Critical accident scenarios for cyclists and how they can be addressed through ITS solutions

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Critical accident scenarios for cyclists and how they can be addressed through ITS solutions

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1. ABSTRACT

It is recognised that ITS applications have been relatively successful in improving road safety primarily through technology applications the vehicle and infrastructure. However, Vulnerable Road Users (VRUs) have not received as much benefit as other road users. The EC-funded VRUITS project places the VRU road user at the centre, assesses the impact of current and upcoming ITS applications on the safety and mobility of VRUs, identifies how the usability and efficiency of ITS applications can be improved and recommends which actions have to be taken at a policy level to improve ITS safety and mobility. A major focus of the VRUITS project involves the safety of cyclists within the EU as a target VRU group.

To provide the evidence-base for ITS applications, data were analysed to determine critical scenarios for cyclists and these data included national data in Spain, Austria, Finland, Sweden and the United Kingdom. This analysis was matched to analysis of the European CARE data to determine the consistency between the national and European databases.
The main findings from the data analysis are as follows;

- The majority of cycling accidents in the accident analysis were found to occur at junctions/intersections.

- One of the most common scenarios involved **vehicles pulling out into the path of the on-coming cyclist at an intersection**
- CARE data suggests that the most common scenario involves both cyclist and vehicle heading in the same direction but the **vehicle then turns into the cyclist's path**
- Overall, males are over-represented in the data.
- The majority of the accidents occur in **fine dry weather during daylight hours**
- The majority occur in **urban areas** at relatively on roads with **relatively low speed limits**

Data from this phase of the VRUITS project will be used to determine the ITS solutions that are relevant to the scenarios determined through accident analysis. Subsequent phases of the project will look at the feasibility of implementation of theses countermeasures which is likely to include some pilot testing of specific applications.

Keywords: Accident Analysis, CARE, cycling accident scenarios, Intelligent Transport System countermeasures.

2. INTRODUCTION

ITS Applications have in recent years assisted in reducing the number of fatalities on European roads. However, the Vulnerable Road Users (VRUs), including pedestrians, cyclists and motorcyclists have not benefited as much as passenger car users. An important sub-group of VRU's are cyclists - according to the European Road Safety Observatory (ERSO) Fact-sheet on cyclist accidents (ERSO, 2011), cyclist fatalities comprised some 6.8% of the total number of road accident fatalities in 2010 in the 20 EU Member States for which data were available. In these countries, 1,994 people riding bicycles were killed in traffic accidents during 2010 which is 9% less than the 2,196 bicycle fatalities reported in 2009. Overall cyclist fatalities fell from 3,217 in 2001 to 1,994 in 2010 however, in a minority of EU countries, cyclist fatality rates increased during the period 20001 to 2010. The Fact-sheet also notes that the majority of EU cyclist fatalities during 2010 were males and that nearly 40% of cyclist fatalities occur at junctions. Whilst the overall numbers of fatalities may be falling, the casualty level is still unacceptable.

The EC-sponsored VRUITS project is currently assessing the safety and mobility impacts of ITS applications for all VRUs and how the ITS applications can be improved to enhance the safety and mobility of VRUs without impacting on traffic efficiency. A fundamental part of this involves an analysis of the critical scenarios in which the VRUs are injured or killed in road accidents. Based on a comprehensive identification of these situations and scenarios, a taxonomy of the major critical or most important scenarios can be derived which will provide an essential input to the development of Intelligent Transport Systems aimed at VRU safety. To achieve this, use of accident data, hospital data and other relevant data are required in order to derive the most commonly occurring events based on a representative sample of data. This paper describes the process of determining these situations and scenarios using data from a number of EU Member States together with CARE (Community Road Accident Database) data.

3. METHODOLOGY

The task involved a number of phases. The first phase of the task was to identify as clearly as possible from existing research and data analyses a number of scenarios that are commonly thought to be implicated in crashes involving cyclists. This was achieved via a review of existing publications on Vulnerable Road User accidents including a report from the WATCHOVER project [1], review of the SafetyNet [2] and PENDANT [3] databases together with review of published data from the European Road Safety Observatory [4] data repository and the Data Collection, Transfer and Analysis (DaCoTA) project [5]. From this review, a total of **11** key scenarios were identified for cyclists and the subsequent accident analysis was then conducted according to these key scenarios in order to determine which of these was the most commonly occurring.

In the main, macroscopic data were used for the analysis conducted within this study. It is acknowledged that macroscopic data normally provide cursory information about accidents and are usually based on police investigations of crashes on the roads in which an injury has occurred. Therefore, these datasets may be somewhat limited in terms of detail. However, the main advantage of this type of data is that it is usually representative of the country in which it is collected.

An alternative would have involved the use of In-depth data which provides very detailed information about specific accidents. However, this type of data is dis-advantaged by the fact that the numbers of cases available for analysis within in-depth databases are usually small and statistical representative-ness is sometimes open to question.

Overall, the CARE database has been used as the most representative database for EU accidents and data from national databases from Austria, Finland, Spain, Sweden and the UK have been compared to the CARE data for consistency of results, and for potential additional information regarding accident situations. A summary of the data analysed is shown in the following table.

Table 1 Databases analysed for VRUITS accident analysis

Member State	Database Name	Database Type	Comments
Finland	Statistics Finland's Road data base and the Finnish in-depth fatal accident data base (VALT)	Macroscopic and microscopic	Representative of Finnish accidents
Austria	The Austrian Statistics of Road Accidents Database	Macroscopic	Representative of Austrian accidents
Spain	DGT	Macroscopic	Representative of Swedish accidents
Sweden	STRADA	Macroscopic	Representative of Swedish accidents
UK	STATS19	Macroscopic	Representative of UK accidents
EU25	CARE	Macroscopic	Representative of EU-25

4. RESULTS

Summary Analysis – EU CARE DATA

Table 2 gives a summary of the data analysis conducted on the CARE database. Overall, many of the results conform to intuitive expectations. However, an important finding is that regarding the most common scenario for cyclist accidents in which cyclists are most likely to be hit by a vehicle travelling in the same direction which then turns into the cyclist. Another surprising finding is that the accident locations were found to be remote from junctions.

Table 2 Summary of CARE Data Analysis – Cyclists

Description
Cyclists are most likely to be hit by a vehicle going in the same direction turning into them
Males are far more likely to be involved than females
Most accidents occur in an urban environment
The road-speed at the accident location is mostly between 30 and 50kmh
Either not at a junction or at a crossroad
The most common time is between 6 am and 12pm
Accidents are least likely to occur on a Sunday-similar number of incidents for the rest of the week
The months of April to September are most common
Most accidents occur in daylight conditions
Most accidents occur in fine weather
The majority of accident-involved cyclists did not wear a helmet

Analysis was then carried out on a country by country basis to see where consistencies between the CARE data and the national data were evident. It was assumed that greater consistency with the CARE data analysis would allow greater confidence that the results could be extrapolated to within the EU.

4.1 Spain

Cyclists (all severities n=11184; fatal and severe only n=1679)

The majority of cyclist accidents in Spain involved males (86.9%) with an average age of 37.9 years old for all severities. When only fatal/ severe incidents accidents were analysed the percentage of males involved in accidents increasing to 89.8% and an increased average age of 42 years old. It was also found accidents predominantly occurred on urban roads (69.9% of all severities accidents; 47.4%of the fatal/severe accidents), between 12pm and 6pm (39.4% all; 37.4% fatal/ severe), between the months of May to August, in the daylight (82.1% all; 81.9% fatal/ severe) and in fine weather (95.4% all; 96.7% fatal/ severe). There was not a large effect based on days of week. The cyclist was most likely to be struck by a passenger car (79.8% all; 75.3% fatal/ severe).

In terms of the scenarios under which the cyclist was hit the vast majority of accidents were classified under 'unknown (32.6% for all severities and 38% for fatal and severe) or 'other', whereby the suggested scenarios did not characterise the incident (53.7% for all severities and 45.2 for fatal/ severe). Of the incidents that did fall under one of the suggested scenarios the greatest percentage could be characterised as occurring 'at a junction' (10.3% all; 12% fatal/ severe).

At junction accidents

For the accidents that occurred at a junction the most common scenario was both vehicles heading straight on with their paths intercepting at the junction (44.6% for all severities) e.g. cyclist heading south whilst the vehicle was heading east. This was closely followed by the vehicle turning into the cyclist at a junction (41.7% all severities). When only fatal or severe incidents were taken into account there was a change in propensity, with the 'vehicle turning into the cyclist' scenario (40.3%) now superseding the 'both parties heading straight on' scenario (35.8%)

In terms of deciding when to enter the junction the majority of the at-junction accidents were categorised under 'not applicable' (45.1% all; 45.8% fatal/ severe). When the variable was considered applicable it was fairly evenly split between being signal controlled (27.7% all; 33.8% fatal/ severe) and uncontrolled (26.3%all; 26.7% fatal/ severe).

When type of junction was considered it was found the majority of at-junction accidents occurred at T-junctions (34.1% all; 31.8% fatal/ severe) or cross roads (28.8% all; 27.5% fatal/ severe).

Not at junction accidents

When the accident did not occur at a junction the accident was most likely to be a result of a vehicle misjudging their overtaking manoeuvre and hitting the cyclist as they passed (44.7% all; 60% fatal/ severe).

4.2 Austria

Cyclists (Individual Accident Severities not known - all severities n=12042)

The majority of Austrian cycle accidents involved males (64.9%) with a mean age of 40.1 years old. Most occurred at junctions (44.2%) or the scenario was unknown (43.8%). The vast majority occurred on urban roads (87.5%), between 12.01pm and 6pm (49%), between May and September. There was a slight decrease in accident rates at weekends (Saturday 10.2%, Sunday 8.1%- compared to around 16% for the weekdays). They were also found to occur in daylight conditions (87.6%), in fine weather (71.7%). The majority of accidents involved the cyclist being struck by a passenger car (65%) with the rider not wearing a helmet (91.4%).

At junction accidents

For accidents occurring at junctions the cyclist was most likely to be hit by a vehicle pulling out into its path (68%) and this most commonly occurred at crossroads (59.7%).

Not at junction accidents

Of the not at junction accidents the most commonly occurring was the cyclist being hit by a vehicle misjudging its overtake manoeuvre (42%) closely followed by scenario of a cyclist being hit by a vehicle's door opening into its path (41.6%).

4.3 United Kingdom

Cyclists (All severities n=17,185)

The majority of UK cycle accidents involved males (82%) with a mean age of 32.2 years old. Most occurred at junctions (74%). 42% of accidents occurred on A-class roads ad 34.5% on 'unclassified' roads. September, July and June were the most frequent months. They were also found to occur in daylight conditions (80.4%), in fine weather (85.7%) with dry roads (78.7%). The speed limit for the accident location in the majority of cases was 50km/h (30mph).

At junction accidents

For accidents occurring at junctions (74%) the junction was more likely to be a 'T' or 'staggered' junction. The cyclist was most likely to be hit by a vehicle pulling out into its path. Most of the junctions where accidents occurred were not signalised but were 'Give Way or 'Yield' junctions (64% of the total accidents)

Not at junction accidents

Not at junction accidents were in a minority overall with 21% occurring whilst the cyclist was not at a junction. The exact circumstances of the accidents could not be discerned. As with junction accidents, the majority occurred on roads with a speed limit of 50km/h (30mph) in fine (84%) dry (89%) daylight (80%) conditions.

Summary of UK Cyclist Accident Analysis

- STATS 19 data suggest that majority occur at a junction (75%)
- Of junction accidents, majority are non-signalised ('Yield/Give Way' - 64% of all cyclist accidents – STATS19)
- Drivers pull out from junction in path of cyclist (STATS19)
- Accidents at "signalised junctions" comparatively low
- However, CARE data suggests that cyclist struck by vehicle travelling in same direction
- 21% occur when cyclist is travelling ahead, not at junction

4.4 Finland

Cyclists (all severities n=12042)

It was found there was a slight bias towards males being involved in the cycle accidents (57.5%). The mean age of those involved 39.6 years old and accidents tended to occur in fine weather (52.2%), in daylight conditions, (83%) between the hours of 12.01pm-18.00pm (51.2%) in the months of May to October (each of these months consisting of around 11% of accidents each, compared to around 3% of accidents occurring each in other months). There was also a noticeable drop in cycle accident occurrences at the weekend (average of 7.6% on Saturday and 6.3% on Sunday as opposed to around 17% for other days of the week). It was further found that the majority of accidents involved the cyclist being hit by a passenger car (79.6%) at a fairly slow speed of 40 km/h (44.8%) in urban environments 88.3%.

At junction accidents

The majority of cycle accidents in Finland occurred at a junction (50.7%), with the most common scenario being the vehicle and cyclist both going straight ahead at an intersection and neither yielding (54.5%). Furthermore, the majority of these occurances happened at a non-signalised intersection (81.2%). Also for elderly cyclists the most frequent scenario occurred at right angle at intersections, 30% of the accidents (44 of 143).

Not at junction accidents

Of the accidnets that did not occur at a junction (accounting for just 84% of cycle accidents) the most common scenario was the cyclist crossing the road into the path of on-coming vehicle.

4.5 Sweden

Cyclists (all severities n=47392)

There was a fairly even split in the number of males and females involved in cycle accidents in Sweden with only slightly more males (54%) than females involved, the mean age was 37.

The type of road that accidents occurred on was predominantly unknown (80.2%) but those that were classified occurred mainly in urban environments (18%). 50kmh was the most common speed (10.8%) other than unknown speed (86%). It was further found the majority of cycle accidents occurred not on a cycle lane (60.6%), not at a junction (75.2%), between 12.01pm and 6pm. There were fewer accidents on Sunday than any other day (11.5% as opposed to around 14% for the other days).Most accidents occurred between the months of May and June (around 11% as opposed to around 7% for other months). Lighting, weather and collision partners were all predominantly unknown (80.4%, 81.4% and 82.2% respectively) but otherwise the majority of accidents that were known occurred in the daylight (15.6%), in fine weather (16.6%) and featured passenger cars as the collision partner (10.2%).

4.6 Comparison of CARE and National Datasets

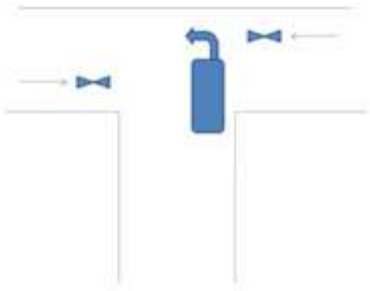
Table 3 below shows a comparison between the CARE data and he national data. Overall, there are many consistencies. However, the main difference concerns the location of the accidents. For the majority of EU Member States, the accidents tended to occur at junctions. For some countries, this figure was high (e.g. 75% in the UK). General characteristics regarding accidents in terms of environmental conditions were broadly similar when the CARE data and national data were directly compared.

Table 3 Summary of Comparison between CARE Data and National data

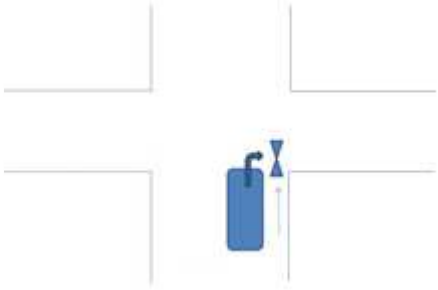
CARE data analysis findings	Spanish data consistency	Austrian data consistency	UK data consistency	Finnish data consistency	Swedish data consistency
More males than females involved	Yes	Yes	Yes	Partial-	Partial
Mostly Urban environments	Yes	Yes	Yes	Yes	Yes
Between 30-50kmh	N/a	Unknown	Yes	Yes (40kmh)	Yes (50kmh)
Either not at a junction or at a crossroad	No – junction accidents	Partially	No – junction accidents	No- junction accidents	Yes-
Between 12pm and 6pm	Yes	Yes	Unknown	Yes	Yes
Least likely to occur on a Sunday	Yes -	Yes-	Unknown	Yes	Yes
In daylight conditions	Yes	Yes	Yes	Yes	Yes
Between the months of April to September	Yes- partially	Yes- partially	Yes partially	Yes- partially	Yes- partially
In fine weather	Yes	Yes	Yes	Yes	Yes
Majority did not wear a helmet	N/a-didn't specify	Yes	Unknown- almost certainly	Unknown	Unknown

Overall, the results can be summarised as follows;

- The majority of cycling accidents in the national accident analyses were found to occur at Junctions/intersections.
- One of the most common scenarios involved **vehicles pulling out into the path of the on-coming cyclist at an intersection (scenario C1)**



- CARE data suggests that the most common scenario involves both cyclist and vehicle heading in the same direction but the **vehicle then turns into the cyclist's path** (scenario C2)



- Overall, **males** are over-represented in the data.
- The majority of the accidents occur in **fine dry weather during daylight hours**
- The majority occur in **urban areas** at relatively on roads with **relatively low speed limits (50km/h)**

6. DISCUSSION AND CONCLUSIONS

The deployment of ITS technologies has the potential to enhance safety and mobility of VRUs. However, it is essential for their success, that these systems are tailored to the specific needs of road users. For this reason, the current investigation has begun with the identification of the critical scenarios for VRUs as well as user needs, in order to find the most promising ITS systems to address them, according to a group of experts.

The data analysed in this study paint a picture of situations and scenarios in which cyclists are injured or killed on European roads. Whilst there is some inconsistency within the analyses, junction accidents do seem to be an important sub-set and the data appear to indicate that overall, cyclist conspicuity is a major issue. In other words, the driver simply does not see or is not aware of the presence of the cyclist within the roadway.

Solutions which improve **Junction Safety** have been one of the most promising ITS countermeasures identified by experts within the VRUITS project. In fact, based on information got from Focus Group discussions, junctions are clearly one of the most relevant critical situations for VRUs, where VRUs are endangered due to being hardly visible or easily overlooked. Moreover situations where cars

overtake cyclists (or Powered Two-wheelers) are especially assessed as being critical due to occasional high traffic speeds and the low-vigilance behaviour of car drivers in some cases.

Data obtained from Focus Group discussions indicated that visibility of VRUs is generally perceived as a major factor in view of traffic safety, especially in connection with heavy traffic and high speed situations. Correspondingly technologies and systems enhancing the **detectability and visibility** of VRUs are considered to have high potential to increase the traffic safety of VRU.

Whilst junctions will be prioritised within VRUITS, other accident scenarios will not be overlooked. In particular, it will be necessary to assess technology that can alert the passenger vehicle driver to the presence of the cyclist on the roadway to ensure that awareness is raised particularly for situations of poor visibility for the driver (for example, night-time driving, complex traffic situations etc.)

For these situations, Blind Spot Detection Systems are seen as relatively promising ITS solutions which will be especially beneficial in helping to avoid truck-cyclist crashes.

It is interesting to note that the majority of ITS solutions for cycling accidents are either vehicle or road infrastructure based. However, it may be worth exploring the issue of (mostly information-based) technologies that can be made available to the cyclist so that their awareness of potentially dangerous conflict situations is raised and subsequent avoiding action can be taken.

In conclusion, cyclist accidents do remain a challenge in terms of road safety particularly with the increased numbers of cyclists on European roads thanks to low-carbon and 'green' initiatives that have been common-place in recent years. The cyclist remains vulnerable because in the event of accidents, there is little protection that can be engineered into collision partners or road infrastructures that can lessen the severity of injury. Therefore the goal of accident avoidance is the best approach and ITS solutions offer the most promising method for achieving this goal.

7. ACKNOWLEDGEMENTS

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