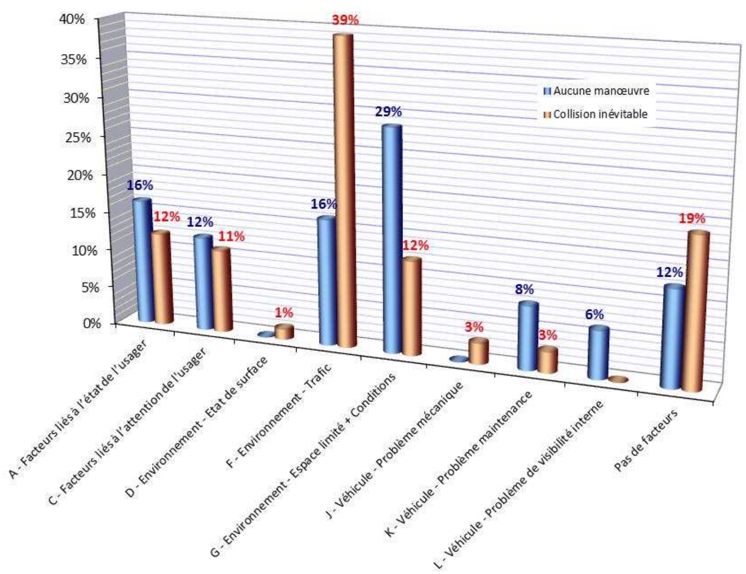

Figure 27 : Répartition des facteurs limitant identifiés chez les conducteurs pour les défaillances avec absence de manœuvre ou les collisions inévitables (n=123)

Pour les piétons, 108 facteurs limitant ont été identifiés. Sur les 100 cas d'accidents traités, on trouve 7 cas avec 2 facteurs, 33 cas avec un seul facteur limitant et dans 60 cas il n'a pas été trouvé de facteur.
Parmi ces facteurs, 37% sont liés à l'usager lui-même, 2% à l'environnement (essentiellement des problèmes associés au trafic environnant ou à des véhicules en stationnement) et spécifique au piéton dans 6%.

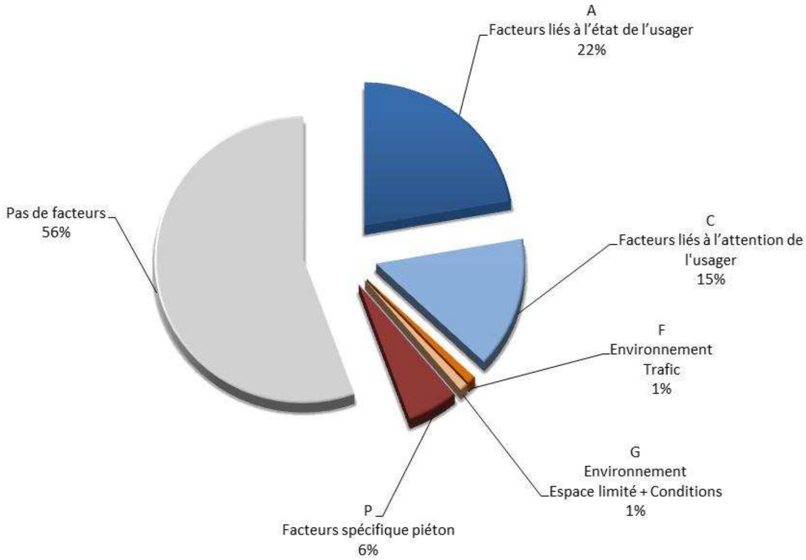

Figure 28 : Répartition des facteurs limitant identifiés chez les piétons (n=108)

3.4.3 Les besoins en correction

Les besoins en correction lors de la phase d'urgence ne sont pas les mêmes que les besoins lors de la phase de rupture. Ils doivent être plus étroitement associés à la manœuvre que ce soit dans la prise de décision ou dans son exécution.
Ainsi les besoins en correction ont été regroupés en 5 classes :

- Les besoins de diagnostiquer une situation d'urgence. Ils s'appliquent lorsque le conducteur n'a pas entrepris de manœuvre car il n'a pas vu ou compris le danger de la situation dans laquelle il se trouve.
- Les besoins en aide ou à la prise de décision. Ici le conducteur a perçu le danger mais ne sait pas quelle est la bonne manœuvre à réaliser.
- Les besoins en freinage ou régulation de freinage. Une manœuvre d'urgence a été réalisée avec un freinage non optimal associé.
- Les besoins en aide au contrôle de la trajectoire. Lors de sa manœuvre d'urgence le conducteur perd le contrôle de son véhicule par des sollicitations trop importantes de son véhicule.
- Les besoins au niveau de l'infrastructure. Ils concernent les cas où l'infrastructure n'offre pas la place suffisante pour la réussite de la manœuvre d'évitement.

Pour les 100 cas d'accidents traités dans cette étude, 93% des besoins en correction sont couverts par les besoins en freinage (58%) et les besoins en diagnostic de la situation d'urgence (35%). On retrouve ensuite mais de façon plus anecdotique les besoins en aide à la décision (3%) et les besoins en contrôle de trajectoire (3%).

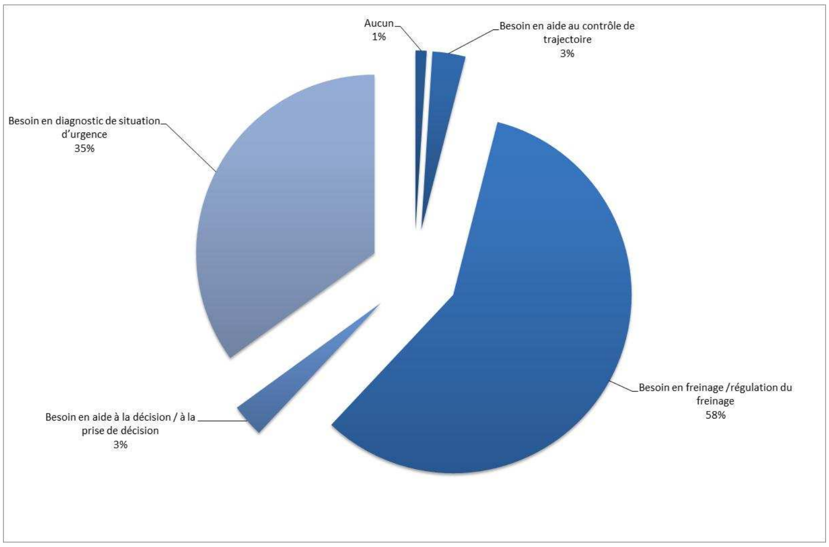

Figure 29 : Répartition des besoins en correction pour les conducteurs (n=100)

3.4.4 Les contre-mesures associées et leur(s) limitation(s)

Sur les 99 besoins en correction identifiés chez les 100 conducteurs, 176 sélections de systèmes de sécurité ont été trouvées.
Parmi les systèmes les plus fréquemment répertoriés on retrouve toute la famille associée au freinage (Assistance au freinage d'urgence 35%, freinage d'urgence automatique 35%, ABS 6%) mais le plus souvent de façon combinée.
Par exemple si le véhicule n'est pas équipé d'ABS et que le conducteur a bloqué ses roues, le 1ier système sélectionné sera l'ABS, puis l'assistance au freinage d'urgence (BA) puis le freinage d'urgence automatique (PBA). De la même façon pour un véhicule équipé de l'ABS mais dont le freinage n'a pas été optimal on associera alors le système BA puis le PBA.
Si l'on ne tient pas compte de cette succession quasi systématique et que l'on s'en tient aux premiers systèmes sélectionnés la répartition est alors la suivante :

- Le freinage d'urgence automatique (PBA) dans 46% des cas
- Le système de détection des usagers vulnérables (30%) pour sa fonction liée au freinage automatique en cas de danger
- L'ABS dans 11% des cas
- Le radar de recul, l'ESC et l'évitement de la collision avec 3% pour chacun d'eux.

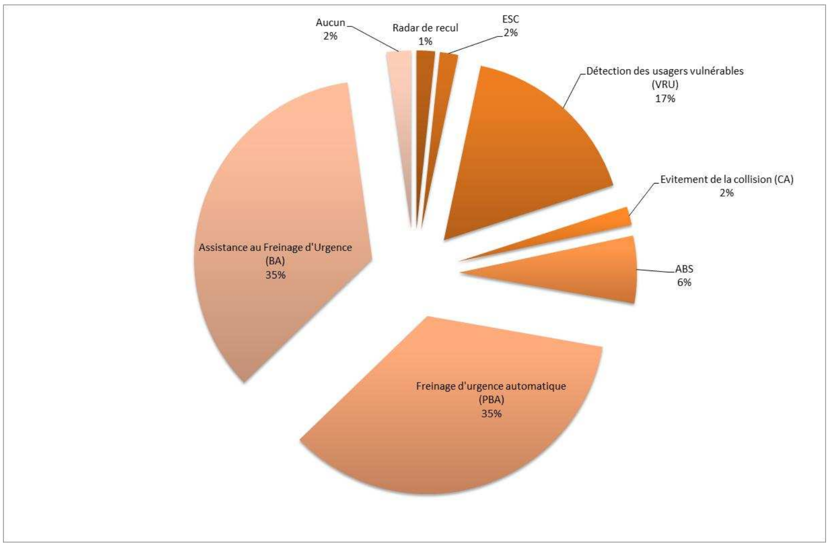

Figure 30 : Répartition des besoins en correction pour les conducteurs (n=100)

Pour les 96 systèmes identifiés, seulement 34% trouvent au moins une limitation dans leur fonctionnement. Ces limitations se regroupent en 8 typologies :

- Problèmes liés aux seuils de déclenchement (19%)
- Faible adhérence (3%)
- Vitesse excessive (3%)
- Pas de freinage (3%)
- Conditions spatio-temporelles trop réduites (2%)
- Etat psychophysiologique (2%)
- Faible conditions de luminosité (1%)
- Problème lié au véhicule (1%)

La liste exhaustive des limitations déterminées en fonction du contexte des accidents ainsi que son degré d'interaction associé est donnée dans le graphique ci-dessous.

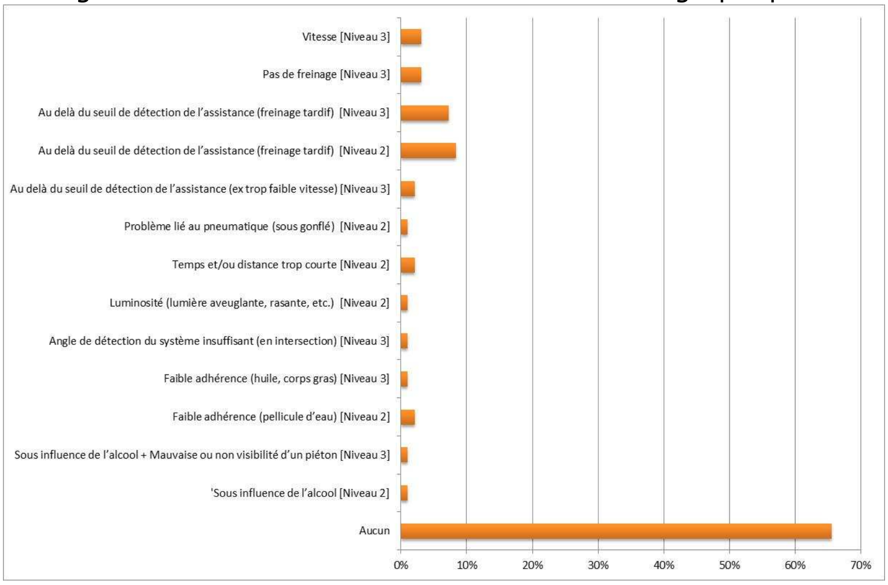

Figure 31 : Répartition des limitations observées en phase d'urgence (n=96)

Pour chaque limitation identifiée nous avons essayé de donner une estimation du degré d'interaction que cette limitation pourrait avoir sur l'efficacité du système de sécurité associé. Si l'on analyse de façon globale ces degrés d'interférence on s'aperçoit que les systèmes proposés pourraient être rendus totalement inefficace (Niveau 3) dans 19% des cas et d'une diminution de cette efficacité (Niveau 2) dans 16%.
Les systèmes seraient donc totalement opérationnels dans 65% des cas. Ce résultat s'explique par le fait que l'on agit principalement sur la réduction de la vitesse en rendant le freinage plus efficace, soit en améliorant ses performances (BA ou ABS) ou par l'automatisation (PBA).

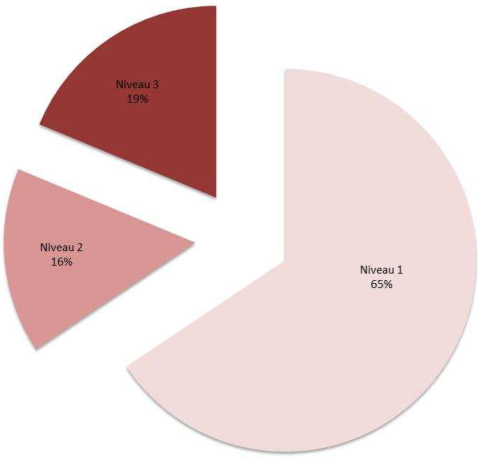

Figure 32 : Distribution des degrés de limitation pour les contre-mesures sélectionnées pour la situation d'urgence (n=96)

3.4.5 Ce qu'il faut retenir

La phase d'urgence fait la part belle aux systèmes de freinage et en particulier aux systèmes automatiques. Ceci est d'autant plus marqué que certains véhicules impliqués dans nos accidents ne sont même pas équipés d'ABS.
Les améliorations apportées par les systèmes de freinage sur les nouveaux véhicules devraient donc porter leurs fruits en particulier avec un renouvellement récent du parc.
Cependant, le problème reste que pour que ce freinage assisté soit efficace faut-il encore que le conducteur appuie sur sa pédale. L'apport d'un système tel que le freinage d'urgence automatique a donc en théorie un fort potentiel en particulier dans les accidents avec piéton. La difficulté majeure reste cependant la détection : elle doit être optimale (toutes les situations accidentelles doivent être détectées) et éviter les fausses alarmes, tout cela dans un environnement en constante évolution et (particulièrement en ville) truffé d'interférences diverses (trafic, mobilier urbain, véhicule en stationnement, etc.) sans compter les modifications de trajectoire ou d'allure du piéton.
A noter également le faible taux de limitations. Elles dépendent fortement du conducteur et de sa volonté de freiner.

3.5 La Collision

La phase de collision est la séquence située après la phase d'urgence. Elle correspond à la collision et à ses conséquences.

Ici nous ne nous intéresserons pas à la partie lésionnelle puisque celle-ci fait l'objet d'un rapport à part entière [9].

Nous allons traiter uniquement les configurations de choc et les facteurs aggravants.

3.5.1 Les configurations de choc

Sur les 100 accidents de piéton, la configuration la plus répandue est celle du choc frontal pour le véhicule et d'un choc latéral pour le piéton.

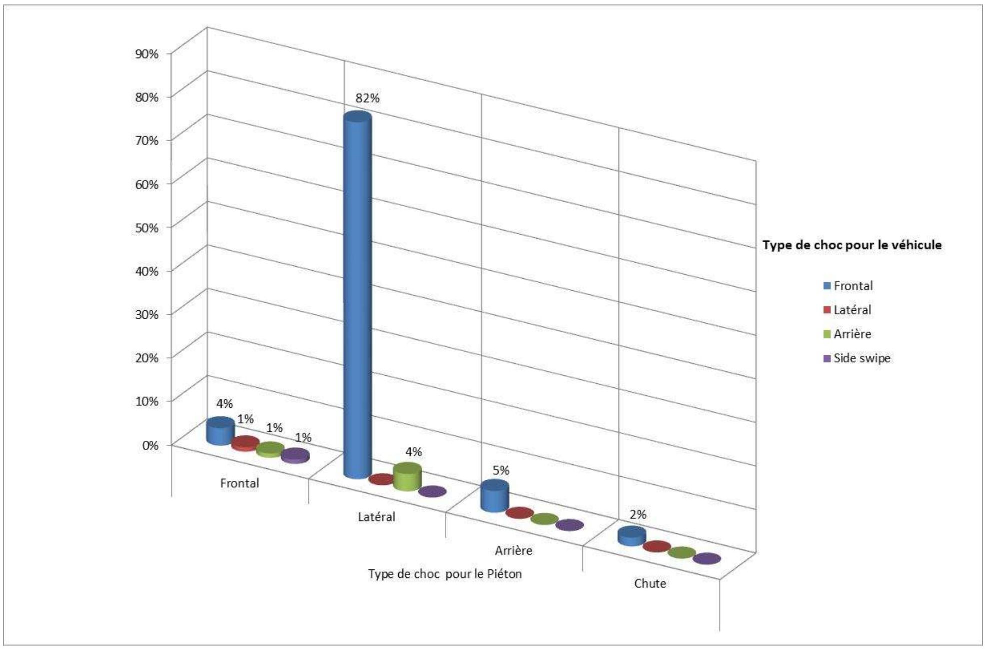

Figure 33 : Distribution des configurations de choc (n=100)

Pour les véhicules, c'est donc le choc frontal le plus répandu (93%) suivi du choc arrière (5%).

Chez les piétons, c'est le choc latéral qui est le plus répandu (86%) puis le choc frontal (7%) et le choc de dos (5%).

Lorsque l'on regarde les facteurs aggravants, bien évidemment les facteurs premiers sont le fait que ce soit un piéton pour le véhicule, et que ce soit un véhicule pour le piéton. Sorti de cette évidence, nous avons essayé de regarder quels étaient les autres facteurs qui ont aggravé la situation. 14 facteurs ont donc été identifiés. On retrouve principalement les problèmes liés au freinage (36%), les problèmes liés à l'âge du piéton (22%), les problèmes liés à la vitesse (14%). Ces résultats sont toutefois à prendre avec précaution au vu de l'effectif associé.

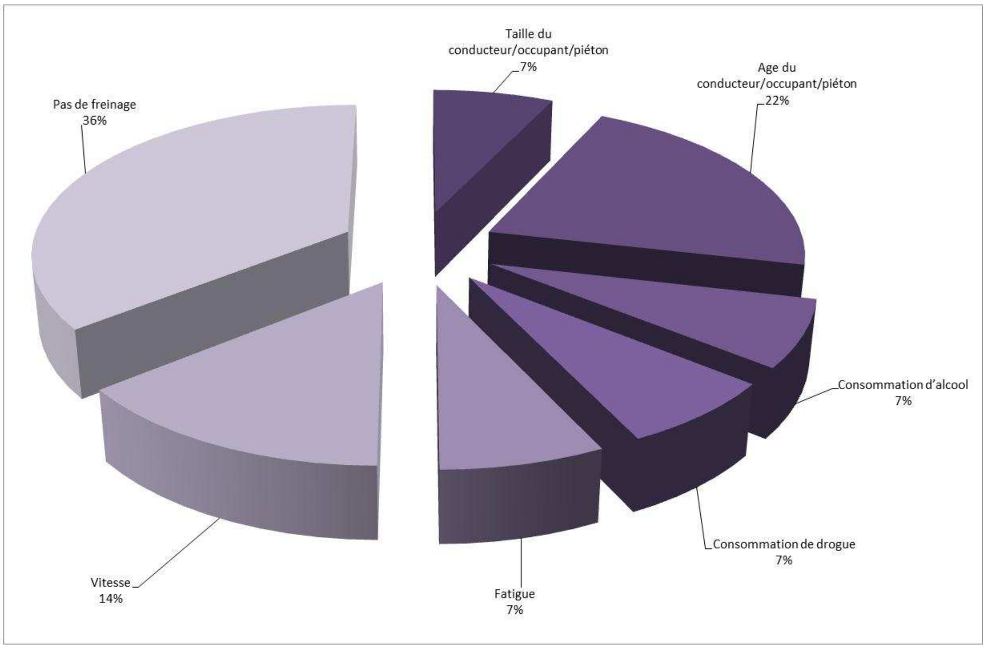

Figure 34 : Distribution des facteurs aggravants (n=14)

3.5.2 Les besoins en protection

Les accidents traités dans le cadre du projet n'étaient pas très violents comme nous avons pu le constater en comparaison avec les cas traités dans le cadre du projet APPA. Aucun conducteur n'a été blessé et le nombre de piéton tués faible comparé aux chiffres nationaux.

Dans l'analyse des cas que nous avons pu faire au cours du projet, nous nous sommes essayés à déterminer pour chaque lésion identifiée quelle était la nature de l'objet impacté qu'il s'agisse soit d'un élément du véhicule, d'un mobilier urbain (poteaux, potelet, barrière, bouche d'égout, etc.), du trottoir ou encore du sol.

Sur les 110 piétons inclus dans la base de données, 485 lésions ont pu être décrites.
La distribution de ces lésions est donnée sur le graphique ci-après.

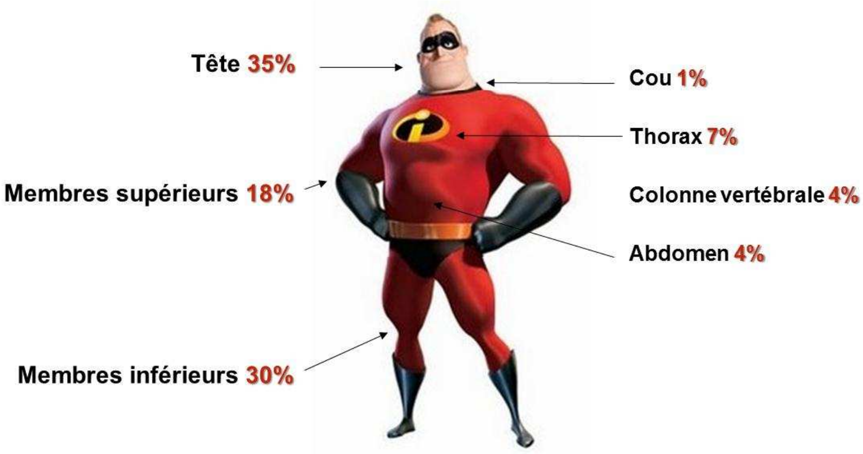

Figure 35 : Répartition des lésions par territoire corporel (n=485)

Sur les 485 lésions observées, nous avons pu identifier que 53% d'entre elles étaient dues au véhicule et 47% principalement au sol et dans une très faible proportion à des éléments de l'infrastructure.
Les parties du véhicule ayant le plus souvent provoquées des blessures sont le capot (18%), le pare-brise (17%) et la partie du bouclier avant, feux compris (11%).

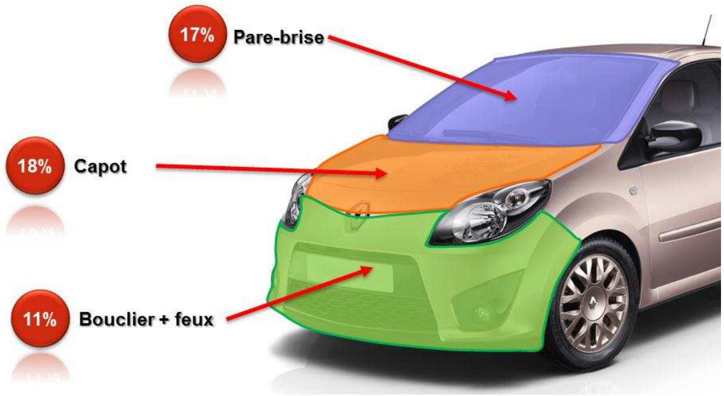

Figure 36 : Répartition des parties impactées sur le véhicule (n=485)

Pour ce qui est de la protection sur le véhicule, nous voyons qu'un airbag spécifique piéton permettrait de réduire considérablement les impacts capot et pare-brise notamment sur les parties les plus rigides.
Cependant, si on améliore la protection du piéton sur le véhicule, il reste la projection à traiter et les chocs contre le sol qui peuvent s'avérer fatals.
La meilleure protection pour le piéton reste donc l'évitement de la collision.

4 Conclusion

L'objectif principal de cette étude est d'identifier les besoins des conducteurs en termes d'aide ou d'assistance à l'exécution de leur tâche de conduite pour éviter l'accident. Cette identification est réalisée à partir de l'analyse de leur(s) défaillance(s) fonctionnelle(s) survenue dans le déroulement de l'accident. Le besoin est ainsi identifié comme le miroir de la défaillance fonctionnelle observée.

L'identification des besoins permet de compléter l'analyse sur les causes d'accidents en développant le volet relatif à l'usager. Elle complète donc le diagnostic de sécurité. Elle permet :

- d'identifier les besoins en termes de prestation de sécurité qui seraient utiles à l'usager pour l'aider dans sa tâche de conduite
- de vérifier l'adéquation entre les besoins réels des usagers (demande) et les systèmes de sécurité proposés (offre)
- de mettre en évidence les limites en termes de performance de ces systèmes en prenant en compte le contexte dans lequel se déroule l'accident.

Partant du constat que l'accident peut être décomposé de façon séquentielle, on pouvait imaginer que les besoins de l'usager pouvaient également évoluer, voire disparaître pour laisser place à de nouveaux. Ainsi les défaillances fonctionnelles et l'analyse du besoin ne sont plus uniquement identifiées pour la phase de rupture, mais sont proposées pour la phase en amont correspondante à la situation de conduite normale, et aux phases suivantes à savoir en situation d'urgence et de collision. Cette extension de la méthodologie a été initiée et utilisée pour la première fois simultanément dans le projet européen DaCoTA et pour le projet CACIAUP.

La valeur ajoutée de cette étude a été d'étendre l'analyse à la spécificité de l'accident avec piéton à savoir, identifier de nouveaux besoins ou la nécessité d'adapter des besoins existants que ce soit pour le conducteur ou l'usager piéton.

Les principaux résultats de cette étude sont les suivants :

Pour la situation pré-accidentelle :
L'analyse des besoins dans la phase pré-accidentelle ainsi que l'identification des contre-mesures associées est délicate à mener car elle est en partie biaisée par la connaissance des circonstances de l'accident. Le cas le plus représentatif est celui d'un piéton masqué par un bâtiment et qui va traverser. Si l'on s'en tient uniquement aux éléments factuels, d'un point de vue du véhicule il n'y a aucun moyen de savoir si derrière le bâtiment se trouve un piéton. Or comme nous savons qu'il s'agit d'un accident et qu'en plus il implique un piéton, la tendance sera d'indiquer un besoin de détection d'un usager masqué. Un autre problème qui trouve son sens ici, ce sont tous les éléments du contexte qui sont intervenus à ce moment-là. A partir des enquêtes EDA seulement une petite partie de ces éléments peuvent être appréhendée, en particulier ceux qui resteront présents lors de l'accident. Or certains « second rôle » à un instant donné peuvent être des « premier rôle » à un autre moment.
Pour revenir sur les résultats relatifs à cette phase de l'accident, ce que l'on peut retenir c'est que dans 19% des cas le véhicule est en situation stabilisée et le piéton traverse sur un passage protégé et dans 14% la traversée se fait hors d'un passage protégé. Les situations où le véhicule se trouve en intersection (rond-point compris) sont également nombreuse avec pour la moitié d'entre elles des situations de tourne à gauche.
D'un point de vue des besoins, on remarque que dans la plupart des cas c'est la détection du piéton qui est mise en avant (72%).
Parmi les systèmes sélectionnés, on retrouve essentiellement le système de détection d'un usager vulnérable (VRU) et concerne toujours la fonction détection. Cependant si l'on tient compte des éléments du contexte (uniquement ceux qui ont été relevés) on

observe alors un nombre important de limitations (principalement de visibilité limitée ou un champ de détection trop éloigné) et qui vont avoir une grande influence sur l'efficacité du système. Ici on reste dans le domaine de l'alerte, le problème est donc de détecter le plus tôt possible dans une forêt d'éléments (trafic, mobilier urbain, végétation, bâti, piétons, etc.) LE piéton qui va traverser et de transmettre la bonne information au conducteur sous une forme qu'il soit capable d'interpréter.

Pour la phase de rupture :

Les besoins pivots sont essentiels car ils sont les principaux acteurs de la situation accidentelle comparés aux besoins amont dont la probabilité de conduire à l'accident est beaucoup moins certaine.

Le besoin le plus fréquent chez les conducteurs est celui de la détection (65%) avec majoritairement une difficulté dans la recherche de l'information due notamment à des masques à la visibilité. La prédiction de la manœuvre du piéton apparait également (21%).

Le piéton est le plus souvent à l'origine de la perturbation, soit parce qu'il néglige la recherche d'information soit parce qu'il attend à ce que le véhicule ralentisse.

Parmi les systèmes de sécurité les plus souvent sélectionnés on retrouve le système de Protection des Usagers Vulnérables (VRU) essentiellement pour sa fonction de détection.

Cependant de nombreuses limitations sont à prendre en compte au niveau des masques à la visibilité (véhicule en stationnement, bâti, végétation, etc.) qui peuvent rendre le système totalement inefficace.

Pour la phase d'urgence :

La phase d'urgence fait la part belle aux systèmes de freinage et en particulier aux systèmes automatiques. Ceci est d'autant plus marqué que certains véhicules impliqués dans nos accidents ne sont même pas équipés d'ABS.

Les améliorations apportées par les systèmes de freinage sur les nouveaux véhicules devraient donc porter leurs fruits en particulier avec un renouvellement récent du parc.

Cependant, le problème reste que pour que ce freinage assisté soit efficace faut-il encore que le conducteur appuie sur sa pédale. L'apport d'un système tel que le freinage d'urgence automatique a donc en théorie un fort potentiel en particulier dans les accidents avec piéton. La difficulté majeure reste cependant la détection : elle doit être optimale (toutes les situations accidentelles doivent être détectées) et éviter les fausses alarmes, tout cela dans un environnement en constante évolution et (particulièrement en ville) truffé d'interférences diverses (trafic, mobilier urbain, véhicule en stationnement, etc.) sans compter les modifications de trajectoire ou d'allure du piéton.

A noter également le faible taux de limitations. Elles dépendent fortement du conducteur et de sa volonté de freiner.

Nous avons vu que ce type d'étude permet d'apporter une autre dimension dans l'analyse des causes de l'accident et en particulier dans l'identification de mesures de sécurité le plus adaptées aux besoins réels de l'usager confronté à une situation accidentelle.

Les résultats ont été obtenus sur un échantillon de 100 cas. Une consolidation serait nécessaire sur un échantillon beaucoup plus important, par exemple à partir de l'échantillon constitué pour le projet VOIESUR.

5 Référence

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Annexe 1
Les Fiches de codages

Identification de la situation

Codification relative à la caractérisation de la situation pré-accidentelle dans laquelle se trouvait l'usager juste avant l'accident. Cette fiche permet la codification de l'étape 1

A. Situation stabilisée	
A.1 : Va tout droit	**A.1.1** va tout droit sur sa route
	A.1.2 va tout droit vers l'accotement gauche
	A.1.3 va tout droit vers l'accotement droit

B. Situation en intersection	
B.1 Sur l'axe prioritaire	**B.1.1** En approche d'une intersection réglementée par un "Cédez-le-passage"
	B.1.2 En approche d'une intersection réglementée par un "Stop"
	B.1.3 En approche d'une intersection réglementée par des feux de circulation
	B.1.4 En approche d'une intersection réglementée par une "Priorité à droite"
	B.1.5 Sur un rond-point
	B.1.6 sur une route glissante
B.2 Sur l'axe non prioritaire	**B.2.1** En approche d'une intersection réglementée par un "Cédez-le-passage"
	B.2.2 En approche d'une intersection réglementée par un "Stop"
	B.2.3 En approche d'une intersection réglementée par des feux de circulation
	B.2.4 En approche d'une intersection réglementée par une "Priorité à droite"
	B.2.5 Sur un rond-point
	B.2.6 sur une route glissante
B.3 Arrêté ou démarrant	**B.3.1** d'un "Cédez-le-passage"
	B.3.2 d'un "Stop"
	B.3.3 d'un feu de circulation
	B.3.4 pour tourner
	B.3.5 sur une intersection
B.4 Avec changement de direction	**B.4.1** Tourne à gauche dans une intersection réglementée par un "Cédez-le-passage"
	B.4.2 Tourne à gauche dans une intersection réglementée par un "Stop »
	B.4.3 Tourne à gauche dans une intersection réglementée par des feux de circulation
	B.4.4 Tourne à gauche depuis l'axe prioritaire dans une intersection réglementée par une "Priorité à droite"
	B.4.5 Tourne à gauche depuis l'axe non prioritaire dans une intersection réglementée par une "Priorité à droite"
	B.4.6 Tourne à droite dans une intersection réglementée par un "Cédez-le-passage"
	B.4.7 Tourne à droite dans une intersection réglementée par un "Stop »
	B.4.8 Tourne à droite dans une intersection réglementée par des feux de circulation
	B.4.9 Tourne à droite depuis l'axe prioritaire dans une intersection réglementée par une "Priorité à droite"
	B.4.10 Tourne à droite depuis l'axe non prioritaire dans une intersection

	réglementée par une "Priorité à droite"

C. Les Manœuvres	
C.1 : Les Dépassement	**C.1.1** Dépasse un véhicule immobile localisé sur sa gauche
	C.1.2 Dépasse un véhicule immobile localisé sur sa droite
	C.1.3 Dépasse un véhicule en mouvement localisé sur sa gauche
	C.1.4 Dépasse un véhicule en mouvement localisé sur sa droite
C.2 : Les Changements de voie	**C.2.1** Changement de voie vers la gauche
	C.2.2 Changement de voie vers la droite
C.3 : Ralenti	**C.3.1** Pour s'arrêter (hors intersection)
	C.3.2 Pour stationner (sur le bas-côté)
C.4 : Démarre	**C.4.1** Démarre (hors intersection)
	C.4.2 Pour quitter un stationnement (sur le bas-côté)
C.5 : Tourne (hors intersection)	**C.5.1** Tourne à gauche depuis l'axe principal dans une voie privée
	C.5.2 Tourne à droite depuis l'axe principal dans une voie privée
	C.5.3 Tourne à gauche depuis une voie privée
	C.5.4 Tourne à droite depuis une voie privée
C.6 : En marche arrière	**C.6.1** Recule
C.7 : Demi-tour	**C.7.1** Demi-tour
C.8 : En Contre sens	**C.8.1** Circule à contresens

D. Autres situations	
D.1 : En stationnement	**D.1.1** En stationnement
D.2 : Arrêté dans un embouteillage	**D.2.1** Arrêté dans un embouteillage
D.3 : Piéton	**D.3.1** Piéton en approche d'un passage piéton
	D.3.2 Piéton arrêté au passage piéton
	D.3.3 Piéton traversant sur passage piéton
	D.3.4 Piéton traversant hors passage piéton
	D.3.5 Piéton courant ou marchant sur un parking
	D.3.6 Piéton courant ou marchant sur le trottoir
	D.3.7 Piéton arrêté sur le trottoir ou le bas côté de la route
	D.3.8 Piéton marchant sur le bord de la route
D.4 : Sur passage à niveau	**D.4.1** En approche
	D.4.2 Arrêté

Les facteurs

Codification relative à la caractérisation des facteurs initiaux (en phase de conduite), déclenchant (en phase de rupture), limitant (en phase d'urgence) et aggravants (lors de la collision). Cette fiche permet la codification des étapes 2 4 8

Origine	Type	Sous-type	Facteurs	Description
Facteurs liés à l'usager	**A** Facteurs liés à l'état de l'usager	**1.** Etat physique physiologique	**A.1.1** Conditions médicales	Problème cardiaque/Epilepsie/Autres problèmes mentaux/Problème respiratoire/Problème sanguin/Autres problèmes
			A.1.2 Déficience préexistante	Auditive/Visuelle/Incapacité physique /Autre déficience
			A.1.3 Comportement lent	Lié à l'âge
		2. Conditions psychologiques	**A.2.1** due à l'absorption d'alcool	Au-dessus de la limite légale/ En-dessous de la limite légale
			A.2.2 dues à la prise de drogues	Drogues illégales
			A.2.3 dues à la prise de médicaments	Utilisé suivant la prescription/ Médicaments oubliés
			A.2.4 Emotionnelles	Contrarié/En colère/Anxieux/Heureux/Autres émotion
			A.2.5 Fatigue	Physique/Mentale
			A.2.6 Est pressé	Est pressé
			A.2.7 Panique	L'usager est submergé par la situation
		3. Conditions internes liées à la tâche exécutée	**A.3.1** Statut prioritaire	Attachement rigide à son statut prioritaire
			A.3.2 Confiance excessive	Confiance excessive dans les signes donnés aux autres
			A.3.3 Identification d'un risque potentiel	Identification d'un risqué potentiel mais sur une partie seulement de la situation
			A.3.4 Contrainte de temps	Liée au trajet
			A.3.5 Contrainte de temps liée à la situation	Liée à la manœuvre
			A.3.6 Situation banale	Néglige le risque potentiel associé à la situation (par excès de connaissance de la situation ou situation inhabituelle)
			A.3.7 Illusion de visibilité	L'usager est persuadé d'avoir été vu par les autres (souvent le cas d'usagers vulnérables tels que les 2 roues ou les piétons)
			A.3.8 Eclairage non allumé	De nuit ou de jour pour les véhicules qui ont une obligation d'éclairage (2RM, ou véhicules dans les pays où cela est obligatoire)
		4. Prise de risque	**A.4.1** Vitesse illégale	Illégale/Irrégulière/Autre
			A.4.2 Vitesse inappropriée	Légale mais inappropriée par rapport à la situation
			A.4.3 Placement du véhicule	Devant/En latéral/Autre
			A.4.4 Signalisation	Signalisation non respectée/Signaux non respectés/Marquage non respecté/Autre
			A.4.5 Intention excentrique	Teste le véhicule/Recherche de sensation/Course/Cascade/Stunt/Autres intentions excentriques
			A.4.6 Accélération atypique	Niveau d'accélération qui peut surprendre les autres usagers (exemple des motos)
			A.4.7 Dépassement atypique	Dépassement sur la mauvaise file / zigzag / gymkhana
			A.4.8 Excès de prudence	Trop de prudence apportée à la tâche de conduite.

Origine	Type	Sous-type	Facteurs	Description
Facteurs liés à l'usager	**B.** Facteurs lies à l'expérience	**1.** Faible ou aucune expérience	**B.1.1** Facteurs liés à la conduite	Apprenti/Nouveau conducteur/Conducteur occasionnel/Autre
			B.1.2 Facteurs liés à la route	Découvre la route/Type de route/Route nouvelle/Nouvel aménagement de la route/Pas habitué à rouler de ce côté de la route (ex à droite pour les anglais)/Autres
			B.1.3 Facteurs lies au véhicule	Nouveau véhicule/Type de transmission/Véhicule avec un autre type de conduite que celui utilisé habituellement (ex conduite à droite pour les anglais)/Autres
			B.1.4 Facteurs lies à l'environnement	Conduite de nuit/Conduite en ville/Conduite hors agglomération/Conduite sur la neige/Conduite sur la glace/Conduite dans le brouillard/Conduite sur route mouillée/Autres
			B.1.5 Facteurs lies à la façon de conduire	Changement de code de la route/Autre
		2. Sur expérimenté	**B.2.1** Facteurs lies à la route	Route en général/Type de route/Nouvelle route/Aménagement/Autre
			B.2.2 Facteurs lies au véhicule	Nouveau véhicule/Autres facteurs lies au véhicule
			B.2.3 Facteurs liés à l'environnement	Conduite de nuit/Conduite en ville/Conduite hors agglomération/Conduite sur la neige/Conduite sur la glace/Conduite dans le brouillard/Conduite sur route mouillée/Autres
	C. Facteurs liés à l'attention	**1.** Attention perturbée (y compris pour les piétons)	**C.1.1** Problème lié à la distraction	Compétition entre la tâche de conduite et une autre tâche (en dehors ou dans le véhicule) Ajustement autoradio/MP3/CD/ Autre occupant/Déplace un objet dans le véhicule/Utilise un autre système acheté (GPS, Lecteur DVD, etc.)/Ajustement de la température-climatisation/Mange/Bois/Téléphone/Fume/Regarde ou cherche un objet dans le véhicule/ Autre distraction interne/Autre distraction externe.
			C.1.2 Problème d'attention liée à plusieurs tâches	Compétition entre plusieurs tâches de conduite (en dehors ou dans le véhicule) Police/Animal sur la route/manipulation autoradio, GPS/ Piéton sur la route/Accidents/Autres perception de danger/Route en travaux/Recherche d'une information pour se diriger
			C.1.3 Problème d'inattention	Compétition entre la tâche de conduite et la pensée/Préoccupation, perdu dans ses pensées/ Préoccupations personnelles ou professionnelles/Problème médical

Origine	Type	Sous-type	Facteurs
Facteurs liés à l'Environnement	**D.** Etat de surface	**D. 1** Chaussée mouillée/inondée/enneigée	Mouillée/Inondée/Enneigée
		D.2 Présence de glace/gel	Glace/Gel
		D. 3 Présence d'huile, hydrocarbure	Huile/Hydrocarbure
		D. 4 Présence de Sable/Gravier/Boue	Sable/Gravier/Boue
		D. 5 Défaut de surface	Trous/Fissures/Bosses
		D. 6 Type de surface	Asphalte/Béton/Non goudronné/Pavés /Brique/Autre
		D. 7 Absence d'accotement	Route sans accotement
	E. Géométrie	**E. 1** Courbure	Gauche/Droite/Grande/Resserré/Multiples
		E. 2 Profil en long	Pente/Montée/Multiple
		E. 3 Lié à la largeur de la chaussée	Large/Etroite/Voie unique/voies multiples/rupture dans la largeur
		E. 4 Dévers inversé	A gauche/A droite
		E. 5 Ralentisseur	Ralentisseur/Chicane
		E. 6 Perturbation temporaire	Travaux/Autre
		E. 7 A caractère trompeur/complexe	Trompeur/Complexe
		E. 8 Route incitant à la vitesse	Grande courbe/route rectiligne/Déclivité/route large/Effet continue
		E.9 Route d'aspect monotone	Ex: autoroute
	F. Trafic	**F.1** Difficultés d'insertion	Pour cause de trafic dense, trafic irrégulier, grande vitesse, etc.
		F.2 Autre usager : Absence de signes d'anticipation de sa manœuvre	Absence de signes d'anticipation de sa manœuvre
		F.3 Autre usager : Ambigüité dans les signes émis pour sa manœuvre	Ambigüité dans les signes émis pour sa manœuvre
		F.4 Autre usager : Manœuvres Atypique	Manœuvres atypiques
		F.5 Manœuvres illégales d'un usager	Non-respect des feux/stop /signal
		F.6 Comportement perturbateur d'un autre usager	Faible vitesse/ Comportement hésitant
		F.7 Est entrainé dans sa manœuvre	Passager/Véhicule devant/Véhicule de derrière/Piéton/Cycliste
		F.8 Observation du trafic	
	G. Problème de Visibilité	**G.1** Eclairage de la route	Type/Couleur/Intensité/Absence
		G.2 Eclairage du véhicule	Type/Couleur/Type de système/Absence
		G.3 Jour/nuit	Jour/Nuit/Crépuscule/Aube
		G.4 Eblouissement du au soleil	Direct/Par réfection
		G.5 Conditions météorologiques	Pluie/Brouillard/Brume/Neige/Tempête
		G.6 Fumée	Véhicule/Feu/Autre
		G.7 Profil de la route	Profil/Courbe/Autre
		G.8 Autre(s) véhicule(s)	Véhicule très large-long/Grand véhicule/Véhicule en stationnement/Véhicule arrêté dans le trafic/Autre
		G.9 Mobilier urbain, objets sur le bord de la route	Arbres végétation en surplomb/Panneaux/Structure d'un édifice (pont, mur, etc.)/Barrière/Glissière/Autre
		G.10 Eblouissement	Par un autre véhicule
		G.11 Problème lié au pare-brise	Embué, sale, givré

Origine	Type	Sous-type	Facteurs
Facteurs liés à l'Environnement (suite)	**H.** Lié à la signalisation	**H.1** Signalisation insuffisante	Signalisation présente mais insuffisante/ Absence de signalisation/ Autre
		H.2 Problème lié à la maintenance de la signalisation	Panneau endommagé/Marquage effacé/Panneau mal positionné /Autre
		H.3 Signalisation inattendue	Signalisation repositionnée/Nouvelle signalisation/Autre
		H.4 Signalisation inappropriée	Signalisation inappropriée/Signalisation apportant de la confusion/Autre
		H.5 Visibilité du marquage insuffisante	Marquage effacé/Marquage non suffisamment visible/Autre
		H.6 Problème de maintenance du marquage	Marquage endommagé/Non entretenu/ Mal positionné/Autre
		H.7 Marquage inattendu	Marquage remplacé/Nouveau marquage/Autre
		H.8 Marquage inapproprié	Marquage inapproprié/Marquage apportant de la confusion /Autre
	I. Autres facteurs environnementaux	**I.1** Accident antérieur	Débris de véhicules/Autre
		I.2 Piéton sur la route	Adulte/Enfant/Autre
		I.3 Incendie sur la route ou aux abords	Véhicule sur la route ou sur l'accotement/Autre
		I.4 Passage à niveau	Contrôlé/Non contrôlé
		I.5 Animal sur la route	Animal
		I.6 Autres obstacles sur la route	Autres obstacles
		I.7 Travaux	Travaux
		I.8 Vent violent	Vent

Facteurs liés au véhicule	**J.** Problème mécanique	**J.1** Direction	Problème partiel ou total
		J.2 Frein	Problème partiel ou total
		J.3 Moteur	Problème partiel ou total
		J.4 Suspension	Problème partiel ou total
		J.5 Electrique/Electronique	Problème partiel ou total
	K. Maintenance	**K.1** Pare-brise/Vitrage	Eclaté/Brisé/Etoilé/Sale/Embué/Autre
		K.2 Pneumatiques	Type incorrect/Pression/Usure/Crevaison/Autre
		K.3 Eclairage extérieur	Type de lampe/Cassé/Ne fonctionnant plus/Autre
		K.4 Eclairage, Témoin, jauge intérieur	Essence/Huile/Eau/Frein/Parking/Autre témoin du tableau de bord/ autre éclairage intérieur
	L. Architecture	**L.1** Problème de Visibilité du aux éléments de la structure du véhicule	Pied avant/Pied milieu /Volant/Rétroviseur/Assise/Autre
		L.2 Bruit	Sons d'avertissement confus
		L.3 Affichage	Couleur/Taille/information confuse/Autre
		L.4 Contrôle	Couleur/Taille/information confuse/Trop/Autre
	M. Chargement	**M.1** Surcharge	Sur ou dans le véhicule
		M.2 Répartition	Sur ou dans le véhicule
		M.3 Obstrue la visibilité	Sur ou dans le véhicule

Facteurs liés à l'usager piéton	**P.** Piéton	**P.1** Enfant	**P.1.1** Sous la responsabilité d'un adulte
			P.1.2 Courant et/ou jouant
			P.1.3 Echappe à la vigilance de l'adulte l'accompagnant
		P.2 Adulte / Handicapé	**P.2.1.** Courant
			P.2.2 Personne handicapée dépendant de la personne qui l'accompagne

Scénarios HFF

Codification relative à l'identification du scénario à partir de l'analyse HFF (Défaillance Fonctionnelle Humaine). Cette fiche permet la codification de l'étape 5

Défaillance	Type de défaillance	Scénario découlant de la défaillance
Problème de Détection	**Detect 1** Problème de non détection dus à la difficulté d'accès à l'information	**Detect 1A**: Conducteur surpris par un véhicule non éclairé sur sa voie (sur accident de nuit)
		Detect 1B: Conducteur surpris par un animal, souvent de nuit
		Detect 1C: Conducteur surprise par un piéton ou un cycliste non visible en approche
		Detect 1D: Conducteur surpris par la manœuvre d'un véhicule non visible en approche
		Detect 1E: Conducteur surpris par un usager masqué, pendant la réalisation d'une manœuvre
		Detect 1F: Conducteur surpris par la découverte tardive d'un site routier
	Detect 2 Mauvaise organisation de la recherche d'informations	**Detect 2A**: Attention focalisée sur un problème directionnel
		Detect 2B: Focalisation vers une source d'information en fonction de la connaissance des lieux (d'une représentation du fonctionnement du site)
		Detect 2C: Focalisation vers une source d'information en fonction de l'importance des flux de trafic (d'une représentation des difficultés de la tâche)
		Detect 2D: Attention focalisée vers un usager (de la route) identifié comme une source de danger identifiée
		Detect 2E: Attention focalisée sur une difficulté liée au guidage
	Detect 3 Acquisition d'information sommaire ou précipitée	**Detect 3A**: Recherche sommaire d'information lors d'un tourne à gauche
		Detect 3B: Recherche sommaire d'information en traversée d'intersection
		Detect 3B bis: Recherche sommaire d'information en traversée de chaussée par un piéton
		Detect 3C: Recherche d'information précipitée
	Detect 4 Interruption momentanée dans l'acquisition de l'information	**Detect 4A**: Non détection de l'approche d'un véhicule qui arrive en face
		Detect 4B: Non détection d'une intersection non prioritaire
		Detect 4C: Non détection d'un véhicule interférent en intersection non prioritaire
	Detect 5 Néglige le besoin de rechercher l'information	**Detect 5A**: Détection tardive du ralentissement du véhicule de devant
		Detect 5B: Détection tardive de l'engagement d'un usager non prioritaire en intersection, ou piéton sur passage protégé
		Detect 5B bis: Non détection de l'arrivée d'un véhicule non prioritaire par un piéton ou un vélo en traversée
		-Detect 5C: Non détection de l'arrivée sur une intersection non prioritaire
		Detect 5C bis: Non détection à l'arrivée d'un péage malgré la signalisation

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Mauvaise évaluation d'une difficulté ponctuelle relative à l'infrastructure</td><td>Diag 1A: Sous-évaluation de la difficulté d'un virage non connu</td></tr>
<tr><td>Diag 1B: Sous-évaluation de la difficulté d'un virage pourtant connu</td></tr>
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<tr><td rowspan="3">Diag 2
Mauvaise évaluation d'un créneau d'insertion par rapport au trafic</td><td>Diag 2A: Mauvaise évaluation d’un créneau liée à la précipitation de la manœuvre</td></tr>
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<tr><td>Prog 1B: Attente erronée du non démarrage d'un véhicule non prioritaire arrêté en bordure de chaussée</td></tr>
<tr><td>Prog 1B bis: Attente erronée de la non traversée d'un piéton arrêté en bordure de chaussée</td></tr>
<tr><td>Prog 1C: Attente erronée du non engagement d'un autre conducteur manifestant une intention de dépasser</td></tr>
<tr><td>Prog 1C bis: Attente erronée du non engagement d'un autre conducteur ne manifestant pas une intention de dépasser</td></tr>
<tr><td rowspan="6">Prog 2
Attente active d'une régulation par autrui</td><td>Prog 2A: Attente erronée d'une correction de trajectoire d'un véhicule circulant sur l'axe</td></tr>
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<tr><td>Prog 2D: S’attend à ce que le véhicule interférent ne s’arrête pas et continue sa route</td></tr>
<tr><td>Prog 2E: S’attend à ce que le véhicule interférent redémarre</td></tr>
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<tr><td rowspan="2">Prog 3
Attente d'absence d'obstacle sur sa voie</td><td>Prog 3A: Ne s’attend pas à la présence d’un véhicule arrivant en face dans un virage sans visibilité</td></tr>
<tr><td>Prog 3B: Ne s’attend pas à une interférence sur sa voie</td></tr>
</table>

Défaillance	Type de défaillance	Scénario découlant de la défaillance
Problème de Décision	**Dec 1** Violation contrainte par les caractéristiques de la situation	**Dec 1A**: Conducteur contraint de s'avancer pour prendre de l'information
		Dec 1B: Conducteur contraint d'effectuer une traversée d'intersection en un seul temps
		Dec 1C: Conducteur contraint de se déporter sur la voie affectée à la circulation inverse
		Dec 1D: Conducteur contraint de dépasser sur la voie d'autrui
	Dec 2 Violation intentionnelle d'une règle de sécurité	**Dec 2A**: Dépassement en situation conflictuelle
		Dec 2B: Dépassement sur une zone à visibilité axiale limitée
		Dec 2C: Traversée d'intersection "dans la foulée"
		Dec 2D: Engagement d'un changement de direction "dans la foulée"
		Dec 2E: Prise de risque délibéré et comportement aberrant (sans usage de psychotrope)
		Dec 2F: Traversée des deux voies de circulation hors intersection
		Dec 2G: Conduite sans éclairage
	Dec 3 Violation - Erreur	**Dec 3A**: Engagement inopiné d'une manœuvre de bifurcation
		Dec 3B: Engagement d'une traversée d'intersection par effet d'entraînement
		Dec 3C: Engagement d'une manœuvre de dépassement par effet d'entraînement

Problème d'Exécution	**Exec 1** Mauvaise contrôlabilité du véhicule face à une perturbation externe	**Exec 1A** : Rencontre soudaine d'une perturbation
		Exec 1B : Rencontre d'une perturbation externe plus ou moins prévisible
	Exec 2 Défaut de guidage	**Exec 2A** : Interruption du guidage suite au détournement de l'attention vers une tâche annexe
		Exec 2B : Interruption du guidage suite à une démobilisation de l'attention
		Exec 2C : Mauvaise manipulation des organes de commande du véhicule
		Exec 2D : Défaut de guidage du véhicule causé par de trop fortes contraintes dynamiques

Défaillance générale	**Over 1** Perte des capacités psychophysiologiques	**Over 1A**: Perte des capacités psychophysiologiques à la suite d'un endormissement
		Over 1A bis: Perte des capacités psychophysiologiques à la suite d'un malaise
	Over 2 Altération des capacités sensori-motrices et cognitives	**Over 2A**: Altération des capacités de négociation de trajectoire
		Over 2B: Altération des capacités de guidage
		Over 2C: Réalisation d'une manœuvre aberrante
		Over 2D: Prise de risque et comportements aberrants en raison d'une forte absorption de psychotropes
	Over 3 Dépassement des capacités cognitives	**Over 3A**: Dépassement des capacités de traitement en situation d'interaction avec le trafic
		Over 3B: Réalisation de manœuvres aberrantes
		Over 3C: Stratégie de conduite inadaptée

Degré d'implication de l'usager

Codification relative au rôle de l'usager dans la survenue de l'accident.

Cette fiche permet la codification de l'étape 6

CODE	Signification	Description
PC	Actif primaire	L'usager est le provocateur de la perturbation pour lui ou pour les autres. Implication déterminante dans la genèse de l'accident. On peut identifier 2 actifs primaires dans un même accident (une manœuvre conduisant à une trajectoire de collision entraînant une réaction conduisant à une perte de contrôle).
SC	Actif secondaire	L'usager n'est pas à l'origine de la perturbation mais fait partie prenante de la genèse de l'accident. Participe à la non résolution du problème par une mauvaise anticipation de l'évolution des évènements (absence d'adaptation comportementale, attente d'une régulation par autrui).
NC	Non actif	L'usager confronté à une manœuvre atypique, légale ou pas de l'autre usager et difficilement prévisible. Aucun élément explicatif endogène. N'est pas actif car les données dont il disposait ne lui permettait pas de prévenir la défaillance de l'autre. Evitement théorique possible de l'accident (gêne à la visibilité).
OP	Passif	L'usager n'est pas impliqué dans la déstabilisation de la situation, tout en étant présent. Aucune mesure bénéfique a priori (conducteur arrêté au feu rouge percuté à l'arrière).

Défaillance intervenue en situation d'urgence

Codification relative à la manœuvre d'urgence entreprise ou pas par l'usager.

Cette fiche permet la codification de l'étape 7

Code	Description
RET	*La manœuvre d'évitement réalisée par l'usager est la bonne et a été correctement menée mais l'accident se produit à cause de l'autre usager.*
ND	*L'usager n'a détecté ni le danger ni la situation d'urgence.*
D	*La manœuvre choisie par l'usager n'est pas appropriée*
E	*La manœuvre décidée est appropriée (adaptée) mais son exécution n'a pas été correctement menée*
INE	*Les conditions de temps et de distance sont trop courtes pour permettre l'évitement de l'accident.*

Configuration de la collision

Codification relative à la caractérisation de la collision dans laquelle est confronté l'usager.

Cette fiche permet la codification de l'étape 9

	Code	Description
Configuration du choc primaire	PCC.0	Pas de choc primaire
	PCC.1	Frontal
	PCC.2	Latéral
	PCC.3	Arrière
	PCC.4	Tonneau
	PCC.5	Renversement
	PCC.6	Side swipe
	PCC.7	Chute/glissade/projection (piéton + 2 roues)
	PCC.8	Contre véhicule (piéton + 2 roues)
	PCC.9	Non classifiable / Inconnue
Localisation du choc primaire	PCS.F	Devant
	PCS.B	Derrière
	PCS.L	Gauche
	PCS.R	Droite
	PCS.Ro	Toit
	PCS.BO	Corps ou partie du corps (piéton + occupant de 2 roues)
	PCS.U	Non classifiable / Inconnue
Configuration du choc secondaire	SCC.0	Pas de choc secondaire
	SCC.1	Frontal
	SCC.2	Latéral
	SCC.3	Arrière
	SCC.4	Tonneau
	SCC.5	Renversement
	SCC.6	Side swipe
	SCC.7	Non classifiable
	SCC.8	Chute (piéton + 2 roues))
	SCC.9	Contre véhicule (piéton + 2 roues)
	SCC.U	Non classifiable / Inconnue
Localisation du choc primaire	SCS.F	Devant
	SCS.B	Derrière
	SCS.L	Gauche
	SCS.R	Droite
	SCS.Ro	Toit
	SCS.BO	Corps ou partie du corps (piéton + occupant de 2 roues)
	SCS.U	Non classifiable / Inconnue

Facteurs aggravants liés à la collision

Codification relative à la caractérisation des facteurs ayant aggravé les conséquences liées à la collision dans laquelle est confronté l'usager. Cette fiche permet la codification de l'étape 10

Typologie	Code	Facteurs aggravants
Facteurs liés à l'usager	U.1	Taille du conducteur/occupant/piéton
	U.2	Poids du conducteur/occupant/piéton
	U.3	Age du conducteur/occupant/piéton
	U.4	Sexe du conducteur/occupant/piéton
	U.5	Conditions médicales
	U.6	Consommation d'alcool
	U.7	Consommation de drogue
	U.8	Prise de médicaments
	U.9	Fatigue
	U.10	Vitesse
	U.11	Pas de freinage
Facteurs liés au type d'obstacle rencontré lors du premier impact	PC.0	Voiture
	PC.1	Aucune
	PC.2	Monospace
	PC.3	Véhicule utilitaire léger (< 3,5 T)
	PC.4	Véhicule tout-terrain
	PC.5	4x4, SUV
	PC.6	Poids lourds et autre VUL (>3,5 T)
	PC.7	Transport public, bus, autocar
	PC.8	Train
	PC.9	Tracteur agricole
	PC.10	Caravane ou remorque
	PC.11	Engin de chantier (grue, rouleau compresseur,)
	PC.12	Vélo
	PC.13	Deux-roues motorisé
	PC.14	Sol (seulement en cas de tonneau)
	PC.15	Poteau, luminaire, etc.
	PC.16	Arbre
	PC.17	Glissière de sécurité, séparateur béton, etc.
	PC.18	Panneau de signalisation
	PC.19	Fossé
	PC.20	Talus
	PC.21	Barrière, clôture, etc.
	PC.22	Mur, bâtiment, pile de pont, etc.
	PC.23	Muret séparateur
	PC.24	Piéton
	PC.25	Animal
	PC.26	Autre

Typologie	Code	Facteurs aggravants
Facteurs liés au type d'obstacle rencontré lors du second impact	**SC.0**	Voiture
	SC.1	Aucune
	SC.2	Monospace
	SC.3	Véhicule utilitaire léger (< 3,5 T)
	SC.4	Véhicule tout-terrain
	SC.5	4x4, SUV
	SC.6	Poids lourds et autre VUL (>3,5 T)
	SC.7	Transport public, bus, autocar
	SC.8	Train
	SC.9	Tracteur agricole
	SC.10	Caravane ou remorque
	SC.11	Engin de chantier (grue, rouleau compresseur,)
	SC.12	Vélo
	SC.13	Deux-roues motorisé
	SC.14	Sol (seulement en cas de tonneau)
	SC.15	Poteau, luminaire, etc.
	SC.16	Arbre
	SC.17	Glissière de sécurité, séparateur béton, etc.
	SC.18	Panneau de signalisation
	SC.19	Fossé
	SC.20	Talus
	SC.21	Barrière, clôture, etc.
	SC.22	Mur, bâtiment, pile de pont, etc.
	SC.23	Muret séparateur
	SC.24	Piéton
	SC.25	Animal
	SC.26	Autre

Autres Facteurs	**SS.1**	Occupant éjecté
	SS.2	Occupant partiellement éjecté
	SS.3	Occupant pushed forward by thrust of rear occupant or load
	SS.4	Ceinture de sécurité non présente
	SS.5	Ceinture de sécurité non attachée
	SS.6	Passager arrière non ceinturé
	SS.7	Absence de ceinture de sécurité à l'arrière
	SS.8	Système de retenu pour l'enfant non attaché et/ou ancré
	SS.9	Système de retenu pour l'enfant non attaché ou ancré / défaut
	SS.10	Airbag frontal absent ou non déployé
	SS.11	Airbag latéral absent ou non déployé

Les besoins de l'usager

Liste relative à la codification des besoins en amont, pivot et en protection associés aux défaillances analysées. Cette fiche permet la codification des étapes 11 14 20

Besoins lors d'une défaillance d'origine liée au diagnostic interne à l'usager	
Code	**Description**
B01	Etat de l'usager (sans autre précision)
B011	Niveau de vigilance (niveau d'éveil/endormissement, etc.)
B012	Niveau d'attention (position de la tête, du regard, etc.)
B013	Niveau d'alcoolémie
B02	Etat du véhicule (sans autre précision)
B021	état des pneumatiques
B022	état des freins
B023	état de la mécanique (direction, moteur, boite de vitesse, etc.)
B024	évaluation des perturbations sonores (volume radio, passagers, etc.)
B025	évaluation des perturbations visuelles (givre, poussières, etc.)

Besoins lors d'une défaillance d'origine liée à la détection	
Code	**Description**
B03	Détection d'une difficulté inattendue liée à la route
B04	Détection d'un obstacle fixe sur la route
B05	Détection d'un obstacle se déplaçant lentement sur la route
B06	Détection d'un usager se déplaçant dans sa voie de circulation
B07	Détection d'un usager/animal qui traverse
B08	Détection d'un usager se trouvant hors du champ de vision (derrière, sur le côté, angle mort, etc.)
B09	Détection d'un usager masqué
B10	Détection d'une sortie de voie (écart de trajectoire)

Besoins lors d'une défaillance d'origine liée au diagnostic	
Code	**Description**
B11	Adaptation de la vitesse par rapport aux conditions environnementales
B12	Adaptation de la vitesse par rapport à la réglementation
B13	Evaluation de la vitesse d'approche sur un usager ralentissant
B14	Evaluation d'une probabilité de collision avec un autre usager
B15	Evaluation de la possibilité d'effectuer un dépassement ou un changement de voie
B16	Evaluation de la possibilité pour traverser ou s'insérer dans le trafic

Besoins lors d'une défaillance d'origine liée au pronostic	
Code	**Description**
B17	Prévision du démarrage ou d'un non arrêt de l'autre usager
B18	Prévision du ralentissement ou de l'arrêt de l'autre usager
B19	Prévision de la manœuvre de l'autre usager
B20	Prévision de la manœuvre à effectuer relative au fonctionnement du site

Besoins lors d'une défaillance d'origine liée au contrôle du véhicule	
Code	**Description**
B21	Contrôle du véhicule

Besoins lors d'une défaillance d'origine liée à la communication	
Code	**Description**
B22	Besoin de montrer sa présence / son intention

Besoins en protection	
Code	**Description**
B30	Besoin en protection des occupants / piéton (Pour un MAIS ≥ 3)

Les besoins en correction

Liste relative à la codification des besoins en correction associés aux défaillances analysées.

Cette fiche permet la codification de l'étape 17

Code	Description
NE.1	Besoin en aide au contrôle de trajectoire
NE.2	Besoin en freinage /régulation du freinage
NE.3	Besoin au niveau de l'infra structure
NE.4	Besoin en aide à la décision / à la prise de décision
NE.5	Besoin en diagnostic de situation d'urgence

Les limitations

Liste relative aux limitations pouvant perturber voire rendre inefficace le fonctionnement du système de sécurité. Cette fiche permet la codification des étapes 13 16 19 22

Limitations endogènes à l'usager pouvant entrainer un rejet intentionnel de l'aide	
AL 1	Rejet ou déconnexion (priorité à la motivation du déplacement)
AL 2	Rejet ou déconnexion (priorité à la vitesse de déplacement)
AL 3	Rejet ou déconnexion (Fatigue)
AL 4	Rejet ou déconnexion (Signes de faiblesse détectés)
AL 5	Rejet ou déconnexion (Attente d'une régulation par l'autre)
AL 6	Rejet ou déconnexion (Sentiment prioritaire)
AL 7	Rejet ou déconnexion (trajet habituel)
AL 8	Rejet ou déconnexion (violation intentionnelle)
AL 9	S'oppose à l'action du conducteur
AL 10	Rejet (autre)
Problèmes associés à un état psychophysiologique	
AL11	Hypovigilance (fatigue)
AL12	Hypovigilance (somnolence)
AL13	Hypovigilance (endormissement)
AL14	Faiblesse
AL15	Sous influence de drogue
AL16	Sous influence de l'alcool
AL17	Alcoolisme chronique
Problèmes attentionnels	
AL18	Inattention
AL19	Distraction "passive"
AL20	Distraction "active"
AL21	Attention portée sur la priorité
AL22	Attention portée sur un danger potentiel
AL23	Excède les capacités cognitives (novice)
AL24	Excède les capacités cognitives (personne âgées)
AL25	Bouleversé, stressé
Problèmes associés à l'attente d'une action par l'autre	
AL26	S'attend à l'absence d'interaction: décélération du véhicule devant
AL27	S'attend à l'absence d'interaction (autre)
AL28	Effet d'entrainement (par exemple lorsqu'un conducteur est inséré dans un flow de véhicules)
AL29	Mauvaise ou non visibilité d'un piéton
AL30	Mauvaise ou non visibilité d'un deux roues motorisé
AL31	Mauvaise ou non visibilité d'un cycliste
AL32	Négligence de l'information (inconscient du danger)
AL33	Négligence de l'information (mauvaise interprétation du signal)
Problèmes liés à l'exécution d'une action	
AL34	Manœuvre restreinte (par exemple par manque de place)
AL35	Vitesse excessive involontaire
AL36	Réaction très lente
AL37	Réaction incontrôlée due à l'effet de surprise

AL38	Figé (entrainant une absence de réaction)

Limitations exogènes à l'usager pouvant rendre l'aide inefficace	
AL39	Faible adhérence (gravier)
AL40	Faible adhérence (pellicule d'eau)
AL41	Faible adhérence (huile, corps gras)
AL42	Faible adhérence (glace, givre, gel)
AL43	Forte sollicitations dynamique (perte de contrôle)
AL44	Forte sollicitations dynamique (chargement)
AL45	Forte sollicitations dynamique (vitesse)
AL46	Angle de détection du système insuffisant (en intersection)
AL47	Angle de détection du système insuffisant (multitudes de voies)
AL48	Angle de détection du système insuffisant (voie opposée)
AL49	Distance de détection insuffisante du système
AL50	Visibilité limitée (problème de contraste)
AL51	Visibilité limitée par un autre véhicule (masque mobile)
AL52	Visibilité limitée par l'infrastructure (exemple rond-point)
AL53	Visibilité limitée par l'environnement (masque végétal, herbes, etc.)
AL54	Visibilité limitée par l'environnement (en courbe)
AL55	Visibilité limitée par l'environnement (maison, bâti, etc.)
AL56	Luminosité (la nuit)
AL57	Luminosité (faible, aube, crépuscule, temps orageux, etc.)
AL58	Luminosité (lumière aveuglante, rasante, etc.)
AL59	Défaut d'éclairage de la zone
AL60	Défaut lié à la route (impraticable ou absence d'accotement)
AL61	Défaut lié à la route (signalisation)
AL62	Défaut lié à la route (intersection atypique)
AL63	Défaut lié à la route (autre)
AL64	Conditions météorologiques (pluie)
AL65	Conditions météorologiques (neige)
AL66	Conditions météorologiques (brouillard, fumée, etc.)
AL67	Conditions météorologiques (vent)
AL68	Type d'intersection (rond-point)
AL69	Type d'intersection (voie privée)
AL70	Type d'intersection (parking)
AL71	Type d'intersection (avec voie de stockage centrale)
AL72	Vitesse réglementaire non appropriée (en courbe)
AL73	Vitesse réglementaire non appropriée (en intersection en ville)
AL74	Vitesse réglementaire non appropriée (en intersection en rase campagne)
AL75	Obstacle fixe sur la route
AL76	Obstacle fixe sur la route (péage, etc.)
AL77	Obstacle fixe sur la route (véhicule non visible)

Limitations exogènes à l'usager pouvant rendre l'aide inefficace (suite)	
AL78	Temps et/ou distance trop courte
AL79	Conditions de faible adhérence non détectable par l'aide (ex. huile)
AL80	Intensité de l'alarme insuffisante
AL81	Type d'alerte non appropriée
AL82	Mauvaise localisation de la source
AL83	Trafic à contresens
AL84	Problème lié au pneumatique (sous gonflé)
AL85	Piéton hors passage protégé
AL86	Au-delà du seuil de détection de l'assistance (ex trop faible vitesse)
AL87	Au-delà du seuil de détection de l'assistance (taux d'alcoolémie)
AL88	Au-delà du seuil de détection de l'assistance (freinage tardif)
AL89	Trafic dense (en ville)
AL90	Durée de la distraction
Limitations pour la collision	
AL 91	Mauvais côté par rapport à l'impact
AL 92	Occupant éjecté
AL 93	Occupant non ceinturé
AL 94	Pas de freinage
AL 95	Vitesse
AL 96	Taille du piéton

Degré de limitation

Liste relative aux différents niveaux de limitations pouvant perturber voire rendre inefficace le fonctionnement du système de sécurité.

Cette fiche permet la codification des étapes 13 16 19 22

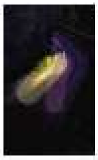
Niveau d'efficacité	Commentaires
Niveau 1 **Pas de limitation**	Lorsque nous ne mettons pas en évidence de limitations à l'aide répondant au besoin.
Niveau 2 **Efficacité modérée ou réduite**	Lorsque des facteurs limitant sont identifiés mais dont leur impact n'est que supposé que mineur sur l'efficacité de l'aide.
Niveau 3 **Inefficace**	Lorsque l'aide répond au besoin identifié mais que les facteurs limitant et le contexte de l'accident n'auraient probablement pas permis à l'aide de répondre au besoin.

Annexe 2
Les systèmes de sécurité pour le véhicule

Advanced Adaptive Front Light System (AAFLS)

SYSTEM STUDIED:

AAFLS - Advanced Adaptive Front Light System
(examined by LOUGH)



Aims of the system

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)
Other technologies closely associated with AAFLS are Cornering light assist and Auto high beam assist

An example of an overall advanced lighting package is described by Mercedes.....

The standard-fit Intelligent Light System brings three key technologies to the S-Class safety repertoire. Adaptive High Beam Assist helps prevent other road users being dazzled by your high beam, automatically dimming it when it detects vehicles ahead. The Active Light System continuously adjusts the range of your low-beam headlamps to suit the driving situation. And the Cornering Light Function significantly increases your field of vision around bends.

http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/passengercars/home/new_cars/models/s-class/w221/overview/driving_safety.html

Functions covered by the system (intentional and unintentional)

Improved vision in darkness and poor visibility (weather conditions) when manoeuvring through bends
Cornering Light Assist illuminates to wider than traditional angle when turning corners (especially at junctions). Can be extra light or extension of AAFLS system (lamps swivel)
Auto High Beam is a feature that takes over the switching of high beam lights away from the driver to improve vision and to avoid dazzling oncoming drivers

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Acting to improve vision in darkness and poor visibility Improved vision reduces driver load
Rupture Phase	Earlier illumination of objects and increased possibly of avoidance
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Note: Improved vision may increase driver's confidence and speed, see note under evaluations below*

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		Improved vision when manoeuvring around bends or turning corners in darkness or poor visibility
Mutual Control	Warning Mode	-
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		(If Auto High Beam is available it automates the switching of high bean headlights)

AAFLS (suite)

Technical specifications

Active Light Function - Mercedes
Part of the optional bi-xenon headlamp system. It makes night-time driving on winding routes even safer by increasing road illumination by as much as 90% compared with conventional headlamps. The illuminated area when driving into a bend with 190 m radius (in relation to the centre lane marking) was previously 30 metres. The active light function, which follows the turning movements of
http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/passengercars/home/passenger_cars_world/innovation_new/new_technology.html#active_light/details

Mercedes report reduction of driver stress with Intelligent Light System of up to 20% - ref: New E Class 2009 marketing brochure printed

Mercedes System Modes
Motorway Mode: From a road speed of 90 km/h the new motorway mode is automatically switched on in two stages: in stage one the output of the xenon lamps is increased from 35 to 38 watts, and in stage two the range of the nearside headlamp is increased when a speed of 110 km/h is reached. The result is a uniform cone of light which illuminates the entire road width to a range of up to 120 metres. At the centre of this cone the driver is able to see around 50 metres further than with conventional low beams, which allows him to recognise vehicles, even at very long distances, and adapt his driving style accordingly.
Enhanced fog light mode: If visibility becomes less than 50 metres, the vehicle speed falls below 70 km/h and the driver switches on the rear fog lamp, the left bi-xenon headlamp of the E-Class swivels outwards by eight degrees and, at the same time, lowers the cone of light. This illuminates the nearside of the road more efficiently, while the wider beam reduces backglare in fog. The enhanced fog lamps remain switched on up to a speed of 100 km/h.
2006 article: The swivel angle of the headlamps has been increased from 12 to 15 degrees
http://www.worldcarfans.com/10602087820/mercedes-intelligent-light-system#ixzz10fEdoE7f

Static Cornering Lights - Ford Mondeo
Integrated into the halogen Adaptive Front lighting System (AFS) and bi-xenon HID headlights, static cornering lights are activated when you turn the steering wheel 30°- turned on when the car is travelling below 37mph.
http://www.ford.co.uk/Cars/Mondeo/Technology

Halogen Adaptive Front lighting System (AFS) ford Mondeo
With AFS, the headlights swivel to the left or right by up to 15° according to your speed and the angle of the steering wheel. So, as you turn the wheel, the dipped lights swivel to illuminate the road as you turn the corner. This boosts forward visibility through bends and creates a safer driving environment. (standard on Titanium X).
In comparative tests between conventional halogen reflector lamps and AFS, the AFS lamps cast light an additional 10 metres into the bend
http://www.ford.co.uk/Cars/Mondeo/Technology
http://www.gizmag.com/go/8227/

High Beam Assist BMW

High-Beam Assistant automatically takes care of switching between high and low beam when you're driving your BMW at night. The camera installed close to your rear-view mirror monitors the traffic situation and reacts immediately to potential light sources at distances of up to 1,000 metres. When the High-Beam Assistant is activated and recognises an approaching vehicle or the rear lights of the vehicle
http://www.bmw.com/com/en/insights/technology/connecteddrive/2010/safety/vision_assistance/autobeam.html#more

Mercedes
http://www.emercedesbenz.com/Sep08/25_001417_Mercedes_Benz_Introduces_New_Adaptive_High_Beam_Assistant.html

Cornering Light Function Mercedes - ref 2006
Cornering light function, in which one of the two fog lamps is automatically switched on when the driver operates an indicator or turns the steering wheel. As a result, the range of side visibility ahead of the vehicle is increased by around 30 metres. The cornering light function is activated up to a speed of 40 km/h.

Dynamic cornering lights - VW
Our Bi-Xenon headlights with dynamic cornering light give up to 90% better illumination of corners as the headlight beam will swivel to follow the angle of your steering wheel
The steering movement of the headlight units, which include small servomotors, is controlled by signals from the steering angle sensor, among other things. The maximum swivel angle of the cornering lights is 15 degrees. This gives you early warning of any hazards and some vital extra time to react.
http://www.volkswagen.co.uk/technology/visibility-and-security/light-systems

Skoda Superb AFS system modes
Interurban – default headlight position for speeds between 0 – 9 mph and 31 – 55 mph.
Urban – light beam shortens and widens for better illumination of pavements and junctions in built-up areas; active between 9 – 30 mph.
Motorway – light beam gradually lengthens and narrows as vehicle speed increases to improve distant vision; light beam lights the lane to the right of the car to facilitate overtaking; active above 56 mph.
Cornering lights – headlight geometry changes and light beam illuminates the curve of the road depending on vehicle speed and steering wheel angle (active from 6 mph); activated by indicators, the fog light strengthens and fades during tight cornering, increasing visibility and highlighting hazards and obstacles in the road.

Rain function – headlight modules rotate down and light beam shortens to limit the glare from the road; activated by windscreen wipers (after two minutes) at speeds between 0 - 43 mph.
Tourist function – using the maxi-dot computer, driver can switch between right hand drive and light hand drive headlamp angle when abroad.
http://www.carpages.co.uk/skoda/skoda-superb-07-11-08.asp

I-AFS - Lexus
When entering a corner, I-AFS technology estimates where the RX will be in 3 seconds time - based on vehicle speed and tyre angle - and adjusts the lateral aim of the headlights accordingly. Adjusting both low and high beams, this delivers the most appropriate light distribution patterns.
http://www.lexus.eu/range/rx/key-features/safety/safety-intelligent-adaptive-front-lighting-system.aspx

Further Functionality - pedestrian illumination
Mercedes have a system that combines with the night vision package to identify pedestrians at night and, after checking that on-coming vehicles won't be dazzled, turns the high beam headlights to illuminate the pedestrian further.
further information on Night Vision (NV) tab and at...
http://www.emercedesbenz.com/autos/mercedes-benz/corporate-news/mercedes-active-view-night-assist-receives-new-safety-feature/
http://www.autocar.co.uk/News/NewsArticle/AllCars/254492/

Motorcycles
AAFLS is a challenge for motorcycles as the motorcycle also banks around the curve - therefore an extra electric motor is required to keep the light flat
http://www.yamaha-motor.co.jp/global/news/2000/11/15/asv2-02.html

Previous evaluations
Are there any evaluation been realized ? If yes, provide a link

TRACE D4.3 - Estimated effectiveness for serious injuries saved 0.6%
http://www.trace-project.org/trace_template.html

eIMPACT D2 - Adaptive headlights (plus similar technologies) seemed to be ranked quite well after a workshop consultation but were not chosen in the set of 12 technologies to be studied
http://www.eimpact.info/results.html

eSafety Support website provides a list of effectiveness studies and summary results for Adaptive head lights in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_02.html
"It is noted that the summaries of results indicate a possible risk compensation effect - possible higher driving speeds with better visibility

AAFLS (suite)

AAFLS not included in COWI report
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

Note: These systems are often optional on cars (Standard on S Class Mercedes) and it is clear that they include advanced technologies in terms of the actual light source (for example, bi-xenon systems) compared to more traditional halogen bulbs. This could be taken into account in any evaluation.
The Medical University of Hanover studied a small number of in-depth cases and found that 'Xenon light can avoid 16% of all night time accidents with injuries or fatalities involved' - the study was supported by Clepa LightSightSafety consortium of automotive lighting companies.
http://esafetychallenge.odeum.com/en/esafety_challenge/news_events/news/xenon_light_study.htm

Future Development

Development of 3D map-based headlight system
http://www.traffictechnologytoday.com/news.php?NewsID=19144

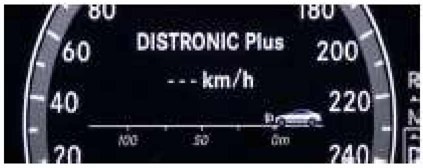
Adaptive Cruise Control (ACC)

SYSTEM STUDIED:

ACC - Adaptive Cruise Control
(examined by NTUA, some additions LOUGH)

Aims of the system

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. 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.



Functions covered by the system (intentional and unintentional)

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

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:
1. The Driving Phase, during this phase no unexpected event or hazard has occurred or been detected.
2. The Rupture Phase, an unexpected event or hazard occurred which surprised the road user.
3. The Emergency Phase is defined as the distance and time between the rupture phase and collision.
4. The Crash Phase, when the impact is taking place.
5. The Rescue Phase is the period after the collision during which the passengers are being evacuated from the vehicle.

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 only intervenes if the current preselected speed or headway would lead to a likely collision
Crash Phase	If a collision is inevitable the system may have been able to decrease speed and lower crash severity
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		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 only 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		-

ACC (suite)

Technical specifications

Two years ago Subaru began fitting a stereoscopic "EyeSight" system to some Japanese market cars. By using two cameras, one each side of the rear view mirror, the system can judge distances and hence assist the driver with a number of driving functions, such as all-speed range adaptive cruise control, pre-collision braking management and lane departure warning. Recent developments with its 3D image processing engine mean that the system has become far more adept at recognizing pedestrians, cyclists and other road users.

Fuji Heavy Industries has announced a "New EyeSight", the latest iteration of Subaru's stereo camera driving assist system. Based on the EyeSight system introduced in Japan in May 2008, the safety device was upgraded with new features to improve driving assist functions, automatic braking management system and user-friendliness. The new system has an advanced, safer "Pre-Collision Braking Control" feature that stops the vehicle if it detects the risk of frontal collision, thereby avoiding the collision or reducing collision damage. The "All-speed range adaptive cruise control system" is claimed to significantly reduce risk at all speeds, particularly in slow or congested traffic.

There are several major enhancements in the new EyeSight system. When one car gets close to another one in front (or cyclist, pedestrian etc), the Pre-Collision Braking Control sets off an alarm to warn the driver of a potential hazard. If the speed difference between that vehicle and the vehicle in front is below 30 km/h, and the driver is not slowing, it automatically slows the car. If the speed difference between that car and the one in front is more than 30km/h, the system will automatically reduce the vehicle's speed. The all-speed Adaptive Cruise control enables the driver to cruise safely on the freeway by monitoring and adjusting speed to maintain a safe distance to the vehicle in front.

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 Once the drivers become reliant upon automotive safety systems actively managing your driving, the potential for expensive accident repair, injury and worse will be dependent on factors that are beyond the drivers' control

http://www.gizmag.com/subaru-new-eyesight-stereoscopic-vision-system/14879/

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

Mercedes-Benz, Distronic Plus system

From motorway driving to stop-and-go traffic, the CL-Class can now be equipped with the optional Distronic Plus system. Available as part of the Driving Assistance Package which also includes Active Blind Spot Assist and Active Lane-Keeping Assist the package offers drivers a more relaxed driving experience.

The DISTRONIC PLUS proximity control system keeps the vehicle at a previously chosen distance from the vehicle travelling in front and, if necessary brakes the vehicle to a complete standstill, depending on the traffic situation. If the distance to the preceding vehicle narrows down too rapidly, the system warns the driver and calculates the required brake pressure, which is then provided instantaneously by the Brake Assist PLUS system as soon as the brake pedal is depressed. Should the driver disregard the warning, the PRE-SAFE® Brake system performs an emergency partial braking manoeuvre, significantly reducing the severity of the impact.

Since 2005, Mercedes-Benz has offered these radar-based assistance systems for the S-Class, and since 2006 for the CL luxury coupe. Around 40 percent of all German customers buying new S-Class vehicles equip them with this safety technology; while the proportion of CL-Class outfitted with DISTRONIC PLUS and Brake Assist PLUSis even higher, exceeding 80 percent. Since 2005 Mercedes-Benz has delivered a total of more than 45,000 passenger cars featuring these innovative systems.

The features of Distronic Plus include BAS Plus (Brake Assist) – proven to reduce the occurrence of rear-end collisions, and Pre-Safe Brake which substantially reduces impact and overall risk of accidents. The additional benefits of Advanced Parking Guidance (APG) and Blind Spot Assist further ensure optimum functionality.

http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/passengercars/home/new_cars/models/cl-class/c216/overview/comfort.html
http://www.benzinsider.com/2008/06/distronic-plus-and-brake-assist-plus-reduce-rear-end-collisions-by-20/

Bosch ACC
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrkomfortsysteme/fahrerassistenzsysteme_2/adaptivecruisecontrol_1/adaptivecruisecontrol.asp

Delphi ACC
http://delphi.com/manufacturers/auto/safety/active/adaptive-cruise-control/

Continental ACC
http://www.conti-online.com/generator/www/de/en/continental/automotive/themes/passenger_cars/chassis_safety/adas/acc_en,tabNr=.html

PRAISE
Adaptive cruise control (ACC) enhances classical cruise control and automatically maintains a following distance to the preceding vehicle (Liang et. al, 1999). The distance to the preceding vehicle is measured by radar either with laser radar or millimetre wave radar. When the vehicle ahead is driving more slowly than the adjusted speed the ACC system will control the vehicle speed and follow the lead vehicle at a safe distance. Once the road ahead is clear again, the ACC will accelerate the vehicle back to the previous set cruising speed. Some employers are being encouraged to purchase vehicles with ACC.
Preventing Road Accidents and Injuries for the Safety of Employees, European Transport Safety Council September 2009

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 11%, no figure for fatalities. This is for Advanced Adaptive Cruise Control (involving vehicle to vehicle communication)
http://www.trace-project.org/trace_template.html

eIMPACT Traffic impact results D4 Full Speed Range ACC - FSR - Adaptation of speed and distance to vehicles ahead down to standstill, including Stop and Go.
http://www.eimpact.info/results.html
Full Speed Range ACC (FSR) has the lowest potential impact on fatalities - of the 12 technologies selected. This system targets only a small share of all accidents (but is expected to be quite effective in preventing those).
This a good study of the technology and worth further examination in the actual deliverable
Assumptions for FSR are:
• The system is more effective in dark conditions, as the drivers' estimation of headway is more difficult then.
• The system is more effective in busy traffic.
• Most avoidable accidents are on motorways.
With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:
2010 0
2020 low 27
2020 high 70

eIMPACT Safety impact results D4 Full Speed Range ACC - FSR - Adaptation of speed and distance to vehicles ahead down to standstill, including Stop and Go.
http://www.eimpact.info/results.html

Table 16: The effect of FSR on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given.

FSR	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-1.4	-3.9
Impact low[1]	100 / 100	-0.3	-2.0
Impact high[1]	100 / 100	-3.0	-6.4
Impact 2010 low	0.01 / 0.01	0.0	0.0
Impact 2010 high	0.01 / 0.01	0.0	0.0
Impact 2020 low	4 / 15	-0.2	-0.4
Impact 2020 high	13 / 28	-0.5	-1.1

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.

[2] Fleet vehicle km equipped

The high estimate for the year 2020 would mean 101 avoided fatalities and 9,774 avoided injuries.

eSafety Support website provides a list of effectiveness studies and summary results for Obstacle and collision warning (inc ACC) in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_06.html

Alcolock Key (AK)

SYSTEM STUDIED:

AK - Alcolock Keys
(examined by NTUA, some additions LOUGH)

Aims of the system

Alcohol detectors typically analyse the level of alcohol intoxication of the user, and determine whether the individual is fit to operate the vehicle. Alcohol interlocks are integrated into the ignition of the vehicle, so that the vehicle is immobilised unless the user passes an alcohol detection test.

Functions covered by the system (intentional and unintentional)

Diagnosing driver condition in terms of breath alcohol level

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Driving phase is not possible if alcohol detector does not allow the vehicle to start. Alcohol detectors typically analyse the level of alcohol intoxication of the user
Rupture Phase	* If the alcohol lock has been effective it should be less likely that a driver reaches a rupture stage and if they do they will be better prepared to react to the situation
Emergency Phase	* If the alcohol lock has been effective the driver will be better prepared to react if possible during this phase
Crash Phase	* If the alcohol lock has been effective the driver may have been able to react better to rupture and emergency phases and may have been able to reduce speed and therefore crash severity
Rescue Phase	-

Note for evaluations: Possible for non-drivers with appropriately low alcohol levels to start vehicle on behalf of driver.

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	-
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		Alcolock Keys determine whether the individual has a low enough alcohol level to operate the

AK (suite)

Technical specifications

Volvo announced their latest innovative technology, a device called the "Alcoguard" to help reduce road accidents caused by drink driving. The main objective of the technology is to sober up driver's decisions. According to Ingrid Skogsmo, director of the Volvo Cars Safety Centre, the device will be available in upcoming models of Volvo S80, V70 and XC70 as a optional feature and positive response is expected from the market, especially the public sector vehicles like taxis, state authorities, municipals and private sectors like company vehicles and privately owned vehicles.
Alcoguard utilizes methanol-based fuel cells, which is similar to the law enforcement alcohol test units. Users of Alcoguard will blow into a wireless handheld unit, which will analyze and transmit data back to Alcoguard inside the vehicle. Results will determine the level of alcohol from the driver as:

- Green: 0.0 - 0.1 g/l alcohol, the car's engine starts
- Yellow: 0.1 - 0.2 g/l alcohol, the car will start, but the driver should not drive
- Red: more than 0.2 g/l alcohol, the car's engine will not start.

Different levels of preset limit of the device can be tweaked according to differing country's legislation. Alcoguard will preserve the test results within 30 minutes after the engine has been turned off to prevent shortstop repeat process. Calibration and battery replacement also can be done at the Volvo service centre, which includes removal of the units if owners do not wish to have it anymore. The Alcoguard handheld test unit is powered by wireless connection; as such, a driver do not need to run the test inside the vehicle in a perimeter of 10 meters from the car. Volvo engineers also designed the unit to be able start up in 5 seconds within room temperature as well as supply it with a power adaptor when use in cold weather.

Alcoguard can be by-passed if required in two ways:

1. Bypass is possible in unlimited number of times
2. Bypass is only possible once.

The bypass can be executed at Volvo service workshops and all information will be kept as private and confidential in the car's log. This technology might as well be used in a wider spectrum, helping authorities and insurance companies and perhaps bring down the cost of producing Alcoguard. However, this technology has already been well accepted by Sweden.

Finally, the Swedish government has already presented two goals for alcolocks: installation in all buses and trucks by 2010 at the latest and installation in all new cars by 2012. Thus, there seems to be a good progress with a broad approach towards the prevention of drinking and driving on roads through the use of alcolock devices and alcolock programs.

References

http://www.volvo.com (December 2010)
Bjerre B., 2005, "Primary and secondary prevention of drink driving by the use of alcolock device and program: Swedish experiences", Accident Analysis & Prevention, Volume 37, Issue 6, Pages 1145-1152

No alcolock systems found to be currently implemented on motorcycles.

In the UK the National Express Coach operator (500 vehicles) has fitted alcohol lock - engine is immobilised and text message sent to central incident control room
Actual limit set by company is not given - implied to be lower than the 35 mg in the breath per 100ml set in law
http://www.nationalexpress.com/coach/ourservice/safe_journey.aspx

Previous evaluations

Are there any evaluation been realized ? If yes, provide a link

TRACE D4.3 - Estimated effectiveness for serious injuries saved 3%, for fatalities saved 6%
http://www.trace-project.org/trace_template.html
"*": Results based on non-European data
#: For the Alcolock Key the results for the mode "All newly registered vehicles (First full year)" with effectiveness 25% is used which gives the highest results but it is above the average performance of Alcolock key

eIMPACT Safety Impact results D4 Not selected as one of the 12 studied technologies
http://www.eimpact.info/results.html

eSafety Support website provides a list of effectiveness studies and summary results for Alcohol (inter)lock in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_05.html
The results of the evaluations show a recidivism reduction of about 28-65% in the period where alcolock is installed compared with the control groups who were not using the alcolock.
The results are based on a literature study.
Department of transport, UK, 2004, The effects of breath alcohol ignition interlock devices in cars. Department of transport, UK.
Five of the six studies found interlocks were effective in reducing DWI (driving while intoxicated) recidivism while the interlock was installed in the car. In the five studies demonstrating a significant effect, participants in the interlock programs were 15%–69% less likely than controls to be re-arrested for DWI. The only reported randomized, controlled trial demonstrated a 65% reduction in re-arrests for DWI in the interlock group, compared with the control group.
The results are based on a literature study.
Coben J. H. , Larkin, G. L., 1999, Effectiveness of Ignition Interlock Devices in Reducing Drunk Driving Recidivism. American Journal of Preventive Medicine, Volume 16, Issue 1, Supplement 1 , January 1999, Pages 81-87

PRAISE report - ETSC
Driving whilst under the influence of alcohol contributes annually to at least 10,000 deaths on EU roads. In the EU as a whole around 1% of journeys are associated with an illegal Blood Alcohol Limit (BAC) (ERSO 2006). If the number of alcohol impaired drivers dropped to zero, some 6,800 lives would be saved, representing 16% of road deaths in 2007. Driving under the influence is less common in commercial transport compared to private transport. Yet, alcohol related road crashes in commercial transport tend to result in more serious outcomes due to the vehicle crash incompatibility caused by increased size and mass of commercial vehicles. Besides, the number of people injured in such a crash may be high in case of vehicles operated by public transport companies (Alcohol in Commercial Transport ETSC 2009 A).

Alcohol interlocks (also termed 'alcolocks') are devices that require the driver to take a breath test before starting the car. If the driver fails the test, the device locks the ignition of the car. Commercial use of alcolocks is the voluntary introduction either by public sector authorities or private commercial vehicle operators for a variety of reasons but mainly as a corporate responsibility towards road safety and limiting risk (Alcohol in Commercial Transport ETSC 2009 A). The gradual introduction of alcolocks starting with target groups (commercial drivers and repeat drink driving offenders) could reduce the high toll of drink driving casualties every year in the EU. Crucially in the commercial context alcohol interlocks must not be seen as a stand-alone issue but should be introduced as an integral part of an employer's drink driving policy. Indeed some employers have a zero tolerance to alcohol policy which is also specified in employee contracts. Alcohol interlocks can also be a good preventative tool for deterring drink driving for drivers still affected by alcohol the morning after drinking has taken place.

Preventing Road Accidents and Injuries for the Safety of Employees, European Transport Safety Council September 2009
http://www.etsc.eu/PRAISE-publications.php

Impact
A rough estimate of the effect of alcohol ignition interlocks is given by the eSafety Forum Working Group (2005). Alcolocks are expected to reduce accidents with at least one drunk driver by 18%, provided that the system has been implemented in 70% of the car fleet/vehicle-kilometres. The total reductive potential of alcolocks is 25%. Regarding fatalities, the reductive potential of alcolocks is approx. 18%

According to COWI et al. (2006) 4.700 lives could be saved annually if a reduction in drink-driving (out of a total potential of 7.500, corresponding to 63%) were to occur. Canadian experience shows an effect of a 60% accident and injury reduction. American experience analogously shows that alcohol ignition interlocks can lead to a 40-95% reduction in the rate of drink driving repeat offences.
SWOV (2001, page 30-34) mentions reductive effects of 28-65% on repeated drink-driving. The positive effects are only valid as long as the alcolock is installed. After removal, recidivism rates seem to equal non-user groups. Some studies may indicate more long-term positive effects, however. To maintain the effect after removal, alcolocks have to be supplemented with e.g. rehabilitation programmes aimed at improving driver behaviour and reducing re-offence rates.
Conversely Elvik (2005) has calculated that alcohol ignition interlocks can only reduce total fatalities by 2% in Norway and 1% in Sweden - if used only for convicted offenders.

Cost-benefit assessment
According to COWI et al. (2006) the cost-benefit analysis ratio for Alcolock Keys is 3,1.
In comparison, Elvik (2005) has calculated a benefit/cost-ratio of between 3.0-4.2 for implementation of alcolocks in Norway and Sweden.
This corresponds well with the general calculations for EU-25 in this study. Although no specific information on the calculation basis for Elvik (2005) is available, this apparent consistency probably hides the fact that the expected effect on, and possibly also the share of, drink driver accidents is higher in this study based on general EU accident data, while costs are lower, as only unit costs are included. Furthermore, the applied unit costs for accidents are likely to be lower in this study than in Elvik (2005).

References

COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf
SWOV Institute for Road Safety Research (2001): Alcolock Interlock Implementation in the European Union, feasibility study.
Elvik, R. (2005): What is the cost-effectiveness of traditional road safety measures compared to using new technology?, presentation at the Nordic Conference on Road Safety, June 2005, Copenhagen
eSafety Forum Working Group (2005): Final report and Recommendations of the Implementation Road Map Working Group, Directorate-General Information Society.

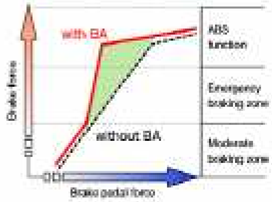
Brake Assist (BA)

SYSTEM STUDIED:

BA Brake Assist

BA is also often referred to as Emergency Brake Assist (EBA)

Brake assist systems have become mandatory for all newly launched car and light commercial vehicle types in the EU. The regulation will apply to all new vehicles from February 24, 2011 as part of a new EU regulation that aims to improve pedestrian safety.
http://www.automotivetestingtechnologyinternational.com/news.php?NewsID=18290



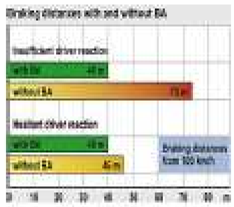
Aims of the system

A brake assist system monitors the driver's use of the brake pedal, automatically sensing an attempt to stop the car as a result of panic. It then generates very high braking power, even when the driver is only pressing lightly on the brake pedal. When this is used together with anti-lock braking systems, it results in faster and safer braking.

Mercedes originally invented the brake assist system in the 1990's.

Their tests showed that although many drivers, especially women, reacted quickly in emergency situations, they did not apply enough pressure to the brake pedal to be completely effective.
Their results also showed that drivers tend to apply the brake with less force in the initial stages of a potentially dangerous situation, and then increase the pressure as they moved further into that situation. The time spent in making the decision to apply the brakes with full force, even if it was only a delay of a split-second, meant that the car was not able to stop as soon as it would have if full pressure had been applied to the brake pedal immediately.
Other studies also made engineers believe that the pulsing experienced when antilock brakes were engaged was mistakenly interpreted as a problem by inexperienced drivers, who then reduced the pressure on the brake pedal too early and inadvertently increased their risk of an accident.
Mercedes theorized that if the car could sense when a driver was applying the brakes in a panic stop situation and automatically go to full force, regardless of how hard the driver pushed the pedal, stopping distances could be greatly reduc

http://www.brakeassist.com/history.html



Functions covered by the system (intentional and unintentional)
Automatically gives full braking when it senses that is the intention of the driver

Hydraulic pressure generator and modulator
Wheel speed sensors
Accelerator velocity sensor
ECU

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Electronic components monitor the speed with which the brake is applied. A small computer keeps track of how you typically apply the brake as you drive the car, both how quickly and how firmly, and learns what your particular pattern is.
Rupture Phase	As it builds up the information, it is able to recognize that driver has applied the brakes much faster than usual
Emergency Phase	Interprets that this is a result of a critical situation and automatically triggers the brake assist system.
Crash Phase	Avoided collision or reduced crash severity and possibly mitigated injuries
Rescue Phase	

Note for evaluation: BA only applicable to accidents in which the driver brakes

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

BA (suite)

		Specifications
Perceptive Mode		
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	
	Mediatised Mode	After sensing that the driver intends full
Automation		

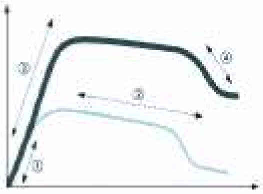
Technical specifications

1: The driver does not press the brake forcefully enough in case of an emergency. Therefore, not enough braking force is generated.

2: Usually, the driver decreased his/her pressure on the brake pedal after "slamming" it initially, causing a further reduction of braking force.

3: When the driver presses the brake pedal more rapidly then normal, brake assist automatically recognizes the situation as emergency braking and increases the braking force.

4: After the emergency brake situation, when the driver releases the brake pedal, the brake assist system reduces the amount of force simultaneously.



http://www.brakeassist.com/diagram.html

Now mandatory on all newly launched car and light commercial vehicle types in the EU.

Example video of BA from Mazda
http://www.youtube.com/watch?v=gpSp1K3WWJ4

Motorcycles
A technology review for motorcycles, including BA (page 35), was carried out in the EC Pisa (Powered Two Wheeler Integrated Safety Systems) - D03 Powered two wheeler Integrated Safety (PISa): Review of PTW safety technologies and literature
http://www.pisa-project.eu/site/en/Deliverables.php
http://www.yamaha-motor.co.jp/global/news/2000/11/15/asv2-03.html

A technology review for motorcycles was carried out by MONASH university, Australia - BA page 35
Intelligent Transport Systems and motorcycle safety, Monash University Accident Research Centre - Report #260 [2006], M. Bayly, M. Regan & S. Hosking
http://www.monash.edu.au/muarc/reports/muarc260.html

Previous evaluations

TRACE D4.3 - Evaluation of brake assist undertaken with already in fleet analysis - Page 29
http://www.trace-project.org/trace_template.html

Safety Configuration	Reduction in injury accidents (accident avoidance)	Reduction in all injuries & fatalities	Reduction in severe injuries and fatalities
Safety benefit of EBA given that the car has four stars.	3.2 %	7.5 %	14.6 %
Safety benefit of ESC given that the car has four stars and an EBA.	5.2 %	10.1 %	16.8%
Safety benefit of ESC given that the car has five stars and an EBA.	3.2%	10.7% (*)	23.4% (*)
Safety benefit of the fifth star given that the car has four stars and an EBA.	6.4 %	6.2 %	N.A.
Safety benefit of the fifth star given that the car has four stars, an EBA and an ESC.	19.3 % (*)	33.8 % (*)	35.1 % (*)
Safety benefit of EBA and ESC given that the car has four stars.	18.6 %	36.3 % (*)	42.2 %
Safety benefit of EBA and a fifth star given that the car has four stars.	26.2 % (*)	36 % (*)	37.5 % (*)
Safety benefit of ESC and a fifth star given that the car has four stars and an EBA.	22 % (*)	38.6 % (*)	37.1 % (*)
Safety benefit EBA, ESC and a fifth star given that the car has four stars.	47.2 % (*)	67.8 % (*)	69.5 % (*)
Safety benefit of a fifth star and removing an ESC given that the car has four stars, an EBA and an ESC.	2.1 %	N.A.	N.A.

* statistically significant

Table 5: A-posteriori evaluation results

eIMPACT D4 - Not selected as technology to study
http://www.eimpact.info/results.html

Some notes on brake assist are given at...
http://ec.europa.eu/transport/road_safety/specialist/knowledge/esave/esafety_measures_unknown_safety_effects/brake_assist.htm

Brake Assist was addressed in the COWI report regarding cost-benefit assessment and prioritisationof vehicle safety technologies
COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf

BA (suite)

It is estimated in this study that EU implementation of brake assistants can save 1,223 lives in 2010 and 1,675 lives in 2020, when all vehicles have the required equipment installed.

Other studies are mentioned...

The German Automobile Industry, VDA (2005), states that investigations with driving simulators have shown that 45% of all collisions with pedestrians, in which the driver applies the brakes, can be avoided with a brake assistant installed.

Fatalities or severe injuries in collisions can be reduced by more than 10% according to VDA(2005).

VDA (2005): Auto safety and Technology. Annual report 2005

If all vehicles are equipped with a brake assistant causing full braking 30 m earlier, the potential for reduction in fatalities in Germany is given at 450, or 7% of the grand total of 6,842 (in 2002). 250 of these can be saved through collision avoidance and 200 through collision mitigation.

Collision avoidance could save a further 3,000 severe and 20,000 slight injuries annually in Germany. This corresponds to approx. 3-5% of the total injuries in Germany in 2002.

Correspondingly, collision mitigation due to brake assistants influences a minimum of 30% of accidents and could save 2,500 severe and 13,000 slight injuries, corresponding to approximately 3% of total injuries according to Bosch

Bosch (2005): Estimated potential for avoiding and mitigating traffic accidents with driver assistance systems and for reducing the economic damage they cause in the Federal Republic of Germany. March 2005.

Bosch (2005): Predictive Safety Systems - From Convenience towards Collision Avoidance and Collision Mitigation. Presentation, ADAS, Nivelles, July 2005.

Trials were carried out at Loughborough University to study driver brake force and reaction

Towards a driver-centred brake assist system

N. GKIKAS, J. H. RICHARDSON, R. HILLN.

Ergonomics & Safety Research Institute, Loughborough University UK

http://hdl.handle.net/2134/5076

A technology review for motorcycles, including BA (page 35), was carried out in the EC Pisa (Powered Two Wheeler Integrated Safety Systems) - D03 Powered two wheeler Integrated Safety (PISa): Review of PTW safety technologies and literature.

http://www.pisa-project.eu/site/en/Deliverables.php

http://www.yamaha-motor.co.jp/global/news/2000/11/15/asv2-03.html

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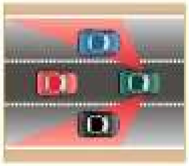
http://www.monash.edu.au/muarc/reports/muarc260.html

Blind Spot Detection (BS)

SYSTEM STUDIED:

BS - Blind Spot Detection
(examined by NTUA, some additions LOUGH)

With manufacturers adopting radar for blind spot monitoring
the overlap between Blind Spot monitoring and Lane Change Assist
is getting larger and they may not need to be seperated in effectiveness evaluations



Mercedes

Aims of the system

The camera based monitoring system keeps watch for other vehicles travelling in the blind spot. When another vehicles enters the monitored zone a warning light is illuminated near the exterior side mirror. Both sides of the vehicle are monitored in the same way. This visual warning gives the driver a clear indication that another vehicle is alongside. The system also alerts the driver both to vehicles approaching from behind and vehicles in front being undertaken.

Can also be radar based.

Audi

Functions covered by the system (intentional and unintentional)

Detecting a user outside the forward field of vision (behind, on the side or in blind spots)
Assessing gaps when merging into or cutting across traffic
Predicting that another user will stop or slow down
Predicting the manoeuvre suited to the layout functioning
Detecting a user outside the frontal field of vision

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

1. The Driving Phase, during this phase no unexpected event or hazard has occurred or been detected.
2. The Rupture Phase, an unexpected event or hazard occurred which surprised the road user.
3. The Emergency Phas

Phases	Evaluation of actions
Driving Phase	A camera based monitoring system, keeps watch for other vehicles travelling in the blind spot
Rupture Phase	When another vehicles enters the monitored zone a warning light is illuminated near the exterior side mirror. On some systems an audible warning is given if the driver activates the indicator when a vehicle is present to the side.
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatio	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		Visual warning if indicator not activated - audible warning if vehicle present and indicator activated
Mutual Control	Warning Mode	-
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

Note: if a collision is predicated the 2011 Mercedes system will brake one side of the car to avoid it

BS (suite)

Technical specifications

The assumptions made in TRACE regarding the blind spot zone are still relevant for camera based systems
We suppose that when another vehicle (car, motorcycle), a bike or a pedestrian enter the blind spot zone - an area of 9.6 meters by 3.0 meters, according to WP6 - a yellow warning light comes on beside the appropriate door mirror in the driver's periphera

Since Blind-spot detection is camera -based, it has the same limitations as the human eye does. This means the system will not function in conditions of poor visibility, for instance in fog or flying snow.

BUT if the system is radar based it should not have the same problems in poor visibility as camera systems can - although Audi state very heavy rain or snow as still being limitations
Also radar based systems are able to detect fast approaching vehicles
The Mercedes system (Blind Spot Assist) is radar based and since late 2010 the new active systems apply the brakes on one side of the car to bring it back onto a straight course if there is a risk of a collision. The driver will still be given warnings as
The active blind spot feature operates at speeds of between 20- and 125mph, although the flashing triangle will be given right up the car's maximum speed of 155mph.
http://www.whatcar.com/car-news/new-safety-systems-for-mercedes-benz/251580

A thorough explanation of the Audi radar based system is given by Audi for EuroNCAP
http://www.euroncap.com/rewards/audi_side_assist.aspx
The Audi system does not give an audible warning when the indicator is activated unlike the Mercedes system. It monitors around 70 metres behind the vehicle

VW system on golf
http://www.volkswagen.co.uk/technology/proximity-sensing/side-assist

Ford system also uses radar
http://www.carsuk.net/ford-s-max-ford-galaxy-2010-get-blind-spot-monitor/

Bosch have an ultrasonic system called side view assist
http://www.automotivepr.com/news_detail.php?Side-View-Assist-the-blind-spot-assistant-Bosch-ultrasonic-sensors-for-safe-lane-changes-Global-debut-in-the-new-Citro-n-C4-622
..capable of registering objects 3 metres to the side and diagonally to the rear of the vehicle. The Side View Assist system can then warn the driver in two ways: first optically, and then, if the driver fails to react, acoustically (if the turn signal i
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrkomfortsysteme/fahrerassistenzsysteme_2/berwachungdestotenwinkels/SideViewAssist.asp

Monitoring for people
EMS manufacturer tbp electronics has delivered the first vehicle blind spot detection system designed to detect the human body (or bio-mass). The PerLex system is designed for use on large goods vehicles and has been developed by PerLex b.v. in associatio

PerLex claims that its Blind Spot Detector System is the first such detector to measure the epsilon of the human body together with its capacitance and can detect a person within 50cm - 100cm of a vehicle. The stand-alone system operates on 24 VDC and com

Once a person positioned in the vehicle's blind spot is detected by a strip sensor, the driver receives one of two signals, either a Warning Signal if a person is detected close to the vehicle or a Distress Signal if the vehicle touches a person.

The Warning Signal consists of an amber light together with an audible warning sound located within the cabin while the Distress Signal consists of a red light with an audible alarm located within the cabin of the vehicle. According to academic research,

http://eetimes.eu/en/blind-spot-detection-system-detects-human-body.html?cmp_id=7&news_id=222902058 (December 2010)

No blind spot systems found to be currently implemented on motorcycles.

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 4%, for fatalities saved 2.5% - Blind Spot Detection
http://www.trace-project.org/trace_template.html

eIMPACT Safety impact results D4 reported under Lane Changing Assist (warning) LCA
http://www.eimpact.info/results.html

eSafety Support website provides a comment on an effectiveness study for trucks
Blind spot detection/Lane change warning was found to have potential to prevent 5.0% of crashes involving large trucks included in the LTCCS database

The estimates are based on real-world crash data collected in Large Truck Crash Causation Study (LTCCS) which was conducted from 2001 to 2003. The LTCCS study conducted on-scene investigations for real-world crashes and produced a database of 1070 acciden

Kingsley, K. J., 2009, Evaluating crash avoidance countermeasures using data from FMCS's/NHTSA's large truck accident causation study. Proceedings of the 21st International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV) - Interna
http://www.esafety-effects-database.org/applications_03.html

Future Development
ABI Research says Blind Spot Detection Systems will be in 25% of new cars by 2016
A new report from industry analysts, ABI Research, says that by 2016 annual Blind Spot Detection (BSD) system installations are forecast by to reach 20 million; just over 25% of the predicted world vehicle market, with a worldwide market value of over US$

"Blind spot detection has struggled for recognition in its early days as a standalone application, perhaps because it has been unfairly classified as a feature for less-competent drivers," commented principal analyst, David Alexander. "But now the feature

BSD can also be linked to lane-keeping systems that can provide steering or individual wheel braking to help the driver stay in lane. By bundling the two systems together as many manufacturers are starting to, drivers get machine vision to help them stay

http://www.traffictechnologytoday.com/news.php?NewsID=28706

Trucks
Commercial vehicles are big and often suffer from very poor visibility, despite being generously equipped with mirrors. Almost invariably, the driver cannot see important areas beside the vehicle. The Blind Spot Detection uses radar sensors mounted at the

Benefits:
Lane changing in the city and on the highway becomes safer
Higher level of safety, due to reliable information on vehicles in the blind spot
Decline in car body and truckload damage

http://www.conti-online.com/generator/www/de/en/continental/automotive/themes/commercial_vehicles/safety/adas/bsd/bsd_en.html

COWI report
The retro fitting of blind spot mirrors to trucks is addressed rather than electronic blind spot monitors aids
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

Collision Avoidance (CA)

SYSTEM STUDIED:

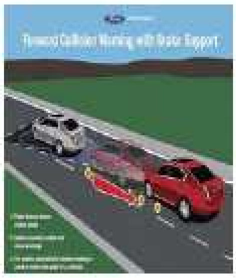
CA - Collision Avoidance
(examined by NTUA, some additions LOUGH)

Although Collision Warning and Avoidance (some braking) operate in different phases of the crash the systems are predominately the same and have been included together here

Also referred to as a AEB - Autonomous Emergency Braking
A description of the different types of AEB systems is given at in the left side panel...
http://www.thatcham.org/adas/index.jsp?page=1181

Aims of the system

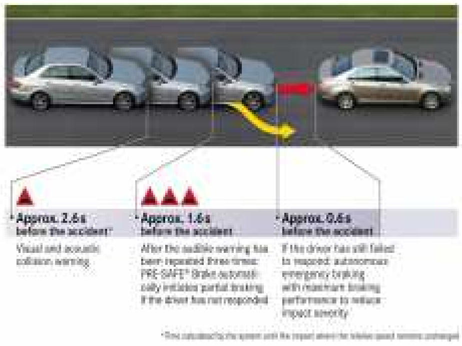
Collision warning incorporating braking
No automated steering control - only braking



With the aid of radar, LIDAR and/or camera systems, this technology actively assesses the driving environment for potential hazards. In particular current systems address rear end collisions but an oncoming vehicle will also activate the system. Specific pedestrian and cyclist aspects are covered in the VRU tab (19)
The systems typically first warn of a potential collision and then most then provide a level of braking support:
1) enhancement of driver's braking
2) partial braking (automatic)
3) full braking (automatic)

The collision is therefore avoided or the crash severity is reduced with the possibility of reduced injury severity. In the warning stages some systems pre-charge the brakes for activation and also activate PreSafe type occupant protection systems (for example reversible pretensioners).

The system is:
useful in bad driving conditions, such as heavy rain or snow as well as at night when visibility is limited.
An alarm will sound to warn the driver progressively louder signals as the vehicle closes in on the hazard.



Assumptions from TRACE...
The assumptions still seem to be reasonable for radar based systems
But the Volvo City Safety and Ford City Stop (Ford Focus) solutions have a much lower distance range as they are LIDAR based and operate at a much lower speed than radar based systems.
As the Ford Focus is such a high selling car, if the option is successful, it may be worth splitting any effectiveness evaluation into two separate technologies.
There is no obvious development of GPS based systems for implementation soon.

Functions covered by the system (intentional and unintentional)

Detecting an obstacle moving slowly
Detecting a user on an intersecting course
Detecting an oncoming user (in movement)
Detecting a fixed obstacle
Predicting that another user will stop or slow down
Estimating a collision course with another user
Evaluating a catching up on a slower road user
Detecting a course deviation
Detecting a road-related difficulty
Pre-charging of brakes
Activation of reversible occupant protection systems

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	System monitors area ahead of vehicle
Rupture Phase	A radar/lidar/camera predicts a collision course with another user or object. Brakes can be pre-charged and PreSafe occupant systems activated
Emergency Phase	The system alerts the driver to avoid the collision. 3 stages of braking then possible (assisting driver, partial automatic, full automatic)
Crash Phase	Crash can either be avoided or injuries mitigated with lower crash severity
Rescue Phase	-

CA (suite)

Level of intervention

Perception	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.		
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.	
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.	
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.	
		ACTION SUGGESTION MODE: It suggests an action to the driver.	
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them	
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.	
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.	
Automatic	The device takes over the control without intervention or intention of the user.		

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	Often visual and audible warning of possible collision
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	Warning is suggesting that the driver should brake
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		System selects the level of braking it will apply

Note for evaluation: Systems can be turned off by the driver

Technical specifications

Volvo - Collision Warning with Full Auto Brake and Pedestrian Detection, the system tracks and anticipates the path of pedestrians and other vehicles, reacting accordingly. According to Volvo, the system can, on its own, completely avoid any collision below 25km/h. At higher speeds, the system will both alert the driver and slow the vehicle, reducing the risk and assisting the driver's reaction time.
http://www.themotorreport.com.au/45127/2010-volvo-s60-to-introduce-collision-avoidance-system, December 2010
This is also covered in the VRU tab (19)

Audi
The full version of the system (Pre-Sense Plus) works in four phases. In the first phase, the system provides warning of impending accident, while the hazard warning lights are activated, the side windows and sunroof are closed and the front seat belts are being tensioned. In the second phase, the warning is followed by light braking, strong enough to win the driver's attention. The third phase initiates autonomous partial braking at a rate of 3 m/s². The fourth phase decelerates the car at 5 m/s² followed by automatic deceleration at full braking power, roughly half a second before projected impact. A second system called (Pre-Sense Rear) is designed to reduce consequences of rear end collisions. Sunroof and windows are being closed, seat belts prepared for impact. The optional memory seats are being moved forward to protect the car occupants. The system uses radar and video sensors and has been introduced in 2010 on the 2011 Audi A8.
http://www.audi.co.uk/new-cars/a8/a8/safety/pre-sense.html
http://www.testdriven.co.uk/the-new-2010-audi-a8/

Ford
Collision Warning with Brake Support on the 2009 Lincoln MKS Ford's Collision Warning with Brake Support was introduced in 2009 on the Lincoln MKS and MKT and the Ford Taurus. This system provides a warning through a Head Up Display that visually resembles brake lamps. If the driver does not react, the system pre-charges the brakes and increases the brake assist sensitivity to maximize driver braking performance.

New Ford Focus - Low Speed Safety System LIDAR based up to 10 metres ahead. This system is designed to assist you in slow moving traffic and at speeds under 20 mph. If its sensors detect the car in front has unexpectedly stopped, the car applies the brakes automatically. Instant reaction time, the instant you need it.
http://www.ford.co.uk/Cars/Focus/Safetyandsecurity Also seems to be referred to as City Stop
http://skiddplayer.com/video/30022/ford-focus-low-speed-safety-sy#

Honda
Honda's Collision Mitigation Brake System (CMBS, although originally introduced with the initials CMS) introduced in 2003 on the Inspire (and later in Honda's child company Acura) uses a radar-based system to monitor the situation ahead and provide automatic braking if the driver does not react to a warning in the instrument cluster and a tightening of the seat belts. The Honda system was the world's first production system to provide automatic braking. The 2003 Honda system also incorporated an "E-Pretensioner" which worked in conjunction with the CMBS system with electric motors on the seat belts. When activated, the CMBS has three warning stages. The first warning stage includes audible and visual warnings to brake. If ignored, the second stage would include the E-Pretensioner tugging on the shoulder portion of the seat belt two to three times as an additional tactile warning to the driver to take action. The third stage, in which the CMBS predicts a collision is unavoidable, includes full seatbelt slack take up by the E-Pretensioner for more effective seat belt protection, and automatic application of the brakes to lessen the severity of the predicted crash. The E-Pretensioner would also work to reduce seatbelt slack whenever the brakes are applied and the brake assist system is activated.

Mercedec-Benz

Pre-Safe Brake, Mercedes-Benz's first forward warning collision system was introduced in the fall of 2005 on the redesigned 2006 S-Class is co-operating with simultaneously introduced Brake Assist Plus and Distronic Plus systems and provides all the functions of previous Pre-Safe system while adding a radar-based system which monitors the traffic situation ahead and provides automatic partial braking (40% or up to 0.4g deceleration) if the driver does not react to the Brake Assist Plus warnings from the cockpit and the system detects a severe danger of an accident. In 2009 Mercedes unveiled Attention Assist on the 2010 E-class which based on 70 parameters attempts to detect the driver's level of drowsiness based on the driver's driving style. This system does not actually monitor the driver's eyes. Also in 2009 Mercedes added the first fully autonomous braking feature that provides maximum braking force approximately 0.6 seconds before impact.

CA (suite)

Volvo

Volvo Cars achieves to address the problem of rear-end collisions by introducing Collision Warning with Auto Brake - a refined warning system that makes the car brake by itself if the driver doesn't act when a rear-end collision with a moving or stationary vehicle is imminent. The new system was available in the Volvo S80, V70 and XC70 at the end of 2007. Rear impacts represent a third of all reported accidents - and in more than 50 percent of these accidents, the driver doesn't brake at all. The new Collision Warning with Auto Brake (CWAB) initially warns the driver and pre-charges the brakes. The brakes are automatically activated if the driver doesn't act when a rear-end collision with a moving or stationary vehicle is imminent. Collision Warning with Auto Brake has an elevated technology level compared to the Collision Warning with Brake Support that was introduced in 2006. Combining radar and camera, while the original system, introduced in the Volvo S80, is radar-based, Collision Warning with Auto Brake uses both radar and a camera to detect vehicles in front of the car. The long-range radar reaches 150 metres in front of the car while the camera range is 55 metres. By using Data Fusion to combine information from the radar and the camera, the system becomes more efficient, as it gives a higher confidence level that automatic braking is possible if a coll

VW - good example of overlap with ACC

Front Assist on the 2011 Volkswagen Touareg can brake to a stop in case of an emergency and tension the seatbelts as a precautionary measure

Front Assist is based on the ordinary cruise control system. If the car in front is moving more slowly, your selected speed is reduced to match. This is achieved by automatic application of the brakes and intervention to control your car's acceleration. By selecting different time gaps, you can adjust the distance maintained. Apart from its function in Front Assist, the radar system also detects situations where the distance to the car in front is critical and helps to reduce your car's stopping distance when needed. The system also warns you of a dangerous situation with visual and sound signals and with a braking jolt.

http://www.volkswagen.co.uk/technology/glossary/front-assist-ambient-traffic-monitoring

The summaries above are from

http://en.wikipedia.org/wiki/Precrash_system

checked against manufacturers websites.

Particularly detailed descriptions of Mercedes, Honda and Volvo City Safe systems are given for EuroNCAP - Limitation sections are relevant for effectiveness evaluations

Mercedes PreSafe Brake

PRE-SAFE® Brake is an autonomous emergency braking system which additionally uses radar sensors to help identify critical situations. At speeds between 30km/h and 200km/h, a distance some 200m ahead of the car is scanned for radar reflective obstacles. Some two and a half seconds before impact, the driver is warned of a potential danger. If, at that stage, the driver applies the brakes, the car automatically delivers the brake force needed to bring the car to a safe stop (if that is physically possible), regardless of the pressure applied by the driver. However, if the critical situation continues to develop and the driver does not react, the car applies partial braking around one and half seconds before the collision and tensions the seat belts in preparation for the impact. Finally, if PRE-SAFE® Brake determines that a collision cannot be avoided, the car applies maximum braking force to reduce the speed of the impact as much as possible.

Limitations:

PRE-SAFE® Brake can be switched off by the driver. If it switched off, it remains off until it is turned back on again and does not default to 'on' at the beginning of a new journey.

PRE-SAFE® Brake requires a sufficient radar reflectance of objects which the car is approaching. Also, the radar sensor needs a clear 'view' of the road in front and its efficiency is compromised by contamination such as snow, mud or leaves.

http://www.euroncap.com/rewards/mercedes_benz_pre_safe_brake.aspx

Honda - Collision Mitigation Brake System (CMBS)

CMBS is a radar-based autonomous emergency braking system. At speeds above 15km/h, moving and stationary vehicles are detected along a path some 100m ahead of the vehicle. When the system senses that the car is likely to hit one of these obstacles, a three stage process is initiated. In the first, typically around 3 seconds before impact, the driver is alerted by visual and audible warnings. In the second stage, when the system senses that a collision is still likely (typically some 2 seconds before impact), three sharp tugs are given on the seat belt and the car automatically starts to apply some braking. Finally, when a collision is unavoidable, CMBS tightens the front seat occupants' seatbelts (using reversible tensioners different from the pyrotechnic devices used during the collision itself) and applies a high level of braking force. This braking can be supplemented by the driver up to the maximum that the car is capable of.

Limitations:

CMBS is not switched on by default at the start of each journey. CMBS can be switched on and off by the driver by means of a dashboard mounted button. CMBS will remain active as long as the button is in the 'on' position.

Not bicycles. CMBS was one of the first autonomous emergency braking systems to be developed and uses a single radar sensor which, in normal circumstances, will detect all vehicles from a small motorcycle upwards. Bicycles are usually not detected. Conversely, the system may sometimes detect metallic objects which pose no threat. More recently, multiple sensor systems are being applied by industry to overcome such issues. However, Honda has carefully balanced the sensitivity of CMBS to maximise its effectiveness when needed and to minimise irritation to the driver when it is not needed.

http://www.euroncap.com/rewards/honda_collision_mitigation_brake_system.aspx

Volvo City Safety - no warning provided - LIDAR no radar

At vehicle speeds between 3.6km/h and 30km/h, City Safety uses a lidar (Light Detection And Ranging) sensor positioned at the top of the windscreen to monitor an area 10m ahead of the car for vehicles which might present a threat of collision. If a collision is likely, City Safety first pre-charges the brakes and makes the Emergency Brake Assist system more sensitive so that, if the driver should notice the risk, the car is ready to respond more quickly to his braking action. However, if the driver still takes no action and a collision becomes imminent, City Safety independently applies the brakes very hard. If the relative speed between the car and obstacle is less than 15km/h, the car will be able to brake such that the collision is avoided. At higher relative speeds, City Safety will not be able to prevent the collision but will reduce the impact speed.

If the driver intervenes to try to avoid the accident, either by accelerating hard or by steering, City Safety will deactivate.

Limitations:

City Safety is turned on by default at the start of each new journey but can be switched off by the driver. If it switched off, the system defaults on again at the beginning of the next journey.

City Safety functions only between 3.6km/h and 30km/h, so will not assist in accidents at 'highway' speeds. Its lidar can detect vehicles which are at a standstill or which are travelling in the same direction and works at night as well as during the day. However, the sensor is compromised if it is covered by dirt or snow, or in adverse weather conditions such as thick fog or heavy rain. To mitigate this, the sensor is sited in the area which is swept by the windscreen wipers.

http://www.euroncap.com/rewards/volvo_city_safety.aspx

Volvo City Safety video - technical description of activation speeds and distances

http://www.volvocars.com/intl/top/about/corporate/volvo-sustainability/safety/pages/default.aspx

Bosch system description..

http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/apr/predictiveemergencybrakingsystem/vorausschauendesnotbremssystem.asp

Delphi system...

http://delphi.com/manufacturers/auto/safety/active/cms/

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 9.1%, no figure given for fatalities saved - Collision Avoidance

TRACE D4.3 - Estimated effectiveness for serious injuries saved 6.6%, no figure given for fatalities saved - Collision Warning

http://www.trace-project.org/trace_template.html

eIMPACT Traffic Impact results D4 page 60 - Emergency Braking (EBR) Description page 115

http://www.eimpact.info/results.html

For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:

- EBR is more effective in the dark.
- EBR is more effective on motorways and rural roads than on urban roads.
- EBR is very useful in high traffic densities, and therefore more effective during peak hours.

With these assumptions, the indirect effects (avoided congestion costs in M EUR) are:

2010	0
2020 low	21
2020 high	53

CA (suite)

eIMPACT Safety impact results D4 page 72 - Emergency Braking (EBR) Description page 116

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 18). The table also shows the range of estimates for full penetration.

Table 18: The effect of EBR on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given.

EBR	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
impact most probable[1]	100 / 100	-7.0	-7.3
impact low[1]	100 / 100	-3.1	-5.0
impact high[1]	100 / 100	-8.8	-8.8
impact 2010 low	0 / 0	0	0
impact 2010 high	0 / 0	0	0
impact 2020 low	4 / 3	-0.3	-0.5
impact 2020 high	11 / 7	-0.9	-1.3

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.

[2] Fleet vehicle km equipped.

The high estimate for the year 2020 would mean 193 avoided fatalities and 10,325 avoided injuries.

eSafety Support website application database provides a list of effectiveness studies and summary results for Emergency Braking in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_18.html
eSafety Support website application database provides a list of effectiveness studies and summary results for Obstacle and Collision Warning in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_06.html

Bosch have undertaken studies regarding effectiveness of emergency braking systems including AEB
www.sae.org/events/gim/presentations/2010/kayslepper.pdf

ISO 15623:2002 Transport information and control systems – Forward vehicle collision warning systems – Performance requirements and test procedures [15623]
SAE J2400 Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements [J2400]
ISO 21994:2007 Passenger cars – Stopping distance at straight-line braking with
ABS – Open-loop test method [21994]

Motorcycles

The EC Pisa (Powered Two Wheeler Integrated Safety Systems) project examined the possibilities for advanced safety systems for motorcycles and produced a demonstration motorcycle with safe follow and an automatic braking system (using a laser scanner)
http://www.pisa-project.eu/index.php

Impact

The potential of a collision warning system (including some pre-crash, but without emergency braking/crash avoidance functions) has been assessed for Germany by the producer Bosch. The system is expected to save 510 fatalities through collision avoidance and 330 fatalities through collision mitigation. The 840 saved fatalities correspond to 12% of the total fatalities in 2002.
Collision avoidance is furthermore expected to save a total of 9,000 severe and 53,000 slight injuries, corresponding to 10% and 14% of total severe and slight injuries in Germany respectively. In the same way collision mitigation is expected to save 6,000 severe and 30,000 slight injuries, corresponding to 7% and 8% of total injuries respectively.

Trucks

Another producer of collision warning systems for trucks (Eaton Vorad) mentions much higher safety effects, from a 51% reduction in serious accidents to 73% fewer accidents. Specifically one fleet is stated to cut rear end and lane change accidents to nil, while another is said to reduce accidents involving fixed objects (left roadway) to 81%. A 92% reduction of the accident rate is also mentioned.
The system on the Actros truck is part of the ACC called Proximity control
http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/truck/home/new_trucks/showroom_by_model/actros_new/telligent.0005.html

Cost-benefit assessment

As no solid cost estimates are available, the benefit/cost-ratio has been estimated for a range of unit costs. For example, the benefit/cost-ratio was calculated as 6, when the cost of implementing collision warning systems was €200 per vehicle.
The break-even costs (i.e. the cost for which the BCR is 1) is estimated at 1.200€ per vehicle. If actual costs are lower it is cost-effective to install collision warning systems in all new vehicles in EU-25.

References

COWI, ECN, Emst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation
of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf

Simulator trial giving data on acceptance and performance

Forward Collision Warning (FCW) systems can reduce rear-end vehicle collisions However, if the presentation of warnings is perceived as mistimed, trust in the system is diminished and drivers become less likely to respond appropriately. In a simulator investigation, 45 drivers experienced two FCW systems: a non-adaptive and an adaptive FCW that adjusted the timing of its alarms according to each individual driver's reaction time. Whilst all drivers benefited in terms of improved safety from both FCW systems, non-aggressive drivers (low sensation seeking, long followers) did not display a preference to the adaptive FCW over its non-adaptive equivalent. Furthermore, there was little evidence to suggest that the non-aggressive drivers' performance differed with either system. Benefits of the adaptive system were demonstrated for aggressive drivers (high sensation seeking, short followers). Even though both systems reduced their likelihood of a crash to a similar extent, the aggressive drivers rated each FCW more poorly than their non-aggressive contemporaries. However, this group, with their greater risk of involvement in rear-end collisions, reported a preference for the adaptive system as they found it less irritating and stress-inducing. Achieving greater acceptance and hence likely use of a real system is fundamental to good quality FCW design (8 Yu A. Hamish Jamson, Frank C.H. Lai, Oliver M.J. Carsten, 2008, "Potential benefits of an adaptive forward collision warning system", Transportation Research Part C: Emerging Technologies, Volume 16, Issue 4, Pages 471-484
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VGJ-4R2Y45J-1&_user=122878&_coverDate=08%2F31%2F2008&_rdoc=1&_fmt=high&_orig=gateway&_origin=gateway&_sort=d&_docanchor=&view=c&_searchStrId=1715057318&_rerunOrigin=google&_acct=C000010119&_version=1&_urlVersion=0&_userid=122878&md5=7145182a71b9736e5905265b389cd22b&searchtype=a

EC report

A thorough consideration of AEBS is given in this EC report...
Automated Emergency Braking Systems: Technical requirements, costs and benefits
http://ec.europa.eu/enterprise/newsroom/cf/itemshortdetail.cfm?item_id=3502&lang=en

Some notes on collision avoidance technologies are given at....
http://ec.europa.eu/transport/road_safety/specialist/knowledge/esave/esafety_measures_unknown_safety_effects/collision_avoidance_systems.htm

Drowzy Driver Detection System (DDS)

SYSTEM STUDIED:

DDS - Drowsy Driver Detection System
(examined by NTUA, some additions LOUGH)

Aims of the system

The ways of detecting drowsiness are based in eyes closure. One way is a video system that detects the eyes of the driver and neasures directly the eye closure. Another way is a neural network model used to estimate the eye closure using measures associated with lane keeping, steering wheel movements and lateral accelaration of the vehicle.

Functions covered by the system (intentional and unintentional)

Diagnosing driver condition (fatigue)

Detecting deviation from the path

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

1. The Driving Phase, during this phase no unexpected event or hazard has occurred or been detected.
2. The Rupture Phase, an unexpected event or hazard occured which surprised the road user.
3. The Emergency Phase is defined as the distance and time between the rupture phase and collision.
4. The Crash Phase, when the impact is taking place.
5. The Rescue Phase is the period after the collision during which the passengers are being evacuated from the vehicle.

Phases	Evaluation of actions
Driving Phase	A video system detects the eyes of the driver and measures directly the eye closure
Rupture Phase	A neural network model estimates the eye closure using measures associated with lane keeping, steering wheel movements and lateral accelaration of the vehicle * If the system has worked it should be less likely that a driver reaches a rupture stage and if they do they will be better prepared to react to the situation
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Note: some systems (e.g Volvo) monitor lane keeping to detect drowiness

Level of Intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	It alerts the driver by using a combination of text and voice messages, or vibrations in the seat cushion, as soon as the risk of drowsiness or inattention is detected
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

DDS (suite)

Technical specifications

Saab

Saab's Driver Attention Warning System is a development project designed to counter two of the most common causes of road accidents: driver drowsiness and inattention at the wheel. It alerts the driver by using a combination of text and voice messages, or vibrations in the seat cushion, as soon as the risk of drowsiness or inattention is detected. Unlike similar systems, the Driver Attention Warning System does not rely on measuring an erratic change in the steered direction of the vehicle. It is designed to detect the onset of drowsiness or inattention, rather than the immediate consequences. It utilizes two miniature infra-red cameras, one installed at the base of the driver's A-pillar and the other in the center of the main fascia, which are focused on the driver's eyes. The image from the cameras is analyzed by software that deploys a series of alerts when the pattern of eye-lid movement indicates the onset of drowsiness, or when the driver is not looking at the road ahead.Infra-red imaging is used to ensure good performance in all day and night light conditions, and even if the driver is wearing dark glasses.

Drowsiness Detection: The system uses a sophisticated algorithm, against which the driver's rate of eye blinking is measured. When the cameras detect a pattern of long duration eye-lid closures, indicating the potential onset of drowsiness, a series of three warnings is initiated.In the first instance, a chime sounds and a text warning message "Tired?" is displayed in the main instrument panel. If the driver's eye-lid movement does not immediately revert to a normal 'wide awake' pattern, a speech message "You are tired" is then delivered through the car's audio system. If there is still no response, a stronger warning tone and the message, "You are dangerously tired "stop as soon as it is safe to do so!" will come over the audio. This can only be canceled when the driver presses a reset button in the fascia. The system is then immediately reactivated.

Inattention Detection: The cameras are also able to monitor the driver's eye-ball and head movement. As soon as the driver's gaze moves away from what is defined as the 'primary attention zone' - the central part of the windshield in front of the driver - a timer starts counting.If the driver's eyes and head do not return to the 'straight ahead' position within about two seconds, the driver's seat cushion will vibrate. This will stop once the position of driver's eyes and head are consistent with the vehicle's direction of travel.The processing of the infra-red image is sufficiently accurate to detect when the driver retains some peripheral vision of the road ahead - such as while looking in the rear-view mirror, the door mirror or turning a corner - and will consequently allow a slightly longer time to elapse before activating the seat vibration.

http://health.dir.groups.yahoo.com/group/justiceforall/message/736/ (December 2010)

Mercedes

Attention Assist, a sophisticated drowsy-driver detection system, is now standard equipment in a new E-class. Mercedes-Benz engineers proved their worth by testing almost 600 drivers, using electrode-studded skullcaps to determine sleepiness.

http://www.technovelgy.com/ct/Science-Fiction-News.asp?NewsNum=2075 (December 2010)

Volvo

Uses cameras that detect the car's relative position on the road, to road markings that are analyzed by sensors. This gives Volvo's system the ability to not only scan for tiredness, but also distractedness from other passengers or if the driver is talking on a cellphone.

If the car detects that a driver is too tired or distracted via their road behavior, it will display a picture of a coffee cup and a warning to take a break from driving. It's not just a one-time warning either; as the journey progresses, the system can track the consistency of the driver over a five-bar progress. As the driver gets more distracted, the number of bars diminishes.

http://www.automobile.com/volvos-driver-alert-control-a-take-down-on-distracted-and-tired-driving.html

Bosch Driver Drowsiness Detection

http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/as/driverdrowsinessdetection/driverdrowsinessdetection.asp

Safety Impacts of Driver Drowsiness Monitoring and Warning

Mechanism 1: Direct in-car modification of the driving task

The system warns drivers when they are inattentive or fall asleep. There are no major inherent problems with the HMI, i.e., the warning given, to be expected with the design specified in eIMPACT. However, there are reliability problems in the diagnostic

Mechanism 2: Indirect modification of user behaviour

Availability of system will bring down the general level of driver alertness, the most so under critical conditions (i.e., in darkness and after long periods of driving). Behaviour under these same conditions will also be slighty sloppier, lane keeping in particular.

Mechanism 3: Modification of road user exposure

Extra exposure will be generated, because drivers will drive on in some conditions – which will be the more critical ones – in which they would formerly have stopped driving.

Mechanism 4: Modification of modal choice

An amount of modal shift towards the DDM-vehicle will be induced from other transportation modes.

eIMPACT, Deliverable D4, Impact assessment of Intelligent Vehicle Safety Systems

No DDS found to be currently implemented on motorcycles.

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 2.9%, no figure given for for fatalities - Drowsy Driver Detection System

http://www.trace-project.org/trace_template.html

A thorough summary of 'in-vehicle detection and warning devices' is given at...

http://ec.europa.eu/transport/road_safety/specialist/knowledge/fatigue/countermeasures/in_vehicle_detection_and_warning_devices.htm

eSafety Support website - no effectiveness evaluations listed

http://www.esafety-effects-database.org/applications_03.html

eIMPACT Traffic impact results D4 page 63 - Driver Drowsiness Monitoring and Warning (DDM)

For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:

- The system is far more effective in evening and night period.
- The system is more effective on motorways and rural roads than on urban roads

With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	0
2010 high	1
2020 low	2
2020 high	8

DDS (suite)

eIMPACT Safety impact results D4 page 83 - Driver Drowsiness Monitoring and Warning (DDM)

Table 28: The effect of DDM on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given.

DDM	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-5.0	-3.6
Impact low[1]	100 / 100	-1.5	-1.0
Impact high[1]	100 / 100	-7.0	-4.9
Impact 2010 low	0.2 / 0.3	-0.01	-0.01
Impact 2010 high	0.4 / 1.1	-0.04	-0.03
Impact 2020 low	1 / 6	-0.1	-0.08
Impact 2020 high	5 / 16	-0.5	-0.3

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.

[2] Fleet vehicle km equipped

The high estimate for the year 2020 would mean 94 avoided fatalities and 2,715 avoided injuries.

http://www.eimpact.info/results.html

COWI report

It is estimated that EU implementation of driver monitoring systems can save 1,962 lives in 2010 and 2,837 lives in 2020, when all vehicles have installed the required equipment. Page 139

No definitive cost benefit ratio given due to a lack of solid cost estimates

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

A short summary of some eCall results is given at... (very bottom of page)

http://ec.europa.eu/transport/road_safety/specialist/knowledge/fatigue/countermeasures/in_vehicle_detection_and_warning_devices.htm

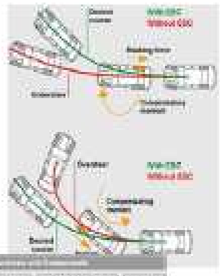
A short summary of some eCall results is given at... (very bottom of page)

http://ec.europa.eu/transport/road_safety/specialist/knowledge/vehicle/safety_design_needs/cars.htm

Electronic Stability Control (ESC)

SYSTEM STUDIED:

ESC - Electronic Stability Control
(examined by NTUA, comments added by LOUGH)



Aims of the system

ESC stabilises the vehicle and prevent skidding under all driving conditions and driving situation within the physical limits by active brake intervention on one or more wheels and by intelligent engine torque management.
http://www.thatcham.org/esc/

Functions covered by the system (intentional and unintentional)

ESC helps the driver stabilise the vehicle - although the extent to which it can do so is of course limited by the physical laws governing the dynamic behaviour of the vehicle.
Maintains stability and enhances performance during non-braking manoeuvres.
Additional yaw (rotational) sensing over RSC system for fleets/vehicle types that need additional stability control.
Integration is available across a variety of vehicle configurations with different engines, transmissions, suspensions, and wheelbases.
Automatically intervening to reduce the risk of the vehicle rotating while in a curve or taking an evasive action.
Prevents a jack-knife and drift out condition through select braking of the tractor and trailer brakes.
http://meritorwvs.com/Product_CVS.aspx?product_id=7&top_nav_str=hvs

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	A yaw-rate sensor and a lateral acceleration sensor continuously monitor the movement of the vehicle about its vertical axis and compare the actual value with the target value calculated on the basis of the driver's steering input and the vehicle speed
Rupture Phase	As the system identifies a critical driving situation it intervenes by applying specific brake pressure to one or more wheels, as required. If necessary, the engine torque is also adjusted automatically
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		
Mutual Control	Warning Mode	-
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		The system stabilises the vehicle by active brake intervention on one or more wheels and by intelligent engine torque management.

ESC (suite)

Technical specifications

Europe - ESC will be mandatory in all new types of vehicles from 1 November 2011, and for all new vehicles from 1 November 2014
http://www.chooseesc.eu/en/news/esc_compulsory_from_2011.htm

Audi

Audi has always held firm the belief that prevention is the best safety feature of all. And the S5 Coupe offers an abundance of features designed to help keep you out of harm's way. For instance, the Electronic Stability Control (ESC) is a vehicle dynamics management system that applies brakes to individual wheels to help make the vehicle easier to control in adverse conditions. Helping to reduce the danger of swerving and improving directional stability, the program identifies the car's intended direction and responds accordingly.
http://allcars.bloguez.com/allcars/tags.Audi-s5-Coupe.p.1.html

Hyundai

ESC compares the driver's intended course with the vehicle's actual response. It then brakes individual front or rear wheels and/or reduces engine power as needed in certain driving circumstances to help correct understeer or oversteer.

Hyundai is the first popular brand to offer electronic active front head restraints, a standard feature on the 2009 Genesis, which are an improvement over mechanically-based active head restraint systems. Until now, electronic active head restraints could only be found on select Mercedes-Benz, BMW and Lexus models. Active front head restraints have been proven by the Insurance Institute for Highway Safety to help prevent whiplash.

Genesis is brought to a halt by large four-wheel anti-lock disc brakes with Brake Assist and Electronic Brake Distribution (EBD). The V6 models feature 12.6-inch front rotors with single-piston floating callipers, while the V8 models feature 13-inch front rotors with four-piston callipers. All models are equipped with 12.4-inch rear rotors.
http://www.distrocars.com/2009-hyundai-rkspot-genesis

Bosch

In 1995, active driving safety reached yet another dimension thanks to the introduction of ESP. ESP incorporates the functions of ABS and TCS, with the additional benefits of stability control. The system supports the driver in all driving situations. It detects if skidding is imminent and intervenes by applying braking power to individual wheels and/or reducing engine power in order to restore the vehicle's stability.

ESP is always on and enabled. A microcomputer monitors the signals from the ESP sensors and checks 25 times a second, whether the driver's steering input corresponds to the actual direction in which the vehicle is moving. If the vehicle moves in a different direction ESP detects the critical situation and reacts immediately – independently of the driver. It uses the vehicle's braking system to stabilize the vehicle. With these selective braking interventions ESP generates the desired counteracting force, so that the car reacts as the driver intends. ESP not only initiates braking intervention, but can also reduce engine torque to slow the vehicle. So, within the limits of physics, the car is kept safely on the desired path.
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/abefmkw/elektronischesstabilitaetsprogrammesp/espprinzip/espprinzip_1.asp
http://www.bosch-esperience.de/de/language2/index.html

Trucks

Bosch offers an ESP system that is specifically designed for vehicles with large-volume hydraulic brakes and a gross vehicle weight of up to 8 tons. The system is ideal for full-size vans, pickup trucks and sport utility vehicles (SUV) in the upper vehicle segments where vehicle parameters such as gross vehicle weight, wheelbase, yaw inertia, and others place more stringent requirements on the braking system.

ESP for light trucks enables faster active pressure build-up and improves the stabilization of the vehicle around its longitudinal and vertical axis without requiring a pre-charge device, such as an active vacuum booster. In addition, the flow-optimized design of the system reduces braking distances and optimizes pedal response, while a faster pressure drop improves stability and steerability during ABS braking, particularly on road surfaces with different friction coefficients. The system is the logical next step to expand Bosch's active safety system ESP into the light truck vehicle segment.
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/abefmkw/elektronischesstabilitaetsprogrammesp/espfrlighttrucks/espfrlighttrucks_1.asp

Subaru

The Subaru Impreza had the ESC button located on the dashboard in close proximity to the driver's knee. The Subaru button is set to turn ESC off completely when it is pressed, so as in other installations of this type there is a risk that the driver could knock the button accidentally and be unaware that ESC was turned off if they did not notice the symbol on the dashboard. When pressed and held it turns traction control off, but keeps the ESC on and this is the opposite of most other systems tested. On most other systems, one press of the ESC button would only turn off the traction control (not ESC), and the driver would have to deliberately press and hold the ESC button to turn off the ESC system, so could not do so accidentally.
http://www.thatcham.org/esc/index.jsp?page=239

Percent ESC availability by vehicle type

		2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
Cars	Standard	90	88	74	65	56	48	37	34	30	28	24	17	8	5	2	1	1
	Optional	5	7	14	18	17	19	18	18	17	16	11	8	8	5	2	2	
	Not available	5	5	12	17	27	34	45	48	53	56	65	75	84	90	97	97	99
SUVs	Standard	100	100	100	96	88	66	38	23	17	10	9	3	1				
	Optional		0		1	2	5	12	18	15	3	2						
	Not available		0		3	11	28	50	58	68	86	89	97	99				
Pickups	Standard	72	62	38	11	9	1											
	Optional	15	2	19	20	14	16	18	5	2								
	Not available	13	36	43	70	77	83	82	95	98								
All	Standard	92	85	74	63	51	41	29	22	19	16	14	9	4	3	1	1	1
	Optional	4	4	11	13	12	14	16	15	12	9	6	4	4	3	1	1	
	Not available	4	11	15	24	36	45	55	63	69	75	80	86	91	94	98	98	99

http://www.iihs.org/ratings/esc/esc.aspx

NHTSA

ESC is increasingly being offered as standard or optional equipment in new model year passenger vehicles. An estimated 29 percent of the 2006 model year (MY) passenger vehicles were equipped with ESC, compared to 10 percent in MY 2003 vehicles. Based on manufacturers' product plans submitted to the agency in the summer of 2006, 71 percent of the MY 2011 light vehicles would have been equipped with ESC. The agency believes that these ESC systems would comply with FMVSS No. 126, because the vast majority of the 2006 ESC systems already met both the definition of "ESC" system and the required performance test. The projected MY 2011 installation rates serve as the baseline compliance rates. The analysis estimates the incremental benefits and costs of the rule, which requires manufacturers to increase ESC installations from 71 percent of the fleet to 100 percent of the fleet.

NHTSA, FMVSS No. 126, Electronic Stability Control Systems, Office of Regulatory Analysis and EvaluationNational Center for Statistics and AnalysisMarch 2007

ESC (suite)

Previous evaluations

TRACE D4.3 - Evaluation of ESC undertaken with already in fleet analysis - Page 29

http://www.trace-project.org/trace_template.html

Safety Configuration	Reduction in injury accidents (accident avoidance)	Reduction in all injuries & fatalities	Reduction in severe injuries and fatalities
Safety benefit of EBA given that the car has four stars.	-3.2 %	7.8 %	14.0 %
Safety benefit of ESC given that the car has four stars and an EBA.	5.2 %	10.3 %	16.8%
Safety benefit of ESC given that the car has five stars and an EBA.	3.2%	18.7% (*)	23.4% (*)
Safety benefit of the fifth star given that the car has four stars and an EBA.	6.4 %	8.3 %	N.A
Safety benefit of the fifth star given that the car has four stars, an EBA and an ESC.	19.3 % (*)	33.8 % (*)	35.2 % (*)
Safety benefit of EBA and ESC given that the car has four stars.	18.6 %	36.3 % (*)	42.3 %
Safety benefit of EBA and a fifth star given that the car has four stars.	28.2 % (*)	36 % (*)	37.5 % (*)
Safety benefit of ESC and a fifth star given that the car has four stars and an EBA.	22 % (*)	38.6 % (*)	37.1% (*)
Safety benefit EBA, ESC and a fifth star given that the car has four stars.	47.2 % (*)	67.8 % (*)	69.5 % (*)
Safety benefit of a fifth star and removing an ESC given that the car has four stars, an EBA and an ESC.	2.1 %	N.A	N.A

* statistically significant

Table 5: A-posteriori evaluation results

eIMPACT Traffic impact results D4 Electronic Stability Control - ESC - Page 47

http://www.eimpact.info/results.html

For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:

• ESC is more effective in the dark, as the drivers' detection of slippery road conditions is more difficult.

• ESC is most effective on rural roads, where speeds are relatively high and curves may be sharp, followed by motorways. The system is least effective on urban roads.

• ESC is more effective at low traffic volumes, since drivers will then be able to drive faster.

With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	136
2010 high	157
2020 low	173
2020 high	217

eIMPACT Safety impact results D4 Electronic Stability Control - ESC - Page 86

http://www.eimpact.info/results.html

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 14). The table also shows the range of estimates for full penetration.

Table 14: The effect of ESC on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given. (%)

ESC	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-10,0	-6,6
Impact low[1]	100 / 100	-9,6	-3,3
Impact high[1]	100 / 100	-24,5	-10,5
Impact 2010 low	29 / 10	-5,3	-2,3
Impact 2010 high	34 / 15	-6,3	-2,7
Impact 2020 low	61 / 54	-11	-4,5
Impact 2020 high	81 / 71	-14	-5,7

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.

[2] Fleet vehicle km equipped

The high estimate for the year 2020 would mean 3,253 avoided fatalities and 52,182 avoided injuries. N.B. For ESC, the accident base used is larger than for the other systems.

COWI report - page 60

The effect on the number of fatalities, severe injuries and slight injures of installing ESC in all new vehicles is presented in the table below.

It is, for example, estimated that ESC can save approx. 2,250 lives in 2020 if it is made mandatory in all new vehicles.

Table 6-5 Study estimate of the effect of ESC in selected years

Category	2010	2020
Fatalities	[illegible]	-2,250
Severe injuries	[illegible]	[illegible]
Slight injuries	[illegible]	[illegible]

Source: Own estimates

COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136

www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf

Tests

ESC systems are assessed by performing a series of tests in which steering and yaw behaviour can be simultaneously evaluated. These are called the "sine-with dwell" tests and are based on an actual double lane change manoeuvre. They are carried out at 80 km/h with sudden steering wheel rotations up to 270 degrees.

A car will pass the "sine with dwell" test when it has met three criteria. The first criteria is the lateral, or sideways displacement, which must be more than 1.83m. In other words, the sideways displacement must be sufficient to actually change lane as intended to avoid the object that was in your lane.

In order to make the double lane change, the car must react to the steering input which is ensured by the ESC system and verified with the lateral displacement criteria. However, after the steering manoeuvre the car must stay stable. This is verified with two other criteria that determine the yaw-rate after the steering manoeuvre is completed. They may only be a small percentage of the maximum yaw-rate during the steering manoeuvre to ensure that the car will follow a straight path after the steering input.

http://www.euroncap.com/Content-Web-Page/bf07c592-4f87-404e-bb06-56f77faee5a2/esc.aspx

ESC (suite)

EuroNCAP

Since 2008, Euro NCAP has been promoting broad fitment of Electronic Stability Control (ESC) by all vehicle manufacturers.

Up to 2012 when ESC becomes mandatory for all new cars sold in the EU, each vehicle manufacturer can decide whether or not to make ESC available on a certain model (variant). Consequently, ESC fitment varies greatly between different European countries and between different vehicle categories. To drive greater levels of fitment, in 2009 Euro NCAP has begun awarding three Safety Assist points to a car if ESC is fitted as standard across the model range, or if it is an option on every variant and the manufacturer also expects to sell at least 95 percent of cars with the system as standard equipment. This fitment requirement is steadily increasing and by 2012 Euro NCAP will only reward equipment which is fitted as standard across the whole of the model range.

In addition, as of 2011, Euro NCAP performs the so called "sine-with dwell" test on all cars that meet the ESC fitment requirement in order to check its performance. The car is eligible for ESC points only when it passes the criteria in this test.

Car manufacturers and their suppliers perform many hundreds of tests when developing ESC systems for their vehicles. They try to ensure that the system will work in every possible circumstance: different speeds and road conditions, and different manoeuvres and driver response.

So far, analyses of real-life accident have demonstrated that cars equipped with ESC are involved in fewer accidents and less serious ones, than cars without. However, it has not yet been possible to differentiate between the safety offered by different types of ESC systems.

With the experience from the dynamic tests of 2011 and onwards, Euro NCAP and its members are continuing to work on possible refinements to the ESC test and assessment methods.

http://www.euroncap.com/Content-Web-Page/bf07c592-4f87-404e-bb06-56f77faee5a2/esc.aspx

NHTSA

As part of a comprehensive plan for reducing the serious risk of rollover crashes and the risk of death and serious injury in those crashes, this rule establishes Federal Motor Vehicle Safety Standard (FMVSS) No. 126 to require electronic stability control (ESC) systems on passenger cars, multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight rating of 4,536 Kg (10,000 pounds) or less. ESC systems use automatic computer-controlled braking of individual wheels to assist the driver in maintaining control in critical driving situations. NHTSA estimates ESC will reduce single-vehicle crashes of passenger cars by 34% and single vehicle crashes of sport utility vehicles (SUVs) by 59%, with a much greater reduction of rollover crashes. NHTSA estimates ESC would save 5,300 to 9,600 lives and prevent 156,000 to 238,000 injuries in all types of crashes annually once all light vehicles on the road are equipped with ESC.

Technology Costs

Vehicle costs are estimated to be $368 (in 2005 dollars) for antilock brakes and an additional $111 for electronic stability control for a total system cost of $479 per vehicle. The total incremental cost of the rule (over the MY 2011 installation rates and assuming 17 million passenger vehicles sold per year) are estimated to be $985 million to install antilock brakes, electronic stability control, and ESC malfunction indicators. The average incremental cost per passenger vehicle is estimated to be $58 ($90 for the average passenger car and $29 for the average light truck), a figure which reflects the fact that many baseline MY 2011 vehicles are projected to already come equipped with ESC components (particularly ABS).

Summary of Vehicle Costs ($2005)

	Average Vehicle Costs	Total Costs
Passenger Cars	$ 90.3	$ 722.5 mill.
Light Trucks	$ 29.2	$ 262.7 mill.
Total	$ 58.0	$ 985.2 mill.

Property Damage and Travel Delay

The rule would prevent crashes and thus reduce property damage costs and travel delay associated with those crashes avoided. Overall, the rule would save $436 million at a 3 percent discount rate to $247 million at a 7 percent discount rate in property damage and travel delay.

Fuel Economy

The rule would add weight to vehicles and consequently would increase their lifetime use of fuel. Most of the added weight is for ABS components and very little is for the ESC components. Since 99 percent of the light trucks are predicted to have ABS in MY 2011, the weight increase for light trucks is less than one pound and is considered negligible. The average weight gain for a passenger car is estimated to be 2.1 pounds, resulting in 2.6 more gallons of fuel being used over their lifetime. The present discounted value of the added fuel cost over the lifetime of the average passenger car is estimated to be $3.35 at a 3 percent discount rate and $2.73 at a 7 percent discount rate. In total, the fuel economic cost would be $26.8 million at a 3 percent discount rate and $21.8 million at a 7 percent discount rate.

NHTSA, FMVSS No. 126, Electronic Stability Control Systems, Office of Regulatory Analysis and EvaluationNational Center for Statistics and AnalysisMarch 2007

eSafety Support website provides a list of effectiveness studies and summary results for Speed Alert in the eSafety Effects database area...

http://www.esafety-effects-database.org/applications_13.html

ESC is estimated to reduce the number of injury accidents by about 7-11%. The reduction in the car occupant fatalities is estimated to be approximately 15-20%. The system affects especially accidents on slippery road surfaces and in general, loss of control accidents.

Management System); CBC (Cornering Brake Control); DSC (Dynamic Stability Control); EDS (Electronic Differential-lock System); DSTC (Dynamic Stability and Traction Control); ESC (Electronic Stability Control); ESP (Electronic Stability Program); ICCS (Integrated Chassis Control System); IVD (Integrated Vehicle Dynamics); PCS (Precision Control System); PSM (Porsche Stability Management); SCS (Stability Control System); StabiliTrac; STC (Stability and Traction Control System); Traxxar; VDC (Vehicle Dynamics Control); VSA (Vehicle Stability Assist); VSC (Vehicle Stability Control); VSES (Vehicle Stability Enhancement System); and YCS (Yaw Control Stability)

Studies

ESC was found to have potential to prevent 19,3% of crashes involving large trucks included in the LTCCS database. The estimates are based on real-world crash data collected in Large Truck Crash Causation Study (LTCCS) which was conducted from 2001 to 2003. The LTCCS study conducted on-scene investigations for real-world crashes and produced a database of 1070 accidents. This data was used to make case by case estimations of the applicability of crash avoidance countermeasures for each crash based on expert knowledge on the analysed systems and their effectiveness in various crash scenarios.

Kingsley K. J., 2009, Evaluating crash avoidance countermeasures using data from FMCS's/NHTSA's large truck accident causation study. Proceedings of the 21st International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV) - International Congress Center Stuttgart, Germany, June 15–18, 2009.

ESC is estimated to prevent 9.587 casualties in 2021 with full fleet penetration which corresponds to annual cost savings of £764 million. Calculation of the reduction of fatalities was based on an earlier studies carried out in UK using case control method and induced exposure, statistics on vehicles equipped with ESC and models used to predict the increase in the share of vehicles equipped with ESC.

Weekes A., Avery M., Frampton R. and Thomas P., 2009, ESC standard fitment and failure to protect young drivers. Proceedings of the 21st International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV) - International Congress Center Stuttgart, Germany, June 15–18, 2009.

ESC drivers were much more likely than drivers of other vehicles to be aware of ESC (77% vs. 39%) and that their own vehicle was equipped with it (63% vs. 8%), but 23 percent had never heard of it. 90%of drivers who knew that their vehicle was equipped with ESC believed that ESC had made it safer to drive and reported being confident that ESC would work in an emergency. 23% of ESC owners who knew their vehicle had ESC reported noticing long-lasting changes in their driving behaviour. Hence, behavioural adaptation to ESC is likely in certain drivers; however, its proven effectiveness in reducing the likelihood of being involved in a serious crash probably outweighs any potential increases in unsafe driving. ESC-equipped vehicles should be marketed in a realistic, safe manner.

Two separate telephone surveys on drivers' perceptions and awareness of ESC. The first surveyed 500 randomly selected owners/drivers of passenger vehicles and the second 1017 owners/drivers of 2006-2008 ESC-equipped passenger vehicles in Canada.

Rudin-Brown C.M., Jenkins R.W., Whitehead T., Burns P.C., 2009, Could ESC (Electronic Stability Control) Change the Way We Drive? Traffic Injury Prevention, 10:4, pp. 340 - 347.

About 90% of the car drivers with ESC know that the car is equipped with the system. More than 35% of those without ESC erroneously state that their car has the system. Almost all drivers (over 95%) are aware that they have antilock brakes. For both ABS and ESC, the drivers state that they have noticed that the systems were mainly activated on snowy/icy roads. They also think that the system is most beneficial under such conditions. In these risk situations, the drivers consistently state that they are more likely to take a risk when they think they have the support system, than when they do not have it. Car drivers which have ESC have a greater tendency to increase their risk taking than the car drivers without ESC. Men and the youngest drivers are most risk-prone. The study concludes that drivers are more risk-prone when they think they have a certain technical support system than when they think they do not have the system. The increased safety offered by the system may be impaired due to that the driver compensates by increasing his or her risk.

Questionnaire based on the "Theory of planned behaviour" has been used. The drivers' intentions to behave in a certain way in three critical driving situations were studied as a post survey sent to 1,000 car drivers with ESC and to 1,000 drivers of similar cars without ESC. The response rate was 48% (53% for those with ESC). There were slight more men and older drivers than in the whole driver population.

ESC (suite)

Vadeby A., Wiklund M., Forward S., 2009, The expectations and views of car drivers concerning antilock brakes (ABS) and electronic stability control (ESC) systems. VTI rapport 647. 66 p. + app. 14 p. (Swedish with English summary)

Socio-economic benefits related to the indirect traffic effects of ESC - the reduction in congestion costs - have been estimated to lie between 135-157 million € in 2010 and 173-217 million € in 2010. ESC was estimated to reduce the number of injuries by 3.3-10.5% and fatalities by 9.8-24.5%, when 100% penetration in terms of vehicle kilometres was assumed.
The estimates for the safety impacts are based on synthesis of earlier studies, the power model presented by Gøran Nilsson and assumptions made by the authors.
Wilmink I., et. Al., 2008, Impact assessment of Intelligent Vehicle Safety Systems. eIMPACT Deliverable D4, Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe (eIMPACT)

This study summarises evidence from empirical studies on the effects of electronic stability control (ESC) on accidents in a meta-analysis. The study concludes on a 49% reduction in single vehicle accidents, 13% reduction head-on collisions and 32% reduction of multi-vehicle fatal accidents due to ESC improving driving dynamics and reducing the probability of loss of control. However, a sensitivity analysis indicates results for single vehicle accidents likely to be affected by publication bias. The results for single vehicle accidents are in excess of what might be expected based on studies that have estimated the total amount of accidents that may be affected by ESC. Consequently, the proportions of accidents that can be avoided by ESC is assumed to be somewhat smaller than suggested by most empirical studies. Properties of the vehicles, time trends, and driver behaviour may have contributed to the large empirical effects.
The study applied meta-analysis on a set of earlier accident statistics based studies.
Erke A., 2008, Effects of electronic stability control (ESC) on accidents: A review of empirical evidence. Accident Analysis & Prevention, Volume 40, Issue 1, January 2008, Pages 167-173.

The results showed that the effectiveness of ESC is 3% for crashes of all severity. The number of serious crashes was 19% smaller for cars with ESC compared to cars with no ESC. The number of fatalities was 15% less for cars with ESC compared to cars with no ESC.
The analysis was carried out on the basis of a database of accidents reported to the police in UK during 2002-2005. The analysis used case-control method and involved 10,475 case vehicles and 41,656 control vehicles involved in accidents and group of manouvres in which ESC effect was considered possible and a group of control manoeuvres.
Thomas P., 2007, Real-world assessment of relative crash involvement rates of cars equipped with electronic stability control. Proceedings of the 20th International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV) in Lyon, France, June 18-21, 2007.

A study undertaken by the University of Cologne concluded that 4 000 lives could be saved each year and 100 000 injuries could be avoided each year on European roads if all cars would be equipped with ESC. The analysis shows that for every Euro invested in ESC cost savings of 3.5-5.8 Euro arise to society.
The results are based on socio-economic cost-benefit analysis. The impacts of ESC have been estimated on the basis of earlier studies. The impacts of ESC have been estimated on the basis of the share of single vehicle accidents of all accidents, the share of single vehicle accidents caused by a skidding vehicle and the estimated effectiveness of ESC in preventing those accidents.
Baum H., Grawenhoff S., Geiler T., 2007, Cost-Benefit-Analysis of the Electronic Stability Program (ESP), Summary Report.

Overall the cars with ESC are involved in 7% fewer crashes although the effectiveness is substantially higher under conditions of adverse road friction i.e. 20% reduction on snowy and icy roads. ESC equipped cars are involved in 25% fewer fatal crashes and in 11 % fewer serious crashes.
The study used the national accident statistics of Great Britain. The crash experience of 10475 cars was analysed and compared to a closely matching set of 41656 non-ESC cars using case-control methods.
Frampton F., Thomas P., 2006, Effectiveness of Electronic Stability Control Systems in Great Britain. Vehicle Safety Research Centre, Loughborough University

ESC reduces the risk of fatal multiple-vehicle crashes by 32 percent amd the risk of all single-vehicle crashes by more than 40 percent — fatal ones by 56 percent.
While both cars and SUVs benefit from ESC, the reduction in the risk of single-vehicle crashes was significantly greater for SUVs — 49 percent versus 33 percent for cars. The reduction in fatal single-vehicle crashes wasn't significantly different for SUVs (59 percent) than for cars (53 percent). ESC reduces the risk of fatal single-vehicle rollovers of SUVs by 80 percent, 77 percent for cars. ESC was found to reduce the risk of all kinds of fatal crashes by 43 percent. Losses under collision coverage are about 15 percent lower for vehicles with ESC than for predecessor models without it. However, ESC doesn't have much effect on property damage liability claims or the frequency of injury claims. These findings track police-reported crashes, which show little effect of ESC on the risk of low-severity multiple-vehicle crashes.
Statistical analysis of road accidents and fatalities as well as traffic insurance claims.
IIHS, 2006, Update on Electronic Stability Control. Insurance Institute for Highway Safety, Status Report, Vol. 41, No. 6 and News Release, June 13, 2006.

ESC decreased the accident rate of single-car accidents by about 44% and that of head-on collisions by about 24%; the decrease was higher for more severe accidents; the decrease of single accidents and head-on collisions was higher on wet road conditions (58%) than on dry conditions (20%).
Comparison of data of 1,471 single-car accidents or head-on collisions not caused by drunk driving or drowsy driving involving ten models that were originally designed and shipped without ESC but subsequently became to be equipped with ESC were chosen from the accident data held by the Institute for Traffic Accident Research and Data Analysis (ITARDA) in Japan. Accident numbers were related to the number of such cars in use.
Ohono & Shimura, 2006, Results from the survey on effectiveness of electronic stability control (ESC). Press release. National Agency for Automotive Safety & Victims' Aid (NASVA) 2006/02/16.

The overall effectiveness of ESC on all injury crashes except for rear end crashes was 16.7 +/- 9.3%, while for serious and fatal crashes the effectiveness was 21.6 +/- 12.8%. The effectiveness for serious and fatal crashes on wet roads was 56.2 +/- 23.5 %. On roads covered with ice and snow, the corresponding effectiveness was 49.2 +/- 30.2 %.
The estimates are based on the assumption that rear end crashes on dry road surfaces are not affected at all by ESC.
Lie A., Tingvall C., Krafft M., Kullgren A., 2006, The effectiveness of ESC (Electronic Stability Control) in reducing real life crashes and injuries. 19th International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV), June 2006.

In Australia, ESC is estimated to reduce road fatalities in light vehicles by 29%. Assuming that ESC can prevent 50% of loss-of-control accidents and that an ESC units costs $1,000, ESC is estimated to have a benefit cost ratio of 0.51.
Paine M., 2006, Electronic Stability Control: Review of Research and Regulations. Vehicle Design and Research Pty Limited for Roads and Traffic Authority of NSW. June 2005.

In Germany, 100 per cent equipment of all cars with ESP is estimated to reduce the number of accidents with car occupant injuries by about 7 -11 %. The reduction in the car occupant fatalities would be approximately 15 -20 %. The study compiled all available accident studies on ESP effectiveness
Langwieder K., 2005, Wissenschaftlicher Erkenntnisstand zu ESP. 10 Jahre ESP, Berlin, 23. February 2005.

Single vehicle crashes were reduced by 35% in passenger cars and by 67 % in SUV crashes. The study also showed significant or borderline-significant reductions in the multi-vehicle crash rates per 100,000 vehicle years with ESC.
As multi-vehicle crashes we used as the control group and it is possible that multi-vehicle crashes are being reduced by ESC, this means that the true effectiveness of ESC could be higher than estimated for single vehicle crashes.
Dang J. ,2004, Preliminary results analyzing the effectiveness of electronic stability control (ESC) systems. National Highway Traffic Safety Agency, USA.

ESC reduced single-vehicle crash involvement risk by approximately 41 % and single-vehicle injury crash involvement risk by 41 %. This translates to an estimated 7 % reduction in overall crash involvement risk and a 9 % reduction in overall injury crash involvement risk. Based on all fatal crashes in the United States over 3 years, ESC was found to have reduced single-vehicle fatal crash involvement risk by 56 percent. This translates to an estimated 34 percent reduction in overall fatal crash involvement risk.
The study compared crash involvement rates for otherwise identical vehicle models with and without ESC systems.
Farmer C., 2004, Effect of electronic stability control on automobile crash risk. Insurance Institute for Highway Safety, Arlington, Virginia, USA.

pdfs of studies can be downloaded at...
http://www.chooseesc.eu/en/news/documents/documents.htm

Intersection Control (IC)

SYSTEM STUDIED:

IC - Intersection Control
(examined by NTUA, comments added by LOUGH)

Aims of the system

A driver warning function based on communication with traffic lights and path prediction of all objects using the intersection.

Functions covered by the system (intentional and unintentional)

Detecting a user on an intersecting course
Predicting that another user will move off or fail to stop
Predicting the manoeuvre suited to the layout functioning
Detecting an oncoming user (in movement)
Detecting an obstacle moving slowly
Detecting a road-related difficulty
Detecting a user outside the frontal field of vision
Estimating a collision course with another user
Predicting that another user will stop or slow down
Detecting a user outside the frontal field of vision (behind, on the sides, or in blind spot)
Assessing gaps when joining or cutting across a traffic flow after changing direction at low speed

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	The function of the system is based on communication with traffic lights and path prediction of all objects
Rupture Phase	The system alerts the driver to avoid the collision.
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		The function of the system is based on communication with traffic lights and path prediction of all objects
Mutual Control	Warning Mode	-
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

IC (suite)

Technical specifications

GreenWave is a distributed traffic intersection traffic-light control system, at research level. The solution couples camera sensors with a novel collaborative multiagent goal oriented control algorithm to outperform both conventional and theoretical approaches. The system uses real time traffic data and an interactive demonstration showed how a multiagent system can directly improve on standard models of sequential phase control of traffic intersections. A video sensor traffic detection model allows input from standard induction loop sensors supplemented with real-time tracking of traffic movement towards and through intersections. This data is then used by the novel, control function distributed to each controlled intersection which changes intersection light phases according to queued and incoming traffic. Through the SUMO tool, the system can manage any network of intersections with the control algorithm either deployed to every intersection, or critically, to only a selection of intersections, i.e., mixed control networks are an option. Distributed deployment will automatically adapt and improve as more intersections adopt the new control scheme. The demonstration will nominally use a collection of pre-generated traffic networks, from a simple grid network to a complex city-wide simulation.
The traffic generation model is stochastic and simulated video sensing will be activated. The simulation is highly visual and interactive; visitors will be able to adjust control parameters and observe the impact on traffic flow patterns in real-time. By either turning on automatic flow adaptation or by manually tuning control parameters the user may observe the emergence of multiple green-wave traffic flows in suitable networks.

References

Greenwood D., Burdillak B., Trencansky I., Armbruster H., Dannegger C.,2009, "GreenWave Distributed Traffic Intersection Control", 8th International Conference on Autonomous Agents and Multiagent Systems, Budapest, Hungary

INTERSAFE-2 project

NEC Europe has announced that it has designed and implemented an innovative vehicle-to-infrastructure (V2I) communication system that allows vehicles and roadside infrastructure to talk to each other and exchange real-time information. The system allows traffic light controllers to transmit their current signal phase of red or green and time changes to approaching vehicles, warning of potential red lights and aiding safer and more efficient driving. The system is currently being evaluated as part of the EU's INTERSAFE-2 project, which is financially supported by the European Commission.
The INTERSAFE-2 project aims to develop and demonstrate a Cooperative Intersection Safety System (CISS) that is able to significantly reduce injury and fatal accidents at intersections. Depending on the region and country, from 30 to 60% of all injury accidents and up to one third of the fatalities occur at intersections. It is hoped that the deployment of the INTERSAFE-2 system could provide a positive safety impact of 80% with respect to injuries and fatal accidents at intersections. This would equate to a possible total safety benefit of up to 40% of all injury accidents and up to 20% of all fatalities in Europe.

The NEC vehicular communication system that has been used in the INTERSAFE-2 project, comprises the LinkBird-MXTM platform and C2X-Software Development Kit. Other members of the project's consortium, which is coordinated by SICK AG, are: BMW Group Research and Technology, Institute für Kraftfahrwesen Aachen, INRIA, SWARCO Traffic Systems, TRW Conekt, Technical University of Cluj-Napoca, Volvo Technology, VTT Technical Research Centre of Finland and Volkswagen AG. Dr Heinrich Stüttgen, head of NEC Laboratories Europe, said, "We are delighted to be part of the INTERSAFE-2 project. The project aims to significantly reduce injuries and fatal accidents at crucial intersections, where 'black spots' still remain. We have successfully installed and demonstrated the NEC vehicular communication system at public intersections in Wolfsburg, Germany and Gothenburg, Sweden and are pleased our technology is reducing accidents.
http://www.traffictechnologytoday.com/news.php?NewsID=28414

Previous evaluations

Deliverable 3.1 of the INTERSAFE-2 project 'User Needs and Operation Requirements for a Cooperative Intersection Safety System' gives an accident analysis and examines user needs
http://www.intersafe-2.eu/public/public-documents/deliverables-1/

TRACE D4.3 - Estimated effectiveness for serious injuries saved 2.34%, no figure given for fatalities - Intersection Control
http://www.trace-project.org/trace_template.html

eSafety Support website - no effectiveness evaluations listed
http://www.esafety-effects-database.org/applications_03.html

eIMPACT Traffic Impact results D4 page 64 - Intersection Safety (INS)

For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:
* Intersection Safety is more effective in off-peak hours (especially for the left-turn function), since the likelihood of a preceding vehicle is lower and drivers may have a lower attention level if the traffic volumes are low; hence the accident probability at intersections is higher then.
* Lighting conditions have no special effects on effectiveness.
* The system is not effective on motorways.

With these assumptions and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010	0
2020 low	1
2020 high	2

eIMPACT Safety Impact results D4 page 88 - Intersection Safety (INS)

Table 34: The effect of INS on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low-high) is given. Figures include also reduction of fatalities by Intersection Safety Left Turn function (estimation done in the PReVAL project. [Scholliers et al. 2008])

Intersection Safety total	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-3.9	-7.3
Impact low[1]	100 / 100	-1.0	-0.9
Impact high[1]	100 / 100	-7.8	-15.3
Impact 2010 low	0 / 0	0	0
Impact 2010 high	0 / 0	0	0
Impact 2020 low	0.3 / 0.4	-0.02	-0.08
Impact 2020 high	0.5 / 0.7	-0.03	-0.08

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.

[2] Fleet vehicle km equipped. Note that the assumed penetration does not take into account the implementation of the infrastructure.

The last row indicates that in the high penetration scenario in 2020 it is assumed that the effects of intersection safety system still are very small. This estimate would mean 7 avoided fatalities and 670 avoided injuries.
http://www.eimpact.info/results.html

This demonstration proposal is for a distributed traffic intersection traffic-light control called GreenWave. The solution couples camera sensors with a novel control algorithm to outperform both conventional and collaborative multiagent goal oriented theoretical approaches. The system is designed for real use, although simulated traffic data will be used for the demonstration.

Greenwood D., et al.,(2008), GreenWave Distributed Traffic Intersection Control, 8th International Conference on Autonomous Agents and Multiagent Systems, Budapest, Hungary

Motorcycles - Honda

Oncoming Vehicle Information Assistance System

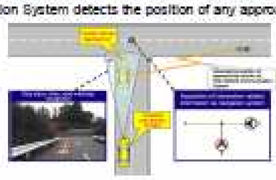
This system exchanges vehicle information between automobiles and motorcycles, such as position, direction and speed. Motorcycle riders can view information about vehicles near them on a display, and can receive information through an in-helmet audio system. Drivers can view information on the status of motorcycles in their vicinity and receive warnings on their navigation system display.

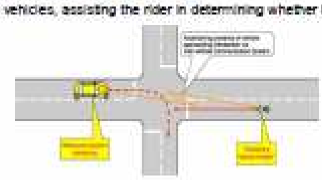
- Motorcycles -

This system analyzes images from the camera mounted on the front of the motorcycle to detect stop signs and either line markings or road markings. If the rider does not slow down when approaching an intersection, a warning appears on the motorcycle's display screen, and an audio warning sounds in the rider's helmet, prompting the rider to decelerate.
In addition, once the motorcycle has come to a stop, the Inter-Vehicle Communication System detects the position of any approaching vehicles, assisting the rider in determining whether it is safe to proceed through the intersection.

TRACE assumptions

As IC is still at a concept stage with no systems in the market the technical specification used in TRACE from PreVENT/PreVAL are still relevant although it is suggested that if IC is selected for evaluation in DaCoTA the final documents of INTERSAFE-2 are sought for an undated generic specification (Final Workshop in May 2011)





Intelligent Speed Adaptation (ISA)

SYSTEM STUDIED:

ISA - Intelligent Speed Adaptation
(examined by NTUA, comments added by LOUGH)
In Europe ISA is often also referred to as SpeedAlert

Aims of the system

ISA describes any system which either warns the driver or automatically limits the speed of the vehicle when it exceeds the legal speed limit of a given area. These systems establish the location of the vehicle and compare the current speed with what is the posted speed for that location. If the vehicle exceeds this speed, the system takes effect, either be in the form of a visual or auditory warning (informative system), or intervention (actively supporting systems). Actively supporting systems may provide haptic feedback to the driver through increased pressure or vibration in the accelerator pedal, but this can be overridden by the user.

Note for evaluation: the points from the UK ISA trials on the type of road users who override the voluntary system are particularly interesting for casualty reduction evaluation (near bottom of sheet)
It is not clear how well speed maps will deal with temporary speed limits

Functions covered by the system (intentional and unintentional)

Adapting speed to road conditions
Predicting the manoeuvre suited to the layout functioning

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	The system either warns the driver or automatically limits the speed of the vehicle when it exceeds the legal speed limit of a given area.
Rupture Phase	* If the ISA system has been effective it should be less likely that a driver reaches a rupture stage due to high speed and if they do they may be better prepared to react to the situation as their speed will at least be at or below the speed limit
Emergency Phase	* If the ISA system has been effective the driver may be better prepared to react if possible during this phase
Crash Phase	* If the ISA system has been effective the driver may have been able to react better to rupture and emergency phases and may have been able to reduce speed and therefore crash severity
Rescue Phase	-

Note for evaluation: Of course ISA does not address speed that in inappropriate for the situation but below the legal speed limit.

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

Just displaying the current speed limit and warning when it is exceeded
- Advisory ISA

Controlling the speed of the vehicle
- Voluntary ISA - possible to override
- Mandatory ISA - not possible to override

ISA (suite)

Advisory ISA

		Specifications
Perceptive Mode		Just displaying the current speed limit and warning when it is exceeded (visual, auditory or haptic warning)
Mutual Control	Warning Mode	-
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

Voluntary ISA

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	If the vehicle exceeds this speed, the system takes effect and lowers the speed
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		If the vehicle exceeds this speed, the system takes effect and lowers the speed

Mandatory ISA

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	-
	Limit Mode	If the vehicle exceeds this speed, the system takes effect (actively supporting systems)
	Corrective Mode	If the vehicle exceeds this speed, the system takes effect and lowers the speed
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		If the vehicle exceeds this speed, the system takes effect and lowers the speed

Technical specifications

There are four types of technology currently available for determining local speed limits on a road and determining the speed of the vehicle. These are:GPS, Radio Beacons, Optical recognition, Dead Reckoning

Global Positioning System (GPS) Receiver based systems

GPS is based on a network of satellites that constantly transmit radio signals. GPS receivers pick up these transmissions and compare the signals from several satellites in order to pinpoint the receiver's location to within a few meters. This is done by comparing the time at which the signal was sent from the satellite to when it was picked up by the receiver. Because the orbital paths of the satellites are known very accurately, the receiver can perform a calculation based on its distance to several of the orbiting satellites and therefore obtain its position. There are currently 24 satellites making up the GPS network, and their orbits are configured so that a minimum of five satellites are available at any one time for terrestrial users. Four satellites is the minimum number of satellites required to determine a precise three-dimensional position.

The popularity of GPS in current ISA and in car navigation systems may give the impression that GPS is flawless, but this is not the case. GPS is subject to a number of fundamental problems. Many of these problems relate to the accuracy of the determined position. The receiver still gets the signal from the satellites, but due to satellites' ephemeris uncertainties, propagation errors, timing errors, multiple signal propagation path, and receiver noises, the position given can be inaccurate. Usually these inaccuracies are small and range from five to ten meters for most systems, but they can be up to hundreds of meters. In most situations this may not matter, but these inaccuracies can be important in circumstances where a high speed road is located immediately adjacent to roads with much lower speed limits (e.g., residential streets). Furthermore, because GPS relies upon a signal transmitted from a satellite in orbit, it does not function when the receiver is underground or in a tunnel, and the signal can become weak if tall buildings, trees, or heavy clouds come between the receiver and the satellites.

Current improvements being made to the GPS satellite network will help to increase GPS reliability and accuracy in the future but will not completely overcome the fundamental shortcomings of GPS. In order to be used for ISA systems, GPS must be linked to a detailed digital map containing information such as local speed limits and the location of known variable speed zones, e.g., schools. Advanced digital maps have the capacity for real-time updating to include information on areas where speed limits should be reduced due to adverse weather conditions or around accident scenes and roadworks.

Radio beacons

Roadside radio beacons, or bollards, work by transmitting data to a receiver in the car. The beacons constantly transmit data that the car-mounted receiver picks up as it passes each beacon. This data could include local speed limits, school zones, variable speed limits, or traffic warnings. If sufficient numbers of beacons were used and were placed at regular intervals, they could calculate vehicle speed based on how many beacons the vehicle passed per second. Beacons could be placed in/on speed signs, telegraph poles, other roadside fixtures, or in the road itself. Mobile beacons could be deployed in order to override fixed beacons for use around accident scenes, during poor weather, or during special events. Beacons could be linked to a main computer so that quick changes could be made. The use of radio beacons is common when ISA systems are used to control vehicle speeds in off road situations, such as factory sites, logistics and storage centres, etc., where occupational health and safety requirements mean that very low vehicle speeds are required in the vicinity of workers and in situations of limited or obscured visibility.

Optical recognition systems

So far, this technology has been focused solely on recognizing speed signs. However, other roadside objects, such as the reflective "cats eyes" that divide lanes could possibly be used. This system requires the vehicle to pass a speed sign or similar indicator and for data about the sign or indicator to be registered by a scanner or a camera system. As the system recognizes a sign, the speed limit data is obtained and compared to the vehicle's speed. The system would use the speed limit from the last sign passed until it detects and recognizes a speed sign with a different limit. If speed signs are not present, the system does not function. This is a particular problem when exiting a side road onto a main road, as the vehicle may not pass a speed sign for some distance.

ISA (suite)

Dead reckoning

Dead reckoning (DR) uses a mechanical system linked to the vehicle's driving assembly in order to predict the path taken by the vehicle. By measuring the rotation of the road wheels over time, a fairly precise estimation of the vehicle's speed and distance travelled can be made. Dead reckoning requires the vehicle to begin at a known, fixed point. Then, by combining speed and distance data with factors such as the angle of the steering wheel and feedback from specialized sensors (e.g., accelerometers, flux gate compass, gyroscope) it can plot the path taken by the vehicle. By overlaying this path onto a digital map, the DR system knows approximately where the vehicle is, what the local speed limit is, and the speed at which the vehicle is travelling. The system can then use information provided by the digital map to warn of upcoming hazards or points of interest and to provide warnings if the speed limit is exceeded. Some top-end GPS-based navigation systems currently on the market use dead reckoning as a backup system in case the GPS signal is lost.

Dead reckoning is prone to cumulative measurement errors such as variations between the assumed circumference of the tyres compared to the actual dimension (which is used to calculate vehicle speed and distance travelled). These variations in the tyre circumference can be due to wear or variations in tyre pressure due to variations in speed, payload, or ambient temperature. Other measurement errors are accumulated when the vehicle navigates gradual curves that inertial sensors (e.g. gyroscopes and/or accelerometers) are not sensitive enough to detect or due to electromagnetic influences on magnetic flux compasses (e.g., from passing under power lines or when travelling across a steel bridge) and through underpasses and road tunnels.

Limitations

An initial reaction to the concept of ISA is that there could be negative outcomes, such as driving at the speed limit rather than to the conditions, but numerous ISA trials around the World have shown these concerns are unsubstantiated. A particular issue is that most ISA systems use a speed database based purely on information regarding the posted maximum speed limit for a roadway or roadway segment. Obviously, many roads have features such as curves and gradients where the appropriate speed for a road segment with these features is less than the posted maximum speed limit. Increasingly, road authorities indicate the appropriate speed for such segments through the use of advisory speed signage to alert drivers on approach that there are features which require a reduction in travelling speed. It is recognised that the speed limit databases used in ISA systems should ideally take account of posted advisory speeds as well as posted maximum speed limits. The New South Wales ISA trial, underway in the Illawarra region south of Sydney currently, is the only trial that is using posted advisory speeds as well as posted maximum speed limits. Some car manufacturers have expressed concern that some types of speed limiters "take control away from the driver".

This is also unsubstantiated, firstly because ISA systems do have provision for over-ride by the driver in the event that the set speed is inappropriate and secondly, the claim is somewhat hypocritical given that cruise control has been in use on vehicles for many years and forces the vehicle to travel at a minimum speed unless there is driver intervention.

For some traffic safety practitioners, active intelligent speed adaptation is thought to be an example of 'hard automation', an approach to automation that has been largely discredited by the Human Factors community. An inviolable characteristic of human users is that they will adapt to these systems, often in unpredictable ways. Some studies have shown that drivers 'drive up to the limits' of the system and drive at the set speed, compared to when they are in manual control, where they have been shown to slow down. Conversely, the experience of some drivers with driving under an active ISA system has been that they find they can pay more attention to the roadway and road environment as they no longer need to monitor the speedometer and adjust their speeds on a continuing basis. There is also concern that drivers driving under speed control might accept more risky headways between themselves and vehicles in front and accept much narrower gaps to join traffic (this fact drawing particular criticism from motorcycling groups).

Wider criticism also comes from the insistent focus on speed and that road safety outcomes could be better achieved by focusing on driving technique, situational awareness, and automation that 'assists' drivers rather than 'forces' them to behave in particular ways. Intelligent speed adaptation has also been held as an example of a technology which, like speed cameras, can often alienate the driving public and represents a significant barrier to its widespread adoption. Some studies which pre-date the development of ISA systems indicated that drivers make relatively little use of the speedometer and instead use auditory cues (such as engine and road noise) to successfully regulate their speed. These studies, however, remain unverified. There is an argument in the literature that suggests that as cars have become quieter and more refined speed control has become more difficult for drivers to perform. Thus an alternative 'soft-automation' approach is simply to re-introduce some of those cues that drivers naturally use to regulate speed (rather than incur the expense and unexpected behavioural adaptations of ISA).

References

Vlassenroot S., Brookhuis K., Marchau V., Witlox F., 2010, "Towards defining a unified concept for the acceptability of Intelligent Transport Systems (ITS): A conceptual analysis based on the case of Intelligent Speed Adaptation (ISA)" Transportation Research Part F: Traffic Psychology and Behaviour, Volume 13, Issue 3, Pages 164-178

PRAISE report - ETSC Page 5

Examples of ISA implementations in commercial fleets are given

There is a well documented relationship between speed and collisions resulting in death and injury with lasting effect. The adaptation of driving speed to the prevailing conditions and speed limits is a primary way of controlling the crash risk of the driver. Different systems exist, ranging from informative to intervening systems. Intelligent Speed Adaptation (ISA) is an Intelligent Transport System (ITS) which warns the driver about speeding, discourages the driver from speeding or prevents the driver from exceeding the speed limit (Regan et al, 2002)6. Information regarding the speed limit for a given location is usually identified from an onboard digital map in the vehicle. Other systems use speed sign reading and recognition either using already built into the vehicle or aftermarket navigators.

There are two major types of systems – informative and supportive. An informative system gives the driver feedback in the form of a visual or an audio signal. A supportive system works in the form of increasing the upward pressure on the pedal or cancelling a driver's throttle demand if it demands more throttle than is required to drive at the speed limit.

Preventing Road Accidents and Injuries for the Safety of Employees, European Transport Safety Council September 2009

http://www.etsc.eu/PRAISE-publications.php

Although more studies are now available regarding ISA trials (see below) the assumptions made in TRACE regarding the 3 modes of operational are still relevant

Although not mentioned in the literature it is thought that Traffic Sign Recognition that reads speed signs can also be part of an Advisory ISA system (or voluntary if coupled with ACC).

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 11%, for fatalities saved 17%

http://www.trace-project.org/trace_template.html

** The numbers are for the 'Driver Select' ISA configuration which has been estimated as the most effective

Dedicated ISA site

http://www.isaweb.be/

In the eIMPACT project ISA was covered under Speed Alert

eIMPACT Traffic Impact results D4 Speed Alert - SPE Page 57

http://www.eimpact.info/results.html

For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:

• SpeedAlert is most effective on urban roads, followed by rural roads. It is least effective on motorways.

• More accidents are avoided with SpeedAlert in the non-peak hours (night, rest of the day), because of low traffic volumes making it possible to drive fast.

With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	6
2010 high	9
2020 low	66
2020 high	94

eIMPACT Safety Impact results D4 Speed Alert - SPE

http://www.eimpact.info/results.html

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 40). The table also shows the range of estimates for full penetration.

Table 40: The effect of SPE on fatalities and injuries for full penetration and four scenarios. For full penetration, the range low/high is given.

SPE	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact: most probable[1]	100 / 100	-8.7	-6.2
Impact: low[1]	100 / 100	-4.5	-2.8
Impact: high[1]	100 / 100	-12.8	-8.5
Impact: 2010 low	2 / 4	-0.2	-0.2
Impact: 2010 high	2 / 7	-0.4	-0.2
Impact: 2020 low	30 / 42	-3.8	-2.8
Impact: 2020 high	40 / 61	-5.2	-4.3

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year. All impacts are given for system including speed advice for fixed, variable and dynamic speed limits (SPE2), except 2010 low and high that are for speed advice for fixed limits (SPE1).

[2] Fleet vehicle km equipped

ISA (suite)

The high estimate for the year 2020 would mean 1,076 avoided fatalities and 34,887 avoided injuries.

eSafety Support website provides a list of effectiveness studies and summary results for Speed Alert in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_07.html

UK ISA study (DfT) - trials of the technology in everyday driving and implementation scenarios (Published 2008) - carried out by Leeds University and MIRA Cars Trucks and Motorcycles
http://www.dft.gov.uk/pgr/roads/vehicles/intelligentspeedadaptation/
Carsten O., et al., 2008, Executive Summary of Project Results, Intelligent Speed Adaption, University of Leeds
Extensive study with 11 reports, Executive summary also available

Some key summary results - Cars (20 vehicles)
In the car trials overridable ISA reduced the amount of speeding among every category of user on every road category, except the 60 mph rural roads (comparatively little speeding by the participants in the pre-ISA baseline)
ISA was overridden the most on motorways, followed by built-up areas (20 and 30 mph zones)
So in urban environments there is some tendency for ISA to be overridden on roads where it is perhaps needed most
In terms of driving population sub-groups, male drivers and young drivers overrode the system more, regardless of speed zones - those drivers who in safety terms stand to benefit most from using it.
The fleet drivers tended to override the system most on 70 mph roads, whereas the private motorists overrode most on 30 mph roads.

ISA Acceptability

Despite an initial dip in acceptability, the rating of the ISA system in terms of usefulness and satisfaction improved over time – long-term experience with an ISA system increases acceptability.
Participants rated certain traffic environments, particularly those where it was easier to speed, as being more risky with ISA. Overtaking was also raised as a concern
Nevertheless, in the majority of situations, participants felt that risk was reduced when driving with ISA
Similarly participants believed that attention to the speed limits and to potential hazards (e.g. other road users, pedestrians) and conflicts had increased
Support for ISA implementation reasonably strong, 56% participants approving of compulsory fitting of ISA to all new vehicles
However, those expressing strong intentions to speed demonstrated the most resistance to ISA – voluntary implementation may fail to target those most in need

ISA Benefits for UK
Analysis of future accidents using the favoured Base Combination of crash reduction models indicates that, over a 60-year period from 2010 to 2070, the Market Driven implementation scenario would be expected to reduce
–fatal accidents by 10% (approx 15,400 fatal accidents)
–serious injury accidents by 6% (96,000 accidents)
–slight injury accidents by 3% (336,000 accidents)
Expected to result in benefits 1.9 times greater than the cost
Authority Driven implementation scenario (mandatory usage in 2045) be expected to reduce
–fatal accidents by 26% (approx 43,300 fatal accidents)
–serious injury accidents by 21% (330,000 accidents)
–slight injury accidents by 12% (1.3 million accidents).
Expected to produce economic benefits 3.2 times greater than cost

Motorcycle trials - test track as transfer of technology from cars a challenge
ISA motorcycle created for test track trials
–Advisory - current speed limit via an LED display and flashing LEDs when slightly above the speed limit along with beeping audio alert in the helmet and vibration pulses in the saddle.
–Assisting - counter-action on the throttle, not strong enough to prevent the rider from keeping the throttle open
–Information - Advisory plus travel information (e.g. upcoming traffic lights and junctions)
Riders experiences
Advisory version found to be the most positive in terms of usefulness, but generally less positive about satisfaction with all versions of the system
ISA was perceived by the participating riders as negative in terms of "Joy" and "Overtaking", and was perceived to increase irritation and the sense of being controlled
However, it was perceived to increase traffic safety and decrease accident risk
–thought by the participating riders to be most suitable for young riders, novices and speed offenders
Riders were least likely to be willing to install Assisting ISA
Assisting ISA was the most effective in reducing speeding, particularly in the case of aggressive riders

Truck trial
The car system was transferred to a truck with a dedicated driver.
Unfortunately "the participating driver had a general dissatisfaction with and mistrust of the ISA system. He appeared to start the trial with a negative attitude towards ISA and his experience with the system did not change his beliefs. However, the ISA system was effective in curtailing speeding across all speed limits."

Impact
According to the eSafety Forum Working Group (2005), the implementation of the SpeedAlert (advisory) system can reduce injury accidents by 10-20% and fatal accidents by 17-18%. Trials with ISA in Sweden have shown that its universal use could reduce injuries by up to 20-25% (in urban areas). A summary even mentions effects of 20-30% savings.
Other research has concluded that a dynamic ISA system which prevents drivers from exceeding the speed limit and applies temporary limitations to maximum speed due to congestion, fog, slippery road surfaces, major accidents, out-side schools at drop-off times, etc. could reduce injury accidents by 36% and fatal accidents by 59%.

Cost-benefit assessment
According to COWI et al. (2006) the cost-benefit analysis ratio for Intelligent Speed Adaptation is 3,3.
In comparison, TØI (2002) has calculated a benefit/cost-ratio of between 0.6-0.9 for implementation of intelligent speed adaptation (to observe speed limit) in Norway and Sweden
The main reason why the benefit/cost-ratio is higher in this study than in the TØI study is, according to Elvik (2005), likely to be the fact that increased travel time due to reduced speed is included as a negative benefit in the TØI study. Besides, the share of relevant accidents may be lower in the TØI study which probably uses detailed Norwegian and Swedish accident data. This study is primarily based on general EU data.

References
COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf
eSafety Forum Working Group (2005): Final report and Recommendations of the Implementation Road Map Working Group, Directorate-General Information Society.
TØI (2002): Trafikksikkerhetshåndboken. [http://tsh.toi.no/]

A summary of some ISA results is also given at...
http://ec.europa.eu/transport/road_safety/specialist/knowledge/vehicle/safety_design_needs/cars.htm

Lane Change Assist (LCA)

SYSTEM STUDIED:

LCA - Lane Changing Assistant
(examined by NTUA, comments added by LOUGH)

Comment from Blind Spot tab:
With manufacturers adopting radar for blind spot monitoring
the overlap between Blind Spot monitoring and Lane Change Assist
is getting larger and they may not need to be separated in effectiveness evaluations

Like BS, LCA only provides warning, LKA provides some steering or braking reaction to keep the vehicle in lane

Aims of the system

The system monitors traffic approaching from behind or in the drivers blind spot, will warn the driver if they are about to make a potentially unsafe lane change or turn. The same radar sensors also provide information for a safe door-opening function, warning the driver of any cyclists, people on rollerblades or vehicles approaching from behind before opening the door.

Functions covered by the system (intentional and unintentional)

Detecting a course deviation
Predicting the manoeuvre suited to the layout functioning
Assessing gaps when joining or cutting across a traffic flow after changing direction at low speed

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	The system monitors traffic approaching from behind or in the drivers blind spot
Rupture Phase	The system warns the driver if he is about to make a potentially unsafe lane change lane or turn.
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	The system monitors traffic approaching from behind or in the drivers blind spot, will warn the driver if they are about to make a potentially unsafe lane change or turn
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

LCA (suite)

Technical specifications

Volkswagen
The "Side Assist" system in Volkswagen cars monitors the area to the left and right of the vehicle and up to 50 m behind it and warns the driver of a potentially hazardous situation by means of flashing warning lights in the exterior mirrors (14).

A thorough explanation of the **Audi** radar based system is given by Audi for EuroNCAP
http://www.euroncap.com/rewards/audi_side_assist.aspx
The Audi system does not give an audible warning when the indicator is activated unlike the Mercedes system. It monitors around 70 metres behind the vehicle

References
http://news.thomasnet.com/fullstory/Driver-Assistance-System-helps-ensure-safe-lane-changing December 2010
http://www.vw.ca/ca/en_ca/inside/glossary/_side_assist__lane1.html December 2010

Bosch have an ultrasonic system called side view assist
http://www.automotiveqr.com/news_detail.php?Side-View-Assist-the-blind-spot-assistant-Bosch-ultrasonic-sensors-for-safe-lane-changes-Global-debut-in-the-new-Citro-n-C4-622
..capable of registering objects 3 metres to the side and diagonally to the rear of the vehicle. The Side View Assist system can then warn the driver in two ways: first optically, and then, if the driver fails to react, acoustically (if the turn signal is activated) .
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrkomfortsysteme/fahrerassistenzsysteme_2/ueberwachungdestotenwinkels/SideViewAssist.asp

Safety Impacts of Lane Change Assistant (Warning) (LCA)
Mechanism 1: Direct in-car modification of the driving task
The system supports the driver to allocate attention resources according to the driving task by warning for vehicles besides or at the rear when starting a lane change. When a collision happens, the severity will be less because evasive action has already
Mechanism 2: Indirect modification of user behaviour
There will be effects on both driver behaviour and overall alertness level because drivers will experience the presence and the activity of the system frequently and directly in everyday driving.
Mechanism 3: Modification of road user exposure
A tiny amount of extra exposure will be generated.
Mechanism 4: Modification of modal choice
A slight amount of modal shift from public transport to the car is to be expected as drivers know that the system is there to support them.
eIMPACT, Deliverable D4, Impact assessment of Intelligent Vehicle Safety Systems
http://www.eimpact.info/results.html

Delphi Side Detection System
http://delphi.com/manufacturers/auto/safety/active/sds/

Continental System
http://www.conti-online.com/generator/www/de/en/continental/automotive/themes/passenger_cars/chassis_safety/adas/bsd_en.html

No LCA systems found to be currently implemented on motorcycles.

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 3.07%, no figure given for fatalities - Lane Changing Assistant
http://www.trace-project.org/trace_template.html

eIMPACT Traffic Impact results D4 page 63 - Lane Change Assistant (Warning) LCA
http://www.eimpact.info/results.html
No direct traffic effects are expected for Lane Change Assistant (Warning) (LCA), a system that gives warning for nearby vehicles in the back or next to the vehicle just before a lane change is started: the presence of the system does not influence choice of speed, following distance etc.
For determining the indirect effects, assumptions have been made based on the safety impact analysis. These assumptions are:
- The system will predominantly be used on motorways and rural roads. It is therefore far less effective on urban roads.
- Lighting conditions and traffic volume have no special effects on effectiveness.

With these assumptions, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	2
2010 high	7
2020 low	19
2020 high	48

eIMPACT Safety Impact results D4 page 78 - Lane Change Assistant (Warning) LCA

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 22).
The table also shows the range of estimates for full penetration.

Table 22: The effect of LCA on fatalities and injuries for full penetration and four scenarios. For full penetration, the range low/high is given.

LCA	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-2.2	-4.8
Impact low[1]	100 / 100	-1.8	-3.1
Impact high[1]	100 / 100	-2.5	-6.4
Impact 2010 low	0.2 / 0.03	0.0	0.0
Impact 2010 high	0.9 / 0.8	0.0	-0.1
Impact 2020 low	4 / 4	-0.2	-0.4
Impact 2020 high	10 / 15	-0.4	-1.0

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.
[2] Fleet vehicle km equipped

The high estimate for the year 2020 would mean 86 avoided fatalities and 8,596 avoided injuries.

FMCSA-MCRR-05-005 Concept of Operations and Voluntary Operational Requirements for Lane Change Warning System (LCWS) On-Board Commercial Motor Vehicles [FMCSA05a]
ISO 17361:2007 Intelligent transport systems – Lane departure warning systems –Performance requirements and test procedures [17361]

Assumptions from TRACE... These assumptions still seem to be reasonable
We suppose LCA can detect vehicles, cyclists and pedestrians in a distance of 50 meters behind the vehicle and in the blind spot, according to WP6. We know that it could be increased to 120m by the addition of a special 3rd radar sensor. But we make the hypothesis that the range of the radar is 50 meters long, according to WP6.
The sensor/radar technology used means that LCA is unaffected by darkness, soiling or other adverse weather conditions.

Lane Keeping Assist (LKA)

SYSTEM STUDIED:

LKA - Lane Keeping Assistant
(examined by NTUA, comments added by LOUGH)

An extension of Lane Departure Warning - additionally to warning the system keeps the vehicle in lane

Aims of the system

Lane keeping assistance (LKA) systems actively support the driver in maintaining lane position. These systems monitor the vehicles lane position with image processing technology in the same manner as lane departure warning systems. LKA provides additional torque to the steering wheel, which increases the resistance in the steering wheel. This makes it more difficult for the vehicle to drift,therefore reducing the occurrence of minor variations in lane position. This minimises the need for the driver to make small corrections in lane position, which as Bishop (2005) notes, can be a source of fatigue in long journeys on highways. LKA systems are typically only active at high speeds and on relatively straight roads. If sharp corners are detected (i.e. through frequent steering input from the driver) the system will disengage. Additionally, the system requires continuous driver steering input to ensure the driver is remaining vigilant and attentive.

Functions covered by the system (intentional and unintentional)

Detecting a course deviation
Vehicle control (handling)
Diagnosing driver state (alcohol, fatigue, health, attention, etc.)
Detecting a user outside the frontal field of vision (behind, on the sides, or in blind spot)

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	System monitors lane markings - gives a visual indication to driver if system is not able to detect the lane markings
Rupture Phase	LKA provides additional torque to the steering wheel, which increases the resistance in the steering wheel or brakes one side of the vehicle
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	Also warns as with LDW systems
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	LKA provides additional torque to the steering wheel, which increases the resistance in the steering wheel or brakes one side of the vehicle. This makes it more difficult for the vehicle to drift, therefore reducing the occurrence of minor variations in lane position. This minimises the need for the driver to make small corrections in lane position
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		Either introduces steering wheel torque or brakes one side of the vehicle

Note for evaluation: As with many systems risk compensation is possible if drivers rely on the system.

LKA (suite)

Technical specifications

Lexus - Steering system

The Lexus LS 460 and LS 460 AWD were the first cars in their class to be offered with Lane Keeping Assist. This system uses a stereo imaging camera to monitor white line road markings (subject to weather, climate and road conditions). Lane Keeping Assist offers two functions:
- Lane Departure Warning: if the possibility of inadvertent lane departure is detected, the system provides an audio-visual warning and applies a brief corrective steering force.
- Lane Keep: This can provide additional steering torque to help the driver apply the appropriate steering input to keep the vehicle within the lane.

http://www.lexus.eu

The active blind spot feature operates at speeds of between 20- and 125mph, although the flashing triangle will be given right up the car's maximum speed of 155mph.
http://www.whatcar.com/car-news/new-safety-systems-for-mercedes-benz/251580

Volkswagen - Steering system

Thorough description with some limitations mentioned...
Lane Assist can be switched on and off by the driver. At the beginning of a new journey, the system restarts with the last on/off status: if the system has been switched off, it remains off at the beginning of the next journey. The system does not switch on by default at the start of a journey.
Lane Assist relies on its camera to be able to distinguish road markings. In some cases, this might not be possible owing to poor contrast: driving towards a low sun, for example, or where there is little distinction between a lane marking and the side of the road. Similarly, Lane Assist may be unable to detect unusual lane markings such as in road works. The maximum corrective steering torque is also limited to ensure that the driver can remain in control of the vehicle. If a higher torque is needed to bring the car back into lane, Lane Assist will be unable to correct the lane departure but, in such circumstances, it will warn the driver.
http://www.euroncap.com/rewards/vw_lane_assist.aspx
Also available on Golf
http://www.volkswagen.co.uk/technology/proximity-sensing/lane-assist

Infiniti's Lane Departure Prevention (LDP) - Braking system

Thorough description with some limitations mentioned...
Lane Departure Prevention must be switched on at the start of each journey. However, even without LDP switched on, the driver will still be given the audible and visual warnings for an unintended lane departure; in addition to the warnings, activation of the corrective braking action of LDP requires a positive 'on' action on the part of the driver.
http://www.euroncap.com/rewards/infiniti_ldp.aspx

Honda Lane Keep Assist System (LKAS) - Steering system

http://www.topgear.com/uk/car-news/Honda-Accord-lane

New Ford Focus - Steering system

http://www.ford.co.uk/Cars/Focus/Safetyandsecurity

Bosch Lane Keeping Support

http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/asr/spurassistenzsysteme/spurhalteassistent/spurhalteassistent.asp

Safety impacts of Lane Keeping Assistance (LKA)

Mechanism 1: Direct in-car modification of the driving task

Single-vehicle accidents will be reduced if the driver obeys the active steering wheel signal. If designed properly, this signal will not confuse the driver, so there is no inherent ergonomic problem.
The accident severity of relevant accidents will decrease because the driver will, in a number of cases, already be in the middle of an evasive action.
Mechanism 2: Indirect modification of user behaviour
Effects are expected on both behaviour (lane keeping will become more sloppy) and on general alertness (driver will become less attentive because he knows system watches over him, and initiates action if needed). Both of these exist because the driver will experience system actions directly and relatively often, even in everyday driving.
Mechanism 3: Modification of road user exposure
Some increase in exposure is expected because drivers will go out more often under relatively bad conditions.
eIMPACT, Deliverable D4, Impact assessment of Intelligent Vehicle Safety Systems

No LKA systems found to be currently implemented on motorcycles.

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 5.67%, no figure given for fatalities - Lane Keeping Assistant
http://www.trace-project.org/trace_template.html

eIMPACT Traffic impact results D4 page 51 - Lane Keeping Support (LKS)

http://www.eimpact.info/results.html
For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:
• The system is most effective on rural roads, followed by motorways. LKS is far less effective on urban roads.
• Lighting conditions and traffic volume have no special effects on effectiveness.
With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	8
2010 high	21
2020 low	28
2020 high	96

eIMPACT Safety impact results D4 page 78 - Lane Keeping Support (LKS)

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 24). The table also shows the range of estimates for full penetration.

Table 24: [illegible] for full penetration and four scenarios. For full penetration, the range [illegible] is given.

LKS	Penetration rate for light/heavy vehicles (%)[2]	Reduction in Fatalities (%)	Reduction in Injuries (%)
Impact most probable[1]	100 / 100	-15.2	-8.8
Impact low[1]	100 / 100	-8.7	-3.5
Impact high[1]	100 / 100	-21.8	-13.8
Impact 2010 low	1.1 / 0.3	-0.2	-0.1
Impact 2010 high	2.9 / 1.4	-0.4	-0.3
Impact 2020 low	6 / 6	-0.9	-0.6
Impact 2020 high	21 / 23	-3.3	-2.5

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.
[2] [illegible]

The high estimate for the year 2020 would mean 678 avoided fatalities and 17,296 avoided injuries.

eSafety Support website application database does not separate LKA
http://www.esafety-effects-database.org/applications.html
Trucks
If a truck strays out of its lane, a critical situation can easily arise. In fact, official statistics show that one in five accidents involving commercial vehicles is the result of a sideways collision.
Lane Departure Warning (LDW) detects the lane up to 40m ahead of the vehicle with a camera, optimized for this specific application. LDW will warn the driver through acoustical or haptic signals like vibrations if he or she is on the verge of inadvertently drifting out of the lane.
In combination with an electric intervention in the steering LDW becomes an active Lane Keeping Assistant (LKS). A smooth recommendation in the steering is another warning to the driver but the driver's decision takes priority at all times. Through these system interventions important seconds are gained which can save lives, especially when at the edge of the verge. Because of a legislative initiative this type of system may become obligatory for all new commercial vehicles registered within the EU as of 2013.
Benefits:
Avoidance of dangerous situations caused by inattention
Effective warning through multileveled HMI-concept
Avoidance of tire damage and the resulting breakdown costs
Optional upgrading with Intelligent Headlamp Control (IHC)
Optional upgrading to Traffic Sign Recognition

http://www.conti-online.com/generator/www/de/en/continental/automotive/themes/commercial_vehicles/safety/adas/ldw/ldw_lks_en.html
Assumptions from TRACE... These assumptions still seem to be reasonable although the systems are more often now camera based than infrared

Night Vision (NV)

SYSTEM STUDIED:

NV - Night Vision
(examined by LOUGH)

Aims of the system

To allow drivers to see animals, pedestrians and cyclists further in darkness (sometimes poor weather conditions) than is possible with conventional headlights.
To allow drivers to see in darkness, dark coloured animals and pedestrians and cyclists in dark clothing

With normal dipped lights, the driver's visibility is reduced to around 40 meters at night.
http://ec.europa.eu/information_society/activities/intelligentcar/technologies/tech_15/index_en.htm

Range of function depends on the system - current market range is from 150 metres to 300 metres

Mercedes E class

Functions covered by the system (intentional and unintentional)

Visual identification of animals, pedestrians or cyclists earlier than possible with conventional headlights - more time to react if required
Visual identification of animals, pedestrians or cyclists if in dark clothing - possibly not possible to see with conventional headlights
Prevents dazzle to oncoming traffic that can be caused by using full head lights at night
Pedestrian detection is available on some systems - image is analysed and moving objects (such as pedestrians) highlighted

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:
1. The Driving Phase, during this phase no unexpected event or hazard has occurred or been detected.
2. The Rupture Phase, an unexpected event or hazard occurred which surprised the road user.
3. The Emergency Phase is defined as the distance and time between the rupture phase and collision.
4. The Crash Phase, when the impact is taking place.
5. The Rescue Phase is the period after the collision during which the passengers are being evacuated from the vehicle.

Phases	Evaluation of actions
Driving Phase	Acting to improve vision in darkness and poor visibility improved vision reduces driver load
Rupture Phase	Earlier identification of animals, pedestrians and cyclists and increased possibly of avoidance
Emergency Phase	
Crash Phase	
Rescue Phase	

Note for evaluation: Clearly this depends on the driver looking at the screen at the appropriate time. Mercedes, Audi and Toyota have the screen between the dials, BMW in the centre binnacle. Honda screen (mirror) emerges on top of instrument binnacle. Only Audi mention an audible warning.

Note for evaluation: Some systems work in poor weather conditions (passive) whilst others are not so effective (active) - see tech spec below

Note for evaluation: Passive systems can only see live objects whilst active can see fallen trees and rocks etc - see tech spec below

Note for evaluation: Often in high specification cars in conjunction with advanced headlight systems anyway (see AAFLS tab)

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		Can alert that pedestrians, cyclists or animals are present
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	
	Mediatised Mode	
Automation		

NV (suite)

Technical specifications

A good summary of Night Vision technologies is given at…
http://electronics.howstuffworks.com/gadgets/automotive/in-dash-night-vision-system3.htm
Main points: Two systems - BMW - Mercedes
Mercedes-Benz uses an active system or near-IR system that illuminates the night with projected infrared light. Can see warmer living things just as clear as it can spot colder, dead animals or non-living objects.
Maximum effective range of less than 600 feet (183 meters). Doesn't handle fog well, while the BMW's FIR system can see through the dense conditions.
BMW's 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) and can pan in the direction the vehicle is heading.

http://news.mercedes-benz.co.uk/article-8316/innovations/night-view-assist-plus-technology-offers-motorists-incredible-images.html
The system has a range of 150 metres, which means motorists can see three times further than when turning on their conventional dipped headlights and it can also distinguish between still and moving objects.

Night Vision (including Pedestrian Detection)

Bosch system for Mercedes - The infrared headlights have a range of 150m, three times more than common low-beam headlights. When a moving object, for example a pedestrian, is detected, it is highlighted on the screen display, allowing early reaction by the driver.
http://www.traffictechnologytoday.com/news.php?NewsID=17674

Mercedes

BMW

Autoliv system for BMW -
The second generation Night Vision system uses Autoliv's far-infrared sensor. Mounted in the grille of the new BMW 7-Series, the sensor scans the road for pedestrians more than two times further than the headlight range.
To provide an extra margin of safety the system will also analyze the scene content and vehicle dynamics to determine if the pedestrian is at risk of being hit by the vehicle. If the pedestrian is at risk, an alert is then sent to the driver with enough time for the driver to react.

When driving at slower speeds in the city, where higher pedestrian traffic is anticipated, the system automatically monitors a smaller and shorter corridor of the road ahead to prevent too many warnings due to higher pedestrian traffic. In the countryside, while driving at higher speed, the system will monitor a wider and deeper corridor of the road.
Diagram shows range to be 300 metres
http://www.traffictechnologytoday.com/news.php?NewsID=8382

Audi - passive system like BMW can 'see' 300 metres - pedestrian marked in red colour and the driver of the car receives an audible warning
http://www.audi.co.uk/new-cars/a8/a8/driver-assistants/night-vision.html

Toyota System (article from 2008)
Night View - Yellow box(es) around pedestrians in range
The system contains multiple sets of image data on the shapes of pedestrians, which is compared with the shape of images shot by the system. When the system determines that a pedestrian is present, yellow frames are displayed around the pedestrian as well as the entire image on the windscreen. The yellow frame surrounding the entire image helps drivers to recognize the presence of pedestrians without needing to look at the LCD display.
The system only works at speeds below about 65km/h (40mph) and does not operate well in the rain, but Toyota is working on improving its system to detect animals and bicycles, while also lowering the cost.
http://www.traffictechnologytoday.com/news.php?NewsID=5868
This article shows the range of night vision - over 200 metres range, pedestrian detection 150 metres
http://www.toyota-global.com/innovation/safety_technology_quality/safety_technology/technology_file/active/night_view.html

Honda - Intelligent Night Vision
Uses FIR (passive) system for pedestrian detection up to 80 metres in 12 degree arc
Screen' is actually mirror that emerges from on top of instrument binnacle
Puts red box around detected pedestrians and audible warning
http://world.honda.com/HDTV/IntelligentNightVision/200408/

Bosch Night Vision Plus
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrkomfortsysteme/fahrerassistenzsysteme_2/nightvision/nightvisionplus.asp

Autoliv Night Vision 2
http://www.autoliv.com/wps/wcm/connect/autoliv/Home/What+We+Do/Night%20Vision%20System

NV (suite)

Future developments - Head Up Displays
When the technology review was done for EC TRACE Night Vision was closely associated with Head up displays - and at the time Chrysler had such a product on the market.
Whilst head up displays are available on vehicles it is only at the moment for information on vehicle status or navigation
http://www.bmw.com/com/en/newvehicles/x6/x6/2006/allfacts/ergonomics_hud.html
http://www.citroen.co.uk/new-cars/car-range/citroen-c6/driving-assistance/#/new-cars/car-range/citroen-c6/driving-assistance/

It is clear that development is taking place (as below) but is does not seem that night vision on the market is as linked with head up display as it was when TRACE took place.
http://media.gm.com/content/media/us/en/news/news_detail.brand_gm.html/content/Pages/news/us/en/2010/Mar/0317_hud

More detail on the specification of the actual sensors is available in this PreVENT report...
http://www.prevent-ip.org/en/public_documents/deliverables/d13400_state_of_the_art_of_sensors_and_sensor_data_fusion_for_automotive_preventive_safety_applicat.htm

A good summary report is available at...
http://www.autoliv.com/wps/wcm/connect/autoliv/Home/What+We+Do/Research/Reports%20and%20Papers
Night Vision: Requirements and possible roadmap for FIR and NIR systems by Jan-Erik Kallhammer, Autoliv Research, Sweden

Previous evaluations

Are there any evaluation been realized ? if yes, provide a link)
TRACE D4.3 - Estimated effectiveness for serious injuries saved 4.9%, for fatalities saved 3.5%
http://www.trace-project.org/trace_template.html

eIMPACT Traffic impact results D4 page 62
Assumptions
- NightVisionWarn is most effective on rural roads, followed by motorways. The system is generally not needed on urban roads.
- The system only works when it is dark.
- The system is most effective in low traffic densities
With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	0
2010 high	1
2020 low	3
2020 high	7

eIMPACT Safety impact results D4 page 80

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 26). The table also shows the range of estimates for full penetration.

Table 26. The effect of NVW on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given.

NVW	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-2.9	-2.0
Impact low[1]	100 / 100	0.6	0.4
Impact high[1]	100 / 100	-4.2	-4.3
Impact 2010 low	0.2 / 0.03	-0.01	-0.01
Impact 2010 high	0.5 / 0.8	-0.03	-0.03
Impact 2020 low	4 / 4	-0.1	-0.1
Impact 2020 high	10 / 16	-0.4	-0.3

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.

[2] Fleet vehicle km equipped

The high estimate for year 2020 would mean 73 avoided fatalities and 2.542 avoided injuries.

http://www.eimpact.info/results.html

Nothing on night vision on eSafety Effects database
http://www.esafety-effects-database.org/applications_02.html

Night Vision not included in COWI report
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

Anecdotal articles can be found on the internet that question effectiveness - in this article due to very effective headlights anyway and the screen not being in the drivers view
http://www.autoexpress.co.uk/carreviews/grouptests/245887/night_vision_mercedes.html

Predicitive Brake Assist (PBA)

SYSTEM STUDIED:

PBA - Predictive Brake Assist

Aims of the system

Uses the vehicle's sensors from ACC and CA (predominantly radar) to detect impending emergency braking situation
Pilot pressure is applied to the brake system so that the required brake pressure can be generated more quickly, and the brakes are applied very gently so that the driver doesn't notice.
In addition PBA lowers the triggering threshold for the hydraulic brake-assist system.
After this initial phase the system then acts like Brake Assist (tab 4 BA)

Functions covered by the system (intentional and unintentional)

Pre-charges braking system
Lowers threshold limit for brake assist system

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Monitoring
Rupture Phase	Detects a possible emergency situation and prepares braking system
Emergency Phase	When driver applies brakes interprets that this is a result of a critical situation and automatically triggers the brake assist system.
Crash Phase	Avoided collision or reduced crash severity and possibly mitigated injuries
Rescue Phase	

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	After sensing that the driver intends full emergency braking, automatically applies brake assist system
	Mediatised Mode	no
Automation		Prepares braking system

Technical specifications

Sensing specification depends on whether integrated with ACC or CA system (see tab 2 ACC and tab 6 CA)
For example this is an integral part of the Mercedes PreSafe Brake system

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 0.2%, no figure given for fatalities saved - Predictive Assist Braking
http://www.trace-project.org/trace_template.html

Vulnerable Road User Protection (VRU)

SYSTEM STUDIED:

VRU - Vulnerable Road Users Protection
(examined by NTUA, comments added by LOUGH)

The definition of VRU (SAVE-U) being fundamentally Collision Avoidance that can detect pedestrians, cyclists and animals is kept from TRACE.

The only system on the market - Volvo - can only detect pedestrians currently

Aims of the system

The system calculates in a matter of seconds the movement of pedestrians within the "capture" zone which can be up to 30 meters away from the vehicle. The camera tracks the pedestrian movement and the information is correlated with the data received from the radar network

Description of system given at.. (pedestrian element)
http://www.fratcham.org/adas/index.jsp?page=1254

Functions covered by the system (intentional and unintentional)

In addition to functions provided by CA....

Detection of pedestrians, cyclists and animals - potential collision
Warning to driver (audible and visual)
Automatic braking

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	The system calculates the movement of pedestrians within the "capture" zone. The camera tracks any pedestrian movement and the information is correlated with the data received from the radar network
Rupture Phase	If a pedestrian is detected and calculated as being in a collision path with the vehicle an audible and visual warning is given to the driver
Emergency Phase	If the driver does not brake the vehicle applies full braking automatically
Crash Phase	Collision is either avoided or crash severity is reduced and injuries possibly mitigated
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: it suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	Audible and visual
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		Applies full brakes if driver does not

Note: Volvo system projects row of warning lights onto lower windscreen

VRU (suite)

Technical specifications

VTT Technical Research Centre of Finland has developed a VRU (Vulnerable Road User) system for warning vehicle drivers. The system detects pedestrian, bicycles or animals, and sends a warning message to drivers about living objects in a dangerous traffic environment such as a motorway exit. The system is part of a cooperative traffic safety system, developed by the SAFESPOT project, which facilitates communication between vehicles and the traffic infrastructure.
This is probably the first roadside sensing system that detects living objects using thermal imaging technology interfaced as part of a cooperative intelligent traffic safety system. The advantage is that an expensive thermal camera is not needed in the vehicle; a warning of a risky situation can be transmitted to each passing identification is based on a thermal vision system that uses image analysis (speed, size, shape and temperature information) to detect humans and animals. The system is integrated into a sensor fusion module which sends data to a local dynamic maps database modelling the driving environment. The system is being tested on a motorway in Turin, Italy.
http://www.ertico.com/new-co-operative-vru-detection-system-developed-by-vtt
http://viewer.zmags.com/publication/95aaedea#/95aaedea/33

Volvo - Collision Warning with Full Auto Brake and Pedestrian Detection,
Object is confirmed by both the radar and the camera.
Pedestrian detection with full auto brake can avoid collisions with pedestrians at speeds up to 35 kilometres per hour, if the driver does not personally react in time. At higher speeds, it is a matter of reducing the car's speed as much as possible prior to colliding.
In case of an emergency, the driver is first alerted by a warning signal combined with a blinking light on the wind-shield's head-up display. The car's brakes are simultaneously pre-loaded. If the driver does not react to the warning and a collision is imminent, full auto brake is activated. The system uses information from a radar and an advanced camera that detects human shapes and movement patterns
http://www.volvocars.com/intl/top/about/corporate/volvo-sustainability/safety/pages/pedestrian-detection-with-full-auto-brake.aspx
http://www.themotorreport.com.au/45127/2010-volvo-s60-to-introduce-collision-avoidance-system. December 2010
http://www.volvoclub.org.uk/press/releases/2008/pedestrian_detection.shtml
Video.. http://singularityhub.com/2011/02/22/volvos-new-pedestrian-detector-brakes-car-for-you-video/
http://www.physorg.com/news/2011-02-volvo-pedestrian.html

Lexus - Active Pedestrian Detection System - very little technical information
http://www.lexus.com/models/LS/features/safety/advanced_precollision_system_apcs_with_driver_attention_monitor.html

Previous evaluations

Assumptions in TRACE
SAVE-U detects pedestrians or cyclist in movement up to 30m in front of the vehicle according to the road wight.
After having analyzed the situation, SAVE-U informs the driver or starts an emergency braking if there is any collision risk.
SAVE-U is efficient by night. But its camera is inefficient when visibility is limited by an object (it cannot see through it).

These assumptions are still true. It is not possible to find any reference to the actual distance that the Volvo system monitors
The Volvo system only detects pedestrians above 80cm
Can avoid collisions up to 35 kph travelling speed

TRACE D4.3 - Not chosen as a technology for evaluation
http://www.trace-project.org/trace_template.html

eIMPACT Traffic impact results D4 page 61 - Pre-Crash Protection of Vulnerable Road users (PCV) (Description page 116)
http://www.eimpact.info/results.html
For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:
• The system is far more effective on urban roads than on rural roads (since the probability of a collision with a pedestrian is largest in urban areas).
The system is not effective on motorways.
• The system is more effective in dark conditions.
• The system is more effective at low traffic volumes.
With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010	0
2020 low	2
2020 high	5

eIMPACT Safety impact results D4 page 72 - Pre-Crash Protection of Vulnerable Road users (PCV)

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 20). The table also shows the range of estimates for full penetration.

Table 20: The effect of PCV on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given.

PCV	Penetration rate for light/heavy vehicles (%)[2]	Reduction in Fatalities (%)	Reduction in Injuries (%)
Impact most probable[1]	100 / 100	-1.8	-1.9
Impact low[1]	100 / 100	-1.3	-1.1
Impact high[1]	100 / 100	-2.3	-2.8
Impact 2010 low	0.1 / 0.1	0.00	0.00
Impact 2010 high	0.4 / 0.1	0.00	0.00
Impact 2020 low	8 / 8	-0.1	-0.1
Impact 2020 high	13 / 14	-0.2	-0.2

[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year.
[2] Fleet vehicle km equipped

The high estimate for the year 2020 would mean 39 avoided fatalities and 1,918 avoided injuries.

Pedestrain Collision avoidance not included seperately to Collision Warning in COWI report
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

Tyre Pressure Monitoring and Warning (TPMS)

SYSTEM STUDIED:

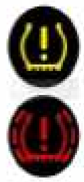
TPMS - Tyre Pressure Monitoring and Warning
(examined by NTUA, comments added by LOUGH)

Aims of the system

The system for Tyre Pressure Monitoring detects small pressure fluctuations locates the affected tires and informs the driver with warnings of varying urgency. A co-rotating wheel module with an integrated valve measures type pressure and temperature and transmits these data as an HF radio signal.
Other systems use the ABS sensors to detect a wheel with a reduced rolling radius.

Functions covered by the system (intentional and unintentional)

Diagnosing vehicle state (mechanical)



Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	The system detects small pressure fluctuations, locates the affected tires and informs the driver with warnings of varying urgency
Rupture Phase	If a vehicle is traveling with correctly inflated tyres its dynamic performance in a rupture or emergency phase is likely to be better than if the tyres are not correctly inflated - if the driver reacts
Emergency Phase	If a vehicle is traveling with correctly inflated tyres its dynamic performance in a rupture or emergency phase is likely to be better than if the tyres are not correctly inflated - if the driver reacts
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: it suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		-
Mutual Control	Warning Mode	The system for Tyre Pressure Monitoring detects small pressure fluctuations locates the affected tires and informs the driver with warnings of varying urgency
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

TPMS (suite)

Technical specifications

A Tyre Pressure Monitoring System (TPMS) helps to improve vehicle safety, and aids drivers in maintaining their vehicle tire pressures. Properly maintained tires help with vehicle safety, performance and economy. In the U.S., the National Highway Traffic Safety Administration (NHTSA) has estimated that every year, 533 fatalities are caused by tire defects in road accidents. Adding TPMS to all
Generally speaking, direct tire-pressure monitoring systems may offer the following features:
Measure (and may display) tire air pressure, with an accuracy able to detect under-inflation conditions of less than 25% of the recommended cold inflation pressure
Measure and display tire air temperature (optional)
Locate tire involved in pressure defect (optional)
React to fast and slow leaks (less than 5 s) for early warning
Do not require initialization or zero button, i.e., self-learning (optional)
Can monitor spare-tire pressure
Can monitor tire pressure when stationary (direct TPMS only)

Indirect detects the change in rolling radius of a wheel as the pressure decreases - compared to other tyres

Ford - Examples of two approaches to tyre monitoring
Indirect
The **Ford Focus** and the **Ford Kuga** can both be specified with a tyre **Deflation Detection System** (DDS), which uses the same sensors as the anti-lock brake/electronic stability programme systems to detect when one or more tyres are becoming deflated.
When the DDS system identifies that a tyre is deflating, it triggers alarm chime and visual warning message to advise the driver to stop and check the tyre pressures and investigate the cause.
Direct

The **Ford Mondeo, S-MAX** and **Galaxy** are available with a system ideally suited to Ford's sophisticated large car range. The **Tyre Pressure Monitoring System** (TPMS) uses sensors in each wheel to measure the actual pressure in all four tyres, and compares these pressures against the recommended settings. If deflation is detected the driver is warned via an alarm chime and visual warning in the instrument display.
http://www.jacksonsford.co.uk/news/latest-news/news-archive/tyre-pressure-monitoring-system/

Toyota
Not all vehicles use the same TPMS system or sensors, however the Toyota Highlander has a pre-programmed sensor as part of the valve stem of the wheel. This computerized valve stem monitors the air pressure in each tire and sends a radio signal to the computer of the Highlander. If the air pressure in one or more of the tires goes below 20 percent or 6 to 8 pounds of the other tires, this TPMS warning light will illuminate on the dash. The Highlander may even have a sensor incorporated with a full-sized spare tire, so be sure to have that checked, as well. Each sensor is part of a valve stem, and special-care needs to be applied to these sensors when changing tires or repairing tires. The sensors are attached through the valve stem hole of the rim by hex head nuts. These sensors should be removed from the valve stem position by removing the hex head nut and dropping the sensor into the bladder of the tire before breaking the tire down to replace or repair. Otherwise, there is a risk of the bead of the tire coming off the rim that could incur damage to the sensor (17).
http://www.ehow.com/how-does_4628738_tire-pressure-warning-system-works.html déc-10

TPMS are mandatory on cars in the United States
http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/TPMSfinalrule_6.pdf

TPMS is currently implemented on some BMW and Honda motorcycles.

Previous evaluations

TRACE D4.3 - Estimated effectiveness for serious injuries saved 1.35%, no figure given for fatalities - Tyre Pressure Monitoring and Warning
http://www.trace-project.org/trace_template.html

eIMPACT Safety impact results D4 not selected as one of the 12 technologies
http://www.eimpact.info/results.html

eSafety Support website no listing for TPMS
http://www.esafety-effects-database.org/applications.html

Impact
In TÜV (2003) it is assumed that all accidents related to tyre pressure problems can be avoided when implementing a tyre pressure monitoring system.
Tyre pressure monitoring systems will naturally not have any effect on the severity of accidents if the accidents occurs.

Cost-benefit assessment
According to COWI et al. (2006) the cost-benefit analysis ratio for Tyre Pressure Monitoring and Warning is 0,04.
Tyre Pressure Monitoring implementation costs significantly exceed the resulted benefits, although it is assumed that all potential accidents are avoided if all vehicles have an active TRMS. The benefit/cost-ratio is estimated at 0.05, which is in line with the findings of TÜV. TÜV (2003) estimate a benefit/cost-rate of 0.0185-0.0554 depending on the price of the system.

References
COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf
TÜV (2003): Motor vehicle tyres and related aspects, DG Enterprises, European Commission.

The assumptions made in TRACE still seem relevant...
TMPS monitors pressure, speed, temperature, and damaged tire. TPMS won't detect worn tire.
We make so the hypothesis that TPMS can detect overload when temperature will increase (only if the initial pressure is correct).
TPMS will inform the driver when there is an under-pressure at a threshold of -0.5bar and an over-pressure at a threshold of +0.5bar.
TPMS will be useful to avoid loss of control linked to an under-pressure.

Traffic Sign Recogniton (TSR)

SYSTEM STUDIED:

TSR - Traffic Sign Recognition
(examined by NTUA, comments added by LOUGH)

Aims of the system

The system incorporates a digital display which informs the driver of all the respectively applicable road signs along the road.
In particular speed limits signs are recognised and then displayed to the driver

Effectively TSR forms a speed alert or advisory ISA system (or voluntary ISA if coupled with ACC)

*Note in TRACE it was assumed that this technology was for the motorway
There is no indication that is the case and this technology is more effective on non-motorway roads where it can warn of hazards such as bends and in particular speed limits when the driver might be otherwise distracted

Functions covered by the system (intentional and unintentional)

Support if the driver is tired or misses the road sign through distraction
When the conditions of visibility are limited
Warning of exceeding speed limit
Speed reduction if coupled with ACC

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	A digital display informs the driver of all the respectively applicable road signs along the road Warning on many systems if speed limit exceeded
Rupture Phase	Possibly lower speed if driver has lowered speed due to previous warning or of a hazard - more possibility to react
Emergency Phase	Possibly lower speed
Crash Phase	Possibly lower speed - lower crash severity
Rescue Phase	-

*note: the first systems only read speed limit signs

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		The system incorporates a digital display which informs the driver of all the respectively applicable road signs along the road
Mutual Control	Warning Mode	Warning to driver if speed limit exceeded
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		If coupled with ACC the system could lower speed

TSR (suite)

Technical specifications

The Traffic Sign Recognition System (TSRS) is based on colour vision. Only traffic signs that are highly important with respect to the driving context are shown to the driver, and different levels of emphasis, tied to the urgency of the warning, are applied to the signal to the driver. The speed limit sign, for example, will be displayed only if the vehicle exceeds the maximum speed allowed, or a traffic sign will be shown if the vehicle is approaching it at a potentially dangerous speed and, in both cases, there will be a different degree of importance (visual, acoustic, visual and acoustic, flashing, etc.) in line with the danger of the situation. This solution consists in a detection and classification of traffic signs based on a three-level algorithm and consisting of: colour segmentation, shape recognition and neural network.
The final objective of the algorithm is to detect and classify just about all the traffic signs along the way. Colour segmentation was included for the purpose of obtaining a reply in real time, since segmentation based on colour is faster than the one based on shape. Two different methods are used to detect the shape; one is based on diagrams that overlap simple shape models while the other is based on the detection of the outline and of the geometric contour. The set of traffic signs taken into consideration was subdivided into different categories, in accordance with their shape and colour. Finally, a neural network was built and instructed for each group of traffic signs. Special devices are used to reduce dependence on external lighting conditions: this is extremely important in terms of good performances in the early morning and late afternoon hours, when sunlight presents a considerable deviation towards the red spectrum. (18)
Mobileye's TSR is currently available from 2008 on the BMW 7 Series as a vision and Satellite Navigation fusion system, together with Mobileyes Lane Departure Warning and Intelligent Headlight Control functions. Additionally it is in series development for multiple other vehicle makers globally for a range of vehicles with a multiple functions bundles as both vision-Satellite Navigation fusion and vision only systems. Mobileye has developed a Traffic Sign Recognition (TSR) algorithm based on its core competence in vehicle and pedestrian detection. The algorithm shares the attention, classification and tracking framework of those other modules and uses the robust classifiers developed in those applications, trained on different examples. The system recognizes and interprets various traffic signs using vision-only information. The Mobileye TSR detects virtually all of the signs that are visible to the driver. The system uses camera based object recognition and can be developed to compare the data with those coming from digital maps of a navigation system and traffic services. This will offer additional system robustness, especially in cases where the vision system cannot provide the needed information, such entering urban areas which are not marked by traffic signs.
The vision based system has an additional advantage of being able to support navigation systems with overhead variable signs that a satellite based system will not have real-time updates. Mobileye is also currently developing vision-only TSR for launch in the timeframe of 2011 that will provide a route for TSR to be implemented in other vehicle segments where integrated Satellite Navigation is not chosen as vehicle option. TSR recognises speed limits in a variety of environmental. It should be noted that the current TSR system is trained for detection of all Vienna Convention compliant signs. Mobileye is working towards the detection of US speed signs as part of series development projects. With a VGA resolution imager the system can provide reliable detection for targets with a lateral distance of 10 m, a vertical distance of 7m and at vehicle speeds of up to 250kph. This provides the current system with a very high performance even in challenging high speed situations on multi lane highways.
http://www.mobileye.com/taxonomy/manufacturer-products/applications/forward/traffic-sign-recog   déc-10

Ford Focus
http://www.ford.co.uk/Cars/Focus/Technicalhighlights/mdp=1204984087334

Opel
http://www.opel.com/experience_opel/innovation/safety.html

VW
https://www.volkswagen-media-services.com/medias_publish/ms/content/en/pressemitteilungen/2010/04/22/phaeton_debuts_with_standard.gid-oeffentlichkeit.html

Bosch road sign recognition camera
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/asr/multifunktionskamera/multifunktionskamera.asp

No TSR systems found to be currently implemented on motorcycles, although concept system by Honda.
http://world.honda.com/news/2005/c050902.html

Previous evaluations

As TSR can effectively form an advisory ISA system (or voluntary ISA if coupled with ACC) please also see ISA section.

TRACE D4.3 - Estimated effectiveness for serious injuries saved 5.82%, no figure for fatalities - Traffic Sign Recognition Page 18
http://www.trace-project.org/trace_template.html

eSafety Support website - some effectiveness evaluations listed under Local danger warnings and Speed alert
http://www.esafety-effects-database.org/applications_12.html
http://www.esafety-effects-database.org/applications_07.html

eIMPACT Traffic Impact results D4 Speed Alert - SPE Page 67
http://www.eimpact.info/results.html
For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:
• SpeedAlert is most effective on urban roads, followed by rural roads. It is least effective on motorways.
• More accidents are avoided with SpeedAlert in the non-peak hours (night, rest of the day), because of low traffic volumes making it possible to drive fast.
With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010 low	6
2010 high	9
2020 low	66
2020 high	94

eIMPACT Safety Impact results D4 Speed Alert - SPE
http://www.eimpact.info/results.html

Finally, the full penetration estimates were applied to the fleet penetrations estimated for the target years 2010 and 2020 (Table 40). The table also shows the range of estimates for full penetration.

Table 40. The effect of SPE on fatalities and injuries for full penetration and four scenarios. For full penetration, the range low/high is given.

SPE	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-8.7	-6.2
Impact low[1]	100 / 100	-4.5	-3.6
Impact high[1]	100 / 100	-12.9	-9.5
Impact 2010 low	2 / 4	-0.2	-0.2
Impact 2010 high	3 / 7	-0.4	-0.2
Impact 2020 low	30 / 42	-3.8	-2.8
Impact 2020 high	46 / 67	-5.3	-4.0

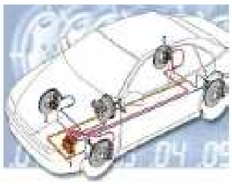
[1] These figures represent the expected impact if all vehicles were equipped, regardless of the year. All impacts are given for system including speed advice for fixed, variable and dynamic speed limits (SPE2), except 2010 low and high that are for speed advice for fixed limits (SPE1).

[2] Fleet vehicle km equipped

The high estimate for the year 2020 would mean 1,076 avoided fatalities and 34,887 avoided injuries.

Traffic Sign Recognition not included in COWI report
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

Anti-lock Brakes System (ABS)



SYSTEM STUDIED:

ABS - Anti-lock Brakes System

Aims of the system

Prevents skidding by avoiding the brakes locking the wheels
Maintains some steering control by avoiding skidding
For most drivers, decrease stopping distances in dry and wet road surfaces

Anti-lock on cars has been mandatory in the EU since 1 July 2004

Functions covered by the system (intentional and unintentional)

System that avoids locking the wheels when braking.
Core technology of Brake Assist (BA), Electronic Stability Control (ESC) and Electronic Brakeforce Distribution (EBD).
Also used to detect decreased rolling radius - indirect tyre pressure monitoring
Can warn drivers of slippery (especially icy conditions) if ABS activation is felt by the driver at low speeds and low brake pedal force

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Monitors rotating speed of each road wheel
Rupture Phase	Monitors rotating speed of each road wheel
Emergency Phase	Releases brake pressure of wheels that are sensed to be approaching locking. Allows some steering control For most drivers may decrease stopping distance
Crash Phase	Possibly avoided collision or reduced crash severity and possibly mitigated injuries
Rescue Phase	

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	
	Mediatised Mode	System prevents wheels from locking under driver braking
Automation		Takes control of activation of brakes but does not increase pressure

ABS (suite)

Technical specifications

ECU constantly monitors the rotational speed of each wheel; if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster. Conversely, if the ECU detects a wheel turning significantly faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. This process is repeated continuously and can be detected by the driver via brake pedal pulsation. Some anti-lock system can apply or release braking pressure 16 times per second.

When the ABS system is in operation the driver will feel a pulsing in the brake pedal; this comes from the rapid opening and closing of the valves. This pulsing also tells the driver that the ABS has been triggered.

Modern ESC systems are an evolution of the ABS concept with the addition of a steering wheel angle sensor and a gyroscopic sensor.

On loose surfaces such as gravel, sand and snow, ABS activation can extend braking distances as the rotating tyre does not dig in to the surface.

Bosch ABS website
http://www.bosch-safebraking.de/de/language2/index.html

Previous evaluations

Are there any evaluation been realized ? If yes, provide a link)

TRACE D4.3 - No evaluation of ABS
http://www.trace-project.org/trace_template.html

eIMPACT D4 - Not selected as technology to study
http://www.eimpact.info/results.html

A good summary of the main ABS evaluations is given at...
http://ec.europa.eu/transport/road_safety/specialist/knowledge/vehicle/safety_design_needs/cars.htm
A meta-analysis of research studies shows that ABS give a relatively small, but statistically significant reduction in the number of crashes, when all levels of severity and types of crashes are taken together.

However, while injury crashes decrease (-5%), fatal crashes increase (+6%). There are statistically significant increases in rollover, single-vehicle crashes and collisions with fixed objects. There are statistically significant decreases in collisions with pedestrians/cyclists/animals and collisions involving turning vehicles. ABS brakes do not appear to have any effect on rear-end collisions.

- Elvik, R.,Vaa T. (2004) Handbook of road safety measures .Amsterdam, Elsevier 2004

A German study found that ABS brakes can lead to changes in behaviour in the form of higher speeds and more aggressive driving. The results also may also be partly due to lack of knowledge or incorrect assumptions amongst car drivers about how ABS brakes actually function:

- Ashenbrenner, K. M., Biehl, B. and Wurm, G.W. (1987) Einfluss Der Risikokompensation auf die Wirkung von Verkehrsicherheitsmassnahmen am Beispiel ABS. Schriftenreihe Unfall- und Sicherheitsforschung Strassenverkehr, Heft 63, 65-70. Bundesanstalt für Strassenwesen (BASt), Bergisch Gladbach

A British study indicated that one reason why ABS was not realising its full potential to reduce crashes was that many drivers had little or no knowledge of ABS

- Broughton, J., and Baughan, C.J., (2000) A survey of the effectiveness of ABS in reducing accidents. TRL Report 453, Crowthorne, Berkshire

Motorcycles

A short piece on motorcycle ABS can be found at...
http://ec.europa.eu/transport/road_safety/specialist/knowledge/vehicle/safety_design_needs/motorcycles.htm
One prospective estimate suggests that ABS might reduce the number of crash victims by at least 10%
Sporner, A. and Kramlich, T. (2000) Zusammenspiel von aktiver und passiver Sicherheit bei Motorradkollisionen. Intermot 2000, München, September 2000

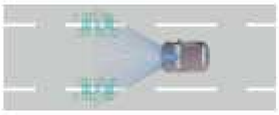
Currently the EU is proposing mandatory ABS on motorcycles above 125cc from 2017
A study presented by Vägverket, the Swedish highways authority, in October 2009 shows that 38 percent of all motorcycle accidents involving personal injury and 48 percent of all serious and fatal accidents could be prevented with the help of ABS.
http://www.automotivepr.com/news_detail.php?EU-Commission-recommends-mandatory-ABS-for-motorcycles-669
http://ec.europa.eu/enterprise/sectors/automotive/documents/proposals/index_en.htm

A technology review for motorcycles, including ABS, was carried out in the EC Pisa (Powered Two Wheeler Integrated Safety Systems) - D03 Powered two wheeler Integrated Safety (PISa): Review of PTW safety technologies and literature
http://www.pisa-project.eu/site/en/Deliverables.php

A technology review for motorcycles was carried out by MONASH university, Australia - ABS page 13
Intelligent Transport Systems and motorcycle safety, Monash University Accident Research Centre - Report #260 [2006], M. Bayly, M. Regan & S. Hosking
http://www.monash.edu.au/muarc/reports/muarc260.html

Bosch ABS systems for motorcycles
A study published by the German Federal Highway Research Institute (BASt) in 2008 concludes that there would be 12 percent fewer fatalities if all motorcycles were equipped with ABS
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/absfrpkw/motorradabs/studienbelegensicherheitspotenzial/studienbelegensicherheitspotenzial_1.asp

Lane Departure Warning (LDW)



SYSTEM STUDIED:

LDW - Lane Departure Warning
(examined by NTUA, comments added by LOUGH)

Aims of the system

LDW is comparable to a virtual road rumble. Drivers who unintentionally cross a road lane marking or the edge of the road receive a visual, audible or haptic warning that allows them to correct the situation. Haptic feedback options include a vibrating steering wheel or seat base.
http://www.trw.com/sub_system/lane_departure_warning_guidance_es
If the indicator is activated the system knows that the manoeuvre is intentional and allows it

Functions covered by the system (intentional and unintentional)

helps support the driver in keeping the vehicle in its lane of travel
Avoidance of dangerous situations caused by inattention
Effective warning through multileveled HMI-concept
Avoidance of tire damage and the resulting breakdown costs
Optional upgrading with Intelligent Headlamp Control (IHC)
Optional upgrading to Traffic Sign Recognition

http://www.conti-online.com/generator/www/de/en/continental/automotive/themes/commercial_vehicles/safety/adas/ldw/ldw_lks_en.html

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	System monitors lane markings - gives a visual indication to driver if system is not able to detect the lane markings
Rupture Phase	Driver receives a visual audible or haptic warning
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: it suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		The system provides a warning to the driver. Depending on the system this can be a light haptic feedback (torque input) to the steering wheel, vibration of the seat cushion (gives direction), visual warning and/or audible warning.
Mutual Control	Warning Mode	The system warns the driver of the situation
	Limit Mode	-
	Corrective Mode	-
	Action Suggestion Mode	-
Delegation of a function	Regulated Mode	-
	Prescriptive Mode	-
	Mediatised Mode	-
Automation		-

LDW (suite)

Technical specifications

can be tuned for sensitivity – for example, the system can be set to warn only when the vehicle is actually crossing the lane marking, or give an early warning, before lane markings are crossed. The warning can be adapted to the type of road – for example, it could provide the driver with more slack in case of narrow roads or allow the driver to "cut" curves. In Lane Keeping Support (LKaS) the LDA is fused to the steering system, which is usually electrically-powered, to provide a light haptic feedback (torque input) to the steering wheel and to warn the driver of the situation.

Kia Motors
Kia Motors offers the 2011 Cadenza premium sedan with an optional Lane Departure Warning System (LDWS) in select markets. This system uses a flashing dashboard telltale and emits an audible warning when a white lane marking is being crossed, and emits a louder audible warning when a yellow line marking is crossed. This system is cancelled when a turn signal is operating, or by pressing a deactivation switch on the dashboard. The system works by using an optical sensor on both sides of the car.

Mercedes-Benz
Mercedes-Benz began offering a Lane Keeping Assist function on the new E-class. This system warns the driver with a vibrating steering wheel if it appears the vehicle is beginning to leave its lane. And a new feature will automatically deactivate and reactivate if it ascertains the driver is intentionally leaving his lane, for instance if the driver is aggressively cornering. A newer version will use the braking system to assist in maintaining the vehicle's lane.

General Motors
General Motors introduced Lane Departure Warning on its 2008 model year Cadillac STS, DTS and Buick Lucerne models. The General Motors system warns the driver, with an audible tone and a warning indicator in the dashboard.

BMW
BMW also introduced Lane Departure Warning on the 5 series and 6 series using a vibrating steering wheel to warn the driver of unintended departures.

Volvo
Volvo introduced the Lane Departure Warning system along with the Driver Alert Control on its 2008 model year S80 and on the new V70 and XC70 executive cars. Volvo's lane departure warning system uses a camera to track road markings and sound an alarm when drivers depart their lane without signalling. The systems used by BMW, Volvo, and General Motors are based on core technology from Mobileye

Citroën
Citroën became first in Europe to offer LDWS on their 2005 C4 and C5 models, and now also on their C6. This system uses infrared sensors to monitor lane markings on the road surface. A vibration mechanism in the seat alerts the driver of deviations.

Audi
Audi began in 2007 offering its Audi Lane Assist feature for the first time on the Q7. This system will not intervene in the actual driving rather vibrate the steering wheel if the vehicle appears to be exiting its lane. The LDW System in Audi is based on a forward-looking video-camera in visible range as opposed to the downward-looking infrared sensors in Citroën

References
http://www.mobileye.com/node/58

Opel Eye
Thorough description with some limitations mentioned…
Opel Eye does not come on by default at the start of each journey. Though the driver can decide to leave the system on all the time, the system can be switched off by the driver and will remain off until it is turned back on again.
Opel Eye operates only at speeds above 60km/h. At lower speeds, such as when driving in town, the system would detect many situations where a warning would be unnecessary and irritate the driver. Poor conditions (snow, fog, heavy rain) can limit the visibility of the lanes.
http://www.euroncap.com/rewards/opel_eye.aspx

New Ford Focus - has three levels of sensitivity for steering wheel vibration
http://www.ford.co.uk/Cars/Focus/Safetyandsecurity

More information on Mercedes system parameters
A newly developed Mercedes assistance system warns the driver if the car leaves its lane unintentionally. The camera on the inside of the windscreen monitors the road markings and detects when the car leaves its lane. Lane Keeping Assist is available for the new E-Class and the S-Class from spring 2009. This is made by a camera on the inside of the windscreen, which can detect road markings by evaluating the difference in contrast between the road surface and the markings.

The image-processing system sends data to an electronic control unit, which determines the position of the car and detects when it leaves its lane on the left or right. Unlike conventional systems of this type, the Mercedes assistance system also assesses the driver's actions and, by doing so, reliably ascertains whether the car has left its lane intentionally or unintentionally. There is therefore no warning if, for example, the driver accelerates before overtaking or joining a motorway, brakes heavily or steers into a bend. If the system determines that the car is leaving its lane unintentionally, it activates an electric motor, causing the steering wheel to vibrate – a discreet yet highly effective way of prompting the driver to countersteer. The timing of the warning depends on the width of the road and the type of lane markings. If the car crosses over a continuous line on the road, as opposed to a broken one, the system emits its warning earlier.

Lane Keeping Assist operates at speeds of between 60 and 250 km/h as soon as the system has detected a lane marking. The steering wheel does not vibrate to warn the driver if the driver :
- cuts a corner intentionally
- uses the turn indicators
- moves back into the original lane after overtaking

Furthermore, Lane Keeping Assist is deactivated immediately if ABS, ESP , Brake Assist or another safety system intervenes.
http://www.emercedesbenz.com/Nov08/12_001505_Mercedes_Benz_TecDay_Special_Feature_Lane_Keeping_Assist_And_Speed_Limit_Assist.html

Bosch LDW
http://www.bosch-kraftfahrzeugtechnik.de/en/fahrsicherheitssysteme/asr/spurassistenzsysteme/spurverlassenswarnung/spurverlassenswarnung.asp

Delphi LDW
http://delphi.com/manufacturers/auto/safety/active/warning/

No LDW systems found to be currently implemented on motorcycles.

Previous evaluations

In TRACE and eIMPACT LDW is not treated as a separate technology

Thatcham's research shows that 6% of insurance claims are related to merging and lane collisions, and international insurance data suggests LDW systems are of positive benefit in reducing costs and crash frequency. They may also be of benefit preventing single vehicle collisions where drivers run off the road.
http://www.thatcham.org/adas/index.jsp?page=1232

Trucks

If a truck strays out of its lane, a critical situation can easily arise. In fact, official statistics show that one in five accidents involving commercial vehicles is the result of a sideways collision.
Lane Departure Warning (LDW) detects the lane up to 40m ahead of the vehicle with a camera, optimized for this specific application. LDW will warn the driver through acoustical or haptic signals like vibrations if he or she is on the verge of inadvertently drifting out of the lane.
In combination with an electric intervention in the steering LDW becomes an active Lane Keeping Assistant (LKS). A smooth recommendation in the steering is another warning to the driver but the driver's decision takes priority at all times. Through these system interventions important seconds are gained which can save lives, especially when at the edge of the verge. Because of a legislative initiative this type of system may become obligatory for all new commercial vehicles registered within the EU as of 2013.

LDW (suite)

Benefits:
Avoidance of dangerous situations caused by inattention
Effective warning through multileveled HMI-concept
Avoidance of tire damage and the resulting breakdown costs
Optional upgrading with Intelligent Headlamp Control (IHC)
Optional upgrading to Traffic Sign Recognition

http://www.conti-online.com/generator/www/de/en/continental/automotive/themes/commercial_vehicles/safety/adas/ldw/ldw_lks_en.html

Impact
The accident prevention potential of combined LDW and LCA systems, according to VDI/VDE/IT, IFV Köln (2005), is 25% for head on collisions, 25% for left roadway accidents and 60% for side collisions. Besides, an accident mitigation effect is expected by VDI/VDE/IT, IFV Köln (2005) in that the severity of accidents is shifted down a severity class - i.e. from fatality to severe injury and from severe to slight injury. No change is expected from slight to no injury. The mitigation effect is 25% for head on collisions, 15% for left roadway accidents and 10% for side collisions.
The reductive potential of lane departure warning and lane change assistant systems has also been assessed for Germany by Bosch (2005b). LDW systems are estimated to save 850 fatalities, 8,000 severe injuries and 20,000 slight injuries annually, corresponding to 12% of all fatalities, 9% of severe and 5% of slight injuries in Germany in 2002. Lane change assistants are further assessed to save 70 fatalities, 800 severe and 3,500 slight injuries.
For Spain it is estimated that LDW can save up to 10% of all rural accidents (corresponding to 5% of all rural and urban accidents). The eSafety Forum Working Group (2005, page 13 & 31-32 & 43-44) mentions the same effects on collision avoidance and mitigation as VDI/VDE/IT, IFV Köln (2005), but also notes that lane departure warning systems and similar measures can only reduce total fatal accidents by 2-4%.

Cost-benefit assessment
According to COWI et al. (2006) the cost-benefit analysis ratio for combined lane departure warning and lane change assistant systems is 1,7.
In comparison, VDI/VDE/IT, IFV Köln (2005, page 119-124) present results on exemplary cost-benefit calculations for combined lane departure warning and lane change assistance systems. Annual benefits and costs for EU-25 are estimated at 173 million € and 86 million € respectively in 2010 and 1.529 million € and 735 million € respectively in 2020. The respective calculated benefit/cost-ratios are 2,0 in 2010 and 2,1 in 2020.
These ratios are in line with the results of the cost-benefit calculations in this study. It probably hides the fact that a lower uniform unit price in this study is neutralised by slightly lower effects of LDW, the expected market penetration in the "business-as-usual" scenario and the continuous change in crash and casualty rates due to improved vehicles and roads.

References
COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and prioritisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf
VDI/VDE/IT, IFV Köln (2005): Exploratory study on the potential socioeconomic impact of the introduction of intelligent safety systems in road transport (SEISS), DG Information Society, January 2005.
Bosch (2005b): Estimated potential for avoiding and mitigating traffic accidents with driver assistance systems and for reducing the economic damage they cause in the Federal Republic of Germany, March 2005.
eSafety Forum Working Group (2005): Final report and Recommendations of the Implementation Road Map Working Group, Directorate-General Information Society.

Studies
http://www.esafety-effects-database.org/applications_08.html
Lane departure warning was found to have potential to prevent 6.1% of crashes involving large trucks included in the LTCCS database.
The estimates are based on real-world crash data collected in Large Truck Crash Causation Study (LTCCS) which was conducted from 2001 to 2003. The LTCCS study conducted on-scene investigations for real-world crashes and produced a database of 1070 accidents. This data was used to make case by case estimations of the applicability of crash avoidance countermeasures for each crash based on expert knowledge on the analysed systems and their effectiveness in various crash scenarios.
Kingsley, K. J., 2009, Evaluating crash avoidance countermeasures using data from FMCS's/NHTSA's large truck accident causation study. Proceedings of the 21st International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV) - International Congress Centre Stuttgart, Germany, June 15–18, 2009.

A collision mitigation braking system which is able to collect information about the environment around the vehicle, warn the driver, and perform a braking manoeuvre could have prevented 17.8% of all accidents involving personal injury in the data sample. The corresponding safety potential of a lateral guidance system consisting of lane keeping assistant and lane change assistant was estimated to be up to 7.3%. It was estimated that a car fleet equipped with both lateral guidance and collision mitigation braking system could have avoided up to 25.1% of all accidents included in the data sample.
The results are based on an in-depth analysis of a sample of 2,025 accidents taken from a database maintained by German Insurers Accident Research (UDV).
Kuehn, M., Hummel, T and Bende, J., 2009, Benefit estimation of advanced driver assistance systems for cars derived from real-life accidents. Proceedings of the 21st International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV) - International Congress Center Stuttgart, Germany, June 15–18, 2009.

Lane departure warning systems reduce the number of accidents and accident-related congestion. The impact on the CO2 emissions was estimated to be 0.008% in Europe.
The impact on the CO2 emissions has been estimated on the basis of safety impact estimates provided by the eIMPACT project and assumptions made by the authors.
Klunder G. A, et. Al., 2009, Impact of Information and Communication Technologies on Energy Efficiency in Road Transport - Final Report. TNO report for the European Commission.

Intelligent
vehicles with
The report is a literature study. The results have been obtained in a Dutch field test.
Reinhardt, W. and Kompfner, P., 2007, ICT for Clean & Efficient Mobility Final Report Draft, v6.0

The number of unintentional lane crossings decreased with 35 % on secondary roads and on highways because of lane departure warning. Drivers also kept better course to prevent warnings.
A field operational test with 20 cars conducted in the Netherlands
Alkim, T. P., Bootsma, G., Hoogendoorn, S. P., 2007, Dutch Field Operational Test experience with "the Assisted Driver", Proceedings of the 14th World Congress on ITS, 9-13 October 2007, Beijing, Peoples' Republic of China.

Lane departure warning system was estimated to reduce the number of single vehicle road departure crashes by 17-19 % and the number of rollover crashes by 17-23 % when applied in large trucks (> 10 000 lbs).
The results are based on a 12 months long field operational test involving 22 trucks.
Orban, J., Hadden, J., Stark, G. and Brown, V., 2006, Evaluation of the Mack Intelligent Vehicle Initiative Field Operational Test, Final Report

25% reduction in accident number and 25% reduction of accident severity in head-on collisions. 25% reduction in accident number and 15% reduction of accident severity in left-roadway accidents. 60 % reduction in the number of accidents and a 10 % reduction in accident severity for side collisions.
Estimates are based on accident statistics assuming a 0.5 sec quicker reaction to lane departure.
Abele, J., et. Al., 2004, Exploratory Study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles. SEISS. VDI/VDE Innovation + Technik GmbH and Institute for Transport Economics at the University of Cologne.

Lane departure warning systems installed in heavy goods vehicles would decrease the number of accidents involving heavy goods vehicles by 10%
Trial involving 40 professional drivers and 36 heavy duty vehicles.
Korse, M., 2003, Results of the trial with the Lane Departure Warning Assistant-system. Rijkswaterstaat 11 September 2003

LDW (suite)

Report [Visvikis C., Smith T. L., Pitcher M., Smith R., 2008, Study on lane departure warning and lane change assistant systems, Final report, Transport Research Laboratory]
http://ec.europa.eu/enterprise/automotive/projects/report_ldwlca.pdf This is a large and thorough examination of LDW and LCA

Lane departure collisions are a relatively small proportion (around 10 percent) of the total number of police-reported collisions in the United States. Nevertheless, if a similar situation exists in Europe, the number of collisions that could potentially be avoided is significant.
There are two main lane departure scenarios. In the first scenario, the vehicle drifts out of the lane slowly, for a range of reasons that can include driver fatigue, inattention or the use of alcohol or drugs. In the second scenario, the driver loses control of the vehicle due to excessive speed (or inappropriate speed in adverse conditions), mechanical failure, once again, the use of alcohol or drugs.
Most road departure collisions occur on straight sections of carriageway; however, same direction and opposite direction lane departure collisions are distributed more evenly between straight and curved roads.
Many lane departure collisions occur during daylight with no adverse weather conditions.
Time to line crossing (a calculated measure of the amount of time before a lane departure would occur) is a key indicator of driver performance and a way of characterising the potential for lane departure.
A warning threshold based on time to line crossing can be set to give drivers enough time to prevent a departure while avoiding nuisance or annoying alarms.
Three warning strategies are possible for lane departure warning: visual, audio or haptic.
Visual warnings are the least effective because they may not be seen by an inattentive driver.
Auditory warnings are more likely to be noticed by the driver, but may disturb other passengers.
Haptic warnings can alert the driver without disturbing other passengers.
Studies of the effectiveness of auditory lane departure warnings in comparison to haptic warnings are broadly inconclusive.
Lane keeping tends to be improved when the vehicle is fitted with a lane departure warning system.
The presence of a lane departure warning system has no effect on the frequency of intended lane changes, but turn signal use increases during these manoeuvres.
Lane departure warning systems are effective in warning drivers (including drowsy drivers) and preventing lane departures.
More research is needed on the effects of lane departure warning and the potential for unintended consequences, particularly when the system is integrated with other functions.
The benefits of lane departure warning (in combination with lane change assistance) are around twice as high as the costs. This is based on the findings of two large European studies.

Effectiveness of LDW systems
in passenger car road departure
12% of fatalities, 9% of severe, 5% slight. [Bosch (2005) in COWI (2006) estimated casualty savings in Germany.]
24% reduction in singular accidents. [Schermers (2000) cited in Malone et al. 2006. US study.]
20% reduction for cars
25% head on collisions, 25% left roadway Mitigation: 25% head on collisions, 15%

Benefit-cost ratios based on target population for each vehicle type assuming mandatory fitment in 2013

Technology	Benefit-cost ratio	Light vehicles	Heavy goods vehicles	Large passenger vehicles
LDW	min	0.35	0.53	1.94
	max	2.29	3.48	12.81

[Visvikis C., Smith T. L., Pitcher M., Smith R., 2008, Study on lane departure warning and lane change assistant systems, Final report, Transport Research Laboratory]

Rollover Detection (RD)

SYSTEM STUDIED:

RD - Rollover Detection

Aims of the system

To prevent instability leading to rollover

From TRACE WP6

Active Rollover Protection is designed to help stabilize a vehicle in order to help reduce the risk of a rollover. This system focuses on the vehicle's center of gravity and the lateral acceleration limit or rollover threshold. The system constantly monitors driving conditions and intervenes if critical lateral acceleration is detected. The system provides control of engine and retarded torque as well as automatically activates the drive axle and trailer brakes. Roll stability control systems take corrective action, such as throttle control or braking, when sensors detect that a vehicle is in a potential rollover situation.

Functions covered by the system (intentional and unintentional)

Rollover detection and protection is an extra function of the ESC system

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

1. The Driving Phase, during this phase no unexpected event or hazard has occurred or been detected.
2. The Rupture Phase, an unexpected event or hazard occured which surprised the road user.
3. The Emergency Phase is defined as the distance and time between the rupture phase and collision.
4. The Crash Phase, when the impact is taking place.
5. The Rescue Phase is the period after the collision during which the passengers are being evacuated from the vehicle.

Phases	Evaluation of actions
Driving Phase	Monitoring vehicle stability
Rupture Phase	As the system identifies a critical driving situation it intervenes by applying specific brake pressure to one or more wheels, as required. If necessary, the engine torque is also adjusted automatically
Emergency Phase	
Crash Phase	
Rescue Phase	

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	
	Mediatised Mode	
Automation		The system stabilises the vehicle by active brake intervention on one or more wheels and by intelligent engine torque management.

RD (suite)

Technical specifications

Delphi paper on detecting rollover...
http://delphi.com/pdf/techpapers/2004-01-1757.pdf

Bosch - Rollover Mitigation System...
http://www.bosch-esperience.de/de/language2/roll_over_mitigation.html

Previous evaluations

(Are there any evaluation being realized ? If yes, provide a link)

No seperate evaluations to ESC in TRACE, eIMPACT or COWI report

Automated Headlights (AHL)

SYSTEM STUDIED:

Automated headlights (driving lights)
(examined by LOUGH)

Aims of the system

To avoid a vehicle being unit in darkness or in a covered area - improved visibility to other road users (front and rear of vehicle)
To avoid poor visibility for a driver who has forgotten to turn the headlights on

Functions covered by the system (intentional and unintentional)

Headlights and rear lights (driving lights) are activated if driver forgets to activate them in darkness
Headlights and rear lights (driving lights) are switched on if the vehicle enters a tunnel or other covered area (multi story car park or road lined with dense trees)

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Improved visibility in dark or covered conditions for driver / Improved visibility of vehicle to other road users - Compared to situation when driver has forgotten to activate headlights
Rupture Phase	Improved illumination of objects and increased possibly of avoidance in dark or covered conditions / Increased possibility of avoidance for other road users - Compared to situation when driver has forgotten to activate headlights
Emergency Phase	-
Crash Phase	-
Rescue Phase	-

Note for evaluation: Light switch/dial has to be set to 'auto' by driver

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		Improved illumination of objects and increased possibly of avoidance in dark or covered conditions - Compared to situation when driver has forgotten to activate headlights
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	The driver has to turn on the system
	Prescriptive Mode	When the light level is below a defined threshold
	Mediatised Mode	
Automation		If light switch is always in automatic position

AHL (suite)

Technical specifications

Most often a light sensor is mounted on the windscreen, often as part of the rear view mirror assembly
Often standard equipment on mid range and upwards versions of mid-range cars (for example Ford Focus)

It is not possible to find any information regarding threshold levels. Some vehicles (e.g. Nissan Murano) offer different sensitivity levels as a switch and web forums feature discussions on changing the threshold on other models but through diagnostic computers or system such as IDrive.

Previous evaluations

Are there any evaluation been realized ? If yes, provide a link)

None evident, not selected in TRACE as a technology to be studied
http://www.trace-project.org/trace_template.html

eIMPACT D2 - Auto Lights not put forward as a technology to be considered for selection
http://www.eimpact.info/results.html

Auto Lights not included in COWI report
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

e-Call

SYSTEM STUDIED:
e-Call
(examined by NTUA, comments added by LOUGH)

Aims of the system
In case of a crash, an eCall-equipped car automatically calls the nearest emergency centre. Even if no passenger is able to speak, e.g. due to injuries, a 'Minimum Set of Data' is sent, which includes the exact location of the crash site. Shorty after the accident, emergency services therefore know that there has been an accident, and where exactly.

http://ec.europa.eu/information_society/activities/esafety/ecall/index_en.htm

Functions covered by the system (intentional and unintentional)
Modification of accident consequences (outcome of injury)
Modification of route choice - likely to be small influence

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions	
Driving Phase	-	
Rupture Phase	-	
Emergency Phase	-	
Crash Phase	-	
Rescue Phase	As soon as the eCall device senses a severe enough impact (usually for airbag activation), it automatically calls the nearest emergency centre and transmits to it the exact accident scene and other data geographic location of the crash	Note for evaluation: In some current systems subscriptions are required (Although PSA system is free after being bought). GSM signal required although the signal needed to send the SMS message is less than that required for a voice call (NCAP website)

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting his own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications	
Perceptive Mode		-	
Mutual Control	Warning Mode	-	
	Limit Mode	-	
	Corrective Mode	-	
	Action Suggestion Mode	-	
Delegation of a function	Regulated Mode	-	
	Prescriptive Mode	-	
	Mediatised Mode	-	
Automation		As soon as the eCall device senses a severe enough impact (usually for airbag activation), it automatically calls the nearest emergency centre and transmits to it the exact accident scene and other data geographic location of the crash	Note for evaluation: In some current systems subscriptions are required (Although PSA system is free after being bought). GSM signal required although the signal needed to send the SMS message is less than that required for a voice call (NCAP website)

e-Call (suite)

Technical specifications

eCall cuts emergency services' response time. It goes down to 50% in the countryside and 60% in built-up areas. Annually, the quicker response will save ± 2,500 lives in the EU. The severity of injuries will be considerably reduced in 15% of cases.
You can also make an eCall by pushing a button inside the car. Witnessing an accident, you can thus report it and automatically give the precise location. As eCall normally 'sleeps', it does not allow vehicle localisation outside emergencies.
In the near future, your car will have an electronic safety system that can automatically call emergency services if you have an accident. Even if you are unconscious, the system informs rescue workers of your exact whereabouts, and the ambulance and the fire brigade will be on their way in minutes. This system will work anywhere in Europe, even if you cannot speak the local language. All this thanks to "eCall", a system now being rolled out across the European Union.

References
http://ec.europa.eu/information_society/activities/esafety/ecall/index_en.htm
http://ec.europa.eu/information_society/doc/factsheets/049-ecall_july10_en.pdf
http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=2842

Current Systems
Volvo OnCall - driver needs to press a button if in difficulty
http://www.volvocars.com/uk/campaigns/misc/oncall/Pages/Overview.aspx
Systems that send a distress call if airbag deployment is detected...
Mercedes (TeleAID), Lexus/Toyota (Safety Connect plus Automatic Collision Notification (ACN)), GM's OnStar based system and BMW (Assist)
*Note: often these are subscription services. It is also surprisingly difficult to find information on the automatic crash notification aspects in the marketing material.
These are being marketed as SOS breakdown services, stolen car trackers and convenience features (navigation/booking tickets/remote unlock) systems - the emphasis is not on automatic crash notification.

PSA Peugeot Citroën eCall
No subscription required
http://www.euroncap.com/rewards/citroen_localized_emergency_call.aspx
http://www.euroncap.com/rewards/peugeot_connect_sos.aspx

BMW Assist Advanced eCall
If crash sensors detect that a vehicle has been involved in an accident, Advanced eCall automatically contacts a BMW call centre and provides detailed information about the accident: its precise location, the number of front-seat occupants, the crash severity and direction, the number of deployed airbags, seat belt status and, in BMWs with rollover sensing, whether a rollover has occurred.
Uniquely, Advanced eCall also predicts the risk of severe injury using a knowledge-based algorithm known as URGENCY, which takes the above crash parameters into account.
BMW Assist Advanced eCall is a subscription service at present
http://www.euroncap.com/rewards/bmw_assist_advanced_ecall.aspx

Mechanism 1: Modification of route choice
Drivers may rely on the system to make the emergency call after an accident and know the location. This may encourage them to drive more in remote rural areas where there are no other people around and where they do not know their exact location all the time. However, this effect is expected to be small.
Mechanism 2: Modification of accident consequences
The system decreases the number of traffic fatalities because swifter arrival of help should prevent some traffic fatalities. E.g. the fatalities in which the delay between the time of accident and the time of emergency call has been unusually long or the accident has been located incorrectly can be partly avoided.
The system decreases the injury levels in some degree: swifter arrival of help alleviates the injuries of some accident victims
In addition, the swifter arrival of help and more exact location provided by the system will make the road operator's incident management more efficient and reduce the impacts of the incident (accident) as well as the number of traffic incidents result.
eIMPACT, Deliverable D4, Impact assessment of Intelligent Vehicle Safety Systems

Previous evaluations

TRACE D4.3 - Estimated effectiveness for fatalities saved 10.8%, for serious injuries stated Not Applicable - Advanced Automatic Crash Notification
Results based on non-European data
http://www.trace-project.org/trace_template.html

eSafety Support website provides a list of effectiveness studies and summary results for eCall in the eSafety Effects database area...
http://www.esafety-effects-database.org/applications_04.html

A list of projects and studies related to eCall is given at.....
http://www.esafetysupport.org/en/ecall_toolbox/related_studies/
A specific area of the website is dedicated to eCall (eCall toolbox)...
http://www.esafetysupport.org/en/ecall_toolbox/index.html

eIMPACT Traffic impact results D4 eCall (one-way communication) (ECA) Page 63
For determining the indirect effects, assumptions have been made based on factors from the safety impact analysis. These assumptions are:
- On rural roads there is less traffic and therefore it is more probable that accidents happen without eyewitnesses. Furthermore, it will take more time before a third party will come to the accident site. Therefore, the system is most effective on rural roads, less effective on motorways and hardly effective on urban roads.
- eCall is more effective at low traffic volumes and in the dark (when accidents are more likely to go unnoticed), so it is effective for reaching accidents more quickly in the night and during off-peak hours.
With these assumptions, and the estimated safety effects, the indirect effects (avoided congestion costs in M EUR) are:

2010	0
2020 low	5
2020 high	7

eIMPACT Safety impact results D4 page 83 - references for previous studies

Table 30: The effect of ECA on fatalities and injuries for full penetration and four scenarios. For full penetration, the range (low/high) is given.

eCall	Penetration rate for light/heavy vehicles (%)[2]	Reduction in	
		Fatalities (%)	Injuries (%)
Impact most probable[1]	100 / 100	-5.8	0.1
Impact low[1]	100 / 100	-2.6	0.0
Impact high[1]	100 / 100	-7.3	0.0
Impact 2010 low	0.2 / 0.2	-0.01	0.0
Impact 2010 high	0.5 / 0.6	-0.03	0.0
Impact 2020 low	43 / 61	-2.6	0.1
Impact 2020 high	60 / 70	-3.5	0.1

[1] These figures represent the expected impact if all vehicles were equipped regardless of the year.
[2] Fleet vehicle km equipped

http://www.eimpact.info/results.html

A summary of some eCall results is given at... (very bottom of page)
http://ec.europa.eu/transport/road_safety/specialist/knowledge/vehicle/safety_design_needs/cars.htm
http://ec.europa.eu/transport/road_safety/specialist/knowledge/esave/esafety_measures_unknown_safety_effects/ecall.htm

e-Call (suite)

Future Development

The Commission has reinforced its efforts to speed up eCall deployment and is helping with additional measures. These measures comprise

- support for the European eCall Implementation Platform,
- awareness-raising and education activities among consumers, drivers and car dealers
- and funding of the eCall pre-deployment pilot projects.

http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=2842

Impact

The eCall system leads to a higher efficiency of the rescue chain in the form of lowering the rescue time. Hence the eCall system does not affect the vehicle collision probability, but instead affects the severity of the accident by reducing rescue time.

When medical care to critically injured people is available faster after the accidents occurred, the death rate can be reduced. Evidence shows that e.g. one hour after the accident, the death rate of people with heart or respiratory failure or massive bleeding is close to 100% (known as the Golden Hour Principle of accident medicine). Furthermore evidence shows that severe accidents can be reduced to slight accidents when rescue time is reduced.

Cost-benefit assessment

According to COWI et al. (2006) the cost-benefit analysis ratio for e-Call is 0,4 for scenario 1 (unit costs=€500) and 2,0 for scenario 2 (unit costs=€90).

It seems clear that the estimated costs of eCall greatly exceed the incurred benefits, if the correct figure for the unit costs is €500. However if the costs per vehicle is only €90, benefits are estimated to exceed costs by a factor 2.

It should, however, be kept in mind that the cost figures presented do not include the total costs of rolling out the eCall-system.

The estimated benefit/cost-ratio is very much in line with the results of Virtanen et al (2006). Virtanen et al (2006) estimates the benefit/cost-ratio to be between 0,5 and 2,3 for Finland.

E-MERGE (2004) estimates that the benefits of eCall will amount to 3-5 billion € on a yearly basis, which is in line with the figures of COWI, whereas the necessary investments are approximatively 20 billion €.

References

COWI, ECN, Ernst & Young Europe and Consultants (2006) "Cost-benefit assessment and priortisation of vehicle safety technologies" - Final Report, European Commission Directorate General for Energy and Transport, p.131-136
www.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf

VDI/VDE/IT, IFV Köln (2005): Exploratory study on the potential socioeconomic impact of the introduction of intelligent safety systems in road transport (SEISS), DG Information Society, January 2005.
Virtanen et al (2006): Impacts of an automatic emergency call system on accident consequences, Ministry of Transport and Communications Finland, AINO publications.
E-MERGE (2004): E-MERGE Compiled Evaluation Results, Deliverable 6.3. By Cap Gemini Ernst & Young.

Studies

The impact of the reduced rescue time on fatalities as a result of eCall was found to be different in different countries due to geography, rescue service performance etc. For Finland, a saving of 4-8% of road fatalities was estimated but the reduction in the UK was estimated to be considerably smaller (1%). The environmental impacts of eCall were found to be negligible or at least very small. For Finland, 0.02–0.05% reduction of vehicle hours spent in congestion was estimated which corresponds to reduction of 0.04–0.10% in of emissions of CO2, PM and NOx.
The results are based on a questionnaire sent at the European level and in-depth studies carried out for four European countries. The impacts have been estimated on the basis of a literature study, expert interviews and information colleted with the questionnaire.
Francsics, J., et. al., 2009, Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/legal issues.

eCall was estimated to reduce the number of road traffic fatalities by 5.8% (3.6-7.3%) in EU25 countries. A small increase (~0,1%) in the number of serious injuries was expected because eCall changes fatalities to injuries and serious injuries to less severe injuries.

The expected percentage changes in the number of fatalities and serious injuries on different accident categories were mostly based on the Finnish AINO study. The percentages obtained with Finnish data were then transformed into EU-25 accident data with different distribution of accidents in various accident types.
Wilmink I., et. al., 2008, Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe, Impact assessment of Intelligent Vehicle Safety Systems. eIMPACT Deliverable D4.

eCall was estimated to reduce the annual number of road traffic fatalities by 1-2% in the Netherlands. The severity of injuries will also be reduced for about 1% of the injured people brought into hospitals.

The estimate for the reduction of fatalities was obtained by analysing a set of accidents. Of all fatal accidents on the road involving potentially eCall equipped vehicles) the authors looked at all accidents in which the fatal cases were not killed instantly but died shortly after the accident. When calculating the effects of eCall, only the time between accident and notification of emergency services was assumed to be reduced because of eCall.
Donkers, E. & Scholten, J., 2008, E-call en Verkeersveiligheidskansen, DEEL 4: De verwachte directe en indirecte effecten van e-call in Nederland. Rijkswaterstaat, Rotterdam, Netherlands.

eCall was estimated to reduce the annual number of road fatalities in UK by 3%.
The effects of eCall on the number of fatalities and serious injuries were estimated on the basis of the reduction in the time between accident and notification of emergency services, classification of accidents on the basis of road type and time of accident and classification of casualties potentially benefiting from eCall or not. When calculating the figure, 66 % fleet penetration was assumed for eCall.
McClure, D. & Graham, A., 2006, eCall - The Case for Deployment in the UK, Final report

The eCall system could very probably have prevented 4.7% of the fatalities in accidents involving motor vehicle occupants. In the accidents involving a fataly injured unprotected road user, however, the system could probably have prevented no fatality. In all, the eCall system was estimated to be able to reduce 4-8% of road fatalities in Finland.
The results are based on Finnish accident data collected by in-depth accident investigation teams. The data was analysed by medical experts having long experience of treating accident trauma.
Virtanen N., 2005, Automaattisen hätäviestijärjestelmän vaikutukset onnettomuustilanteessa. (Impacts of an automatic emergency call system on accident consequences).
AINO publications 14/2005.

From 5 to 10% of road fatalities would be changed to severe injuries in EU. In addition, 10 to 15% of severe injuries would be changed to slight injuries.
The study is based on official European accident statistics, traffic analyses, available market reports, and other sources. Effectiveness estimates were based on results from surveys of the E-MERGE project.
Abele, J., et. al., 2004, Exploratory Study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles. SEISS. VDI/VDE Innovation + Technik GmbH and Institute for Transport Economics at the University of Cologne.

The foreseen live savings are estimated on an average between 5-10% which means 2000 to 4000 lives given the current number of fatalities of approx. 40000 and the reduction of the severity of injuries is estimated at the same number 5-10%.
The results are based on a questionnaire targeted to public safety answering point operators in E-MERGE test sites.
Cap Gemini Ernst & Young, 2004, E-MERGE Compiled evaluation results. Deliverable 6.3

Low Friction Detection (LoFrctD)

SYSTEM STUDIED:

Low Friction Detection
(examined by LOUGH)

Aims of the system

To warn the driver of low friction levels on the road surface ahead
To prepare ADAS systems for a low friction surface

NOTE: It is clear that advanced dynamic driver assist functions such as ESC and traction control will detect low levels of friction (grip) 'underneath' the vehicle and act accordingly. The definition here is that the warning of the situation ahead is given.

Also it is very common for cars to have external temperature sensor with a display in the vehicle that will flash for low temperatures (typically at and below 2 or 3 degrees centigrade).

Functions covered by the system (intentional and unintentional)

Alert to the driver of a road surface condition ahead that will lead to low friction (grip)
Automatic preparation of ADAS systems for low friction surface

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Improved understanding of grip levels ahead - possibility to decrease speed
Rupture Phase	Possible to react to situation more effectively if speed has already been decreased in response to warning
Emergency Phase	Possible that impact speed has been decreased in response to warning
Crash Phase	Possible that impact speed has been decreased in response to warning
Rescue Phase	

Note for evaluation: In very low grip situations (such as snow) the system is only warning the driver of something that is clearly obvious anyway.
Note for evaluation: As this system is not yet implemented in the fleet it is not clear how the warning will be realised - the continental system (tech spec below) mentions that head up display is possible.

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		Warns of low friction (grip) levels ahead
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	Preparation of ADAS systems
	Mediatised Mode	
Automation		The system will provide information to ADAS systems to prepare for low friction surface

LoFrctD (suite)

Technical specifications

There are no systems currently available in the fleet but Continental has developed a system in the EC project FRICTION
http://www.conti-online.com/generator/www/com/en/continental/pressportal/themes/press_releases/3_automotive_group/interior/press_releases/pr_2010_10_12_sensorfusion_en,version=4.html
http://www.sae.org/mags/tbe/9108
Compared to using dynamic sensors at the wheels this system uses environmental sensors to capture and calculate data ahead of the vehicle.

Environmental and tire sensors

Environmental sensors provide data to the second sub-module which computes the environmental features:

- An optical sensor measures changes in the amount of light that is reflected by the road surface directly in front of the front wheel (0.4 to 1.5 meters ahead).
- A polarization camera detects differences in vertical and horizontal polarization caused by road surface conditions between 5 and 20 meters in front of the vehicle.
- Finally, a laser scanner checks the weather conditions by detecting objects such as snow flakes or rain drops within a range of 50 to 100 meters ahead of the vehicle.
- The road surface temperature is measured by a thermometer.
- An air thermometer measures the ambient temperature.

In addition the intelligent tire sensors, which are integrated into the tires, deliver information about the current tire distortion of the rolling tire.
The system warns against early stages of aquaplaning.

The system was developed in this EC 6FP project....
http://friction.vtt.fi/index.html

A paper by VTT was published regarding the radar sensor needed to realise low surface friction...
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5170038&tag=1

Previous evaluations

Are there any evaluation been realized ? If yes, provide a link)

Not in TRACE
http://www.trace-project.org/trace_template.html

eIMPACT D4 - Local Risk Warning examined at first stage but not chosen in the set of 12 technologies to be studied but WILLWARN (from PreVENT) was considered as Wireless Local Danger Warning (WLD).
Low friction is mentioned but not considered as a separate technology
http://www.eimpact.info/results.html

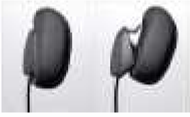
PreVENT - WILLWARN A lot of information on hazard warning and reduced friction is mentioned as part of the WILLWARN package
http://www.prevent-ip.org/en/prevent_subprojects/safe_speed_and_safe_following/willwarn/
The reduced friction part of the system is addressed with a yaw-rate sensor and the action of the traction control (electronic stability program) Page 24/25
http://www.prevent-ip.org/en/public_documents/deliverables/willwarn_final_report.htm

Study on signs activated to warn of slippery road conditions - reduction in mean speeds
http://virtual.vtt.fi/virtual/proj6/fits/impacts/effect_of_variable_road_condition_warning_signs.htm

Low Friction Detection not included in COWI report
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

Anti-Whiplash (AW)

SYSTEM STUDIED:
Anti - Whiplash
(examined by LOUGH)



Aims of the system
To prevent or reduce neck injury in rear impacts

Functions covered by the system (intentional and unintentional)
In rear impact the head restraint moves to meet the head so that the movement of the head is controlled and the possibility of neck injury reduced

Phases of the accident sequence upon which the system is acting
(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	
Rupture Phase	
Emergency Phase	
Crash Phase	Head restraint moves to control head movement in rear impact
Rescue Phase	

Level of intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		
Mutual Control	Warning Mode	
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	Automatically adjusts in rear impact
	Mediatised Mode	
Automation		Automatically adjusts in rear impact

AW (suite)

Technical specifications

The Thatcham website gives a good summary of the many anti-whiplash systems on the market...
http://www.thatcham.org/ncar/index.jsp?page=152

RHR	Reactive Head Restraint: A head restraint that automatically moves up and forward during the crash, actuated by the weight of the occupant in the seat. (Example: Saab)
PAHR	Pro-Active Head Restraint: A head restraint that automatically moves up and forward at the start of the crash, actuated by crash sensors on the bumper or within the car. (Example: Mercedes-Benz C & E —Class)
RAS	Reactive Seat: An entire seat and head restraint that absorbs the energy of a rear end crash. (Example: Volvo WHIPS)
PAS	Passive Seat: A seat that uses passive foam technology to absorb the energy of the crash and allow the occupant to engage the head restraint without neck distortion. (Example: Audi A4 backguard)
No Caption	A traditional fixed or adjustable head restraint that has no specific anti-whiplash technology.

Previous evaluations

(Are there any evaluation been realized ? If yes, provide a link)

None in TRACE or eIMPACT

From...
http://ec.europa.eu/transport/road_safety/specialist/knowledge/vehicle/safety_design_needs/cars.htm

Evaluation in real crashes has shown that an anti-whiplash system can reduce average whiplash injury risk by 50%; that energy absorption in the seat back reduced occupant acceleration and the risk of sustaining a whiplash injury; and further reductions in injury risk could be achieved by improved head restraint geometry.
Krafft, M., Kullgren, A., Ydenius, A., Boström, O., Håland, Y. and Tingvall, C. (2004) Rear impact neck protection by reducing occupant forward acceleration - a study of cars on Swedish roads equipped with crash recorders and a new anti-whiplash device, Proceedings IRCOBI Conference

A Norwegian meta-analysis indicated that the effects of WHIPS systems differ with respect to injury severity. Slight injuries are reduced by about 20%, serious injuries by about 50%.
Eriksen, K. S., Hervik, A., Steen, A.,Elvik, R.,Hagman, R. (2004) Effektanalys av nackskadeforskningen vid Chalmers. Vinnova Analys VA (7). Stockholm

Anti Whiplash seats not included in COWI report
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

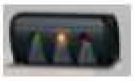
Driver Monitoring (DrvM)

SYSTEM STUDIED:

Driver monitoring
(examined by LOUGH)

Aims of the system

Monitors acceleration, braking and cornering
Provides feedback via dashboard lights, SMS or internet on driving performance
Improves driver training and skills
Also promoted as saving fuel



Functions covered by the system (intentional and unintentional)

Gives feedback through green, amber and red indicators (dashboard, SMS or internet) on driving performance
Accelerometers measure accelerations during acceleration, braking and cornering and 'events' are triggered when acceleration exceeded predefined thresholds

Phases of the accident sequence upon which the system is acting

(Can be several, with different potential actions)

During driving 5 phases can be defined:

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

Phases	Evaluation of actions
Driving Phase	Less risk of reaching rupture phase through lower levels of acceleration, braking and cornering speeds
Rupture Phase	Possibly lower speed
Emergency Phase	Possibly lower speed
Crash Phase	Possibly lower speed
Rescue Phase	

Level of Intervention

Perception	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.	
Mutual control	Form of cooperation: the device takes over various control activities.	WARNING MODE: The device provides a judgement on driver performance under the form of a warning.
		LIMITING MODE: The driver request the device to control actions by limiting its own actions so they do not exceed a pre-defined level.
		CORRECTIVE MODE: The driver request the device to control by correcting his actions if they result in exceeding a predefined level.
		ACTION SUGGESTION MODE: It suggests an action to the driver.
Delegation of function	Form of cooperation: the decision to take action is delegated to the device in more or less a durable fashion	REGULATED MODE: The driver explicitly requests the device to take the necessary decisions and implement them
		PRESCRIPTIVE MODE: At the initiative of the infrastructure, which forces the device to take the necessary decisions and implement.
		MEDIATISED MODE: The driver retains the initiative but an action initiated by the driver must be amplified to avoid the accident.
Automatic	The device takes over the control without intervention or intention of the user.	

		Specifications
Perceptive Mode		Amber or red dashboard lights warn of high levels of acceleration or cornering Driver performance is recorded and viewed on the internet
Mutual Control	Warning Mode	Amber or red dashboard lights warn of high levels of acceleration or cornering
	Limit Mode	
	Corrective Mode	
	Action Suggestion Mode	
Delegation of a function	Regulated Mode	
	Prescriptive Mode	
	Mediatised Mode	
Automation		

DrvM (suite)

Technical specifications

Not possible to find information regarding the thresholds used to trigger amber or red events

It seems likely that these systems will be implemented through pressure from insurance companies rather than policy decisions, this is one such example...
http://www.co-operative.coop/corporate/Press/Press-releases/Headline-news/The-Co-operative-Insurance-launches-groundbreaking-new-Young-Driver-Insurance/

Previous evaluations

Are there any evaluation been realized ? If yes, provide a link)

Greenroad report decreases in at-fault crashes (42%), risky driving (50%) and crash overall (54%)
http://www.greenroad.com/programs/overview/

Example of implementation in a fleet
http://www.roadsafe.com/news/article.aspx?article=1475
- Driver risk drop 63%.
- Crash rate reduce by 50%.
- Fuel consumption drop by 6%.

although vehicles numbers and mileage not given

no TRACE eIMPACT or eSafety support evaluations
http://www.trace-project.org/trace_template.html
http://www.eimpact.info/results.html
http://www.esafety-effects-database.org/applications_02.html

This type of driver monitoring is not included in COWI report
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
But Event Data Recorders EDR are and some comments are made regarding driver awareness - page 143

Driver awareness of accident data recorders improves driver behaviour. Thus drivers are much more careful if their cars are equipped with accident data recorders. The behaviour change reduces the risk and severity of accidents and repair costs by up to 25% according to VERONICA (2005).

SAMOVAR (2005) calculates an effect of 41% accident reduction (given the uncertainty of results at least 13%,).

Icelandic tests correspondingly show a 56% accident reduction among equipped mail vans

The Danish Road Safety and Transport Agency states that field trials indicate a potential for a 20% (+/- 15%) reduction in accidents and costs.

Elvik (2005) has calculated that accident data recorders can reduce fatalities by 7% in Norway and 6% in Sweden.

Conversely, the eSafety Forum Working Group (2005, page 40) asserts that no significant effect on accidents is expected.

Annexe 3
Les mesures de sécurité de l'infrastructure

Liste relative aux contre-mesures spécifiques à l'infrastructure.

Cette fiche permet la codification des étapes 12 15 18

INFRA AS-1 : Bandes de rives sonores:

L'idée est équipée systématiquement toutes les routes (pas uniquement autoroute) d'une bande de rive sonores, i.e. avec des aspérités provoquant des vibrations au volant ainsi qu'un son lorsque le pneu passe dessus. Ce système permet d'alerter le conducteur qu'il est en train de franchir la ligne.

Cas concernés	toutes les sorties de voie involontaires à droite (inattention, hypovigilance, tâche annexe, etc.)
Véhicules concernés	tout type
Situations défavorables	endormissement, alcool, malaise

INFRA AS-2 : Sur largeur praticable

L'idée est équipée systématiquement toutes les routes d'une sur largeur praticable de 1m, dégagée de tout obstacles (arbre, panneau, poteau, etc.) et permettant le rattrapage du véhicule en cas de sortie de voie.

Cas concernés	toutes les sorties de voie involontaires
Véhicules concernés	tout type
Situations défavorables	endormissement, alcool, malaise, pas d'action de rattrapage du conducteur

Communication Infra-Véhicule :

Dialogue entre l'infrastructure et le véhicule.

INFRA AS-3 : Alerte Virage

L'idée est de poster dans le virage une balise qui envoie un message d'alerte aux véhicules circulant aux abords. La balise connait les caractéristiques géométriques du virage et avoir une estimation de l'état de surface (adhérence). Elle propose une vitesse "limite" pour un passage en sécurité.

Le signal est envoyé à tous les véhicules mais seuls ceux dont la vitesse de roulage est supérieure à cette vitesse "limite" sont alertés.

Distance d'alerte	100m avant entrée du virage Calcul de la vitesse limite V_L : $$V_L = \sqrt{\mu.* R_{\min i}}$$ Où μ est l'adhérence moyenne sur l'ensemble du virage corrigée des conditions climatiques et R_{mini} le rayon minimum de la courbe.

Véhicules concernés	Tout type
Situations défavorables	endormissement, alcool, verglas soudain, inondation

INFRA AS-2 : Alerte intersection

L'idée est de poster des balises sur l'intersection donnant les informations suivantes:
a) dans le cas d'un axe non prioritaire, une alerte de survitesse fonction de la distance séparant le véhicule de la ligne d'arrêt (Stop) ou de ralentissement (cédez le passage ou priorité à droite), et indication de véhicules en approche détectés.
b) dans le cas d'un axe prioritaire, une alerte de survitesse (par rapport à la vitesse réglementaire) et indication de véhicules en approche sur l'axe non prioritaire détectés + alerte de franchissement.

Ce système permet en particulier de palier les problèmes liés aux masques à la visibilité (le conducteur à l'information sur les véhicules qui se trouvent dans ou en approche de l'intersection), les sur vitesses et les sentiments de « prioritaire ».

Distance d'alerte	Distance d'alerte: 100m avant entrée sur intersection Alerte survitesse axe non prioritaire: • à 10m si V > 25 km/h • à 25m si V > Vitesse réglementaire ou V > 40 km/h • à 50m si V > Vitesse réglementaire ou V > 55 km/h • à 100 si V > Vitesse réglementaire ou V > 80 km/h Alerte survitesse axe prioritaire: • à 100 si V > Vitesse réglementaire
Véhicules concernés	Tout type
Situations défavorables	endormissement, alcool, véhicule arrivant lentement sur axe non prioritaire (sauf stop)