2-BE-SAFE
2-WHEELER BEHAVIOUR AND SAFETY

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# Naturalistic Riding Study:

## Data Collection & Analysis

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# Executive summary

The ‘2-wheeler behaviour and safety’ (2-BE-SAFE) study is a cross-European, multi-disciplinary research project seeking to understand and address the issues behind powered two-wheeler (PTW) riders being over-represented in accident statistics. As part of this project a pilot naturalistic riding study (NRS) was carried out, forming work-package 2 (WP2) of the project. WP2 consisted of three activities:

- Activity 2.1 – Review of previous naturalistic driving studies
- Activity 2.2 – Design of a naturalistic riding study
- Activity 2.3 – Naturalistic riding study: data collection and analysis

This document presents the work conducted under Activity 2.3 and forms Deliverable 6 (D6) of 2-BE-SAFE. Deliverable 5 (D5) is a previously documented work that describes in detail the process and findings of Activity 2.2 and which therefore defines the methodology of the study. D6 is intended to be read in conjunction with D5 and therefore focuses on the results rather than reiterating the methodology. This report is therefore essentially a final ‘Results’ chapter following on from the previous work documented in the previous WP deliverables (particularly D5). Given that this study was a pilot investigation into the practicality of a NRS, each chapter within this document represents a stage in the project methodology and includes a critique of that stage in terms of the efficacy of the approach used, problems encountered and recommendations as to how the methodology could be refined and improved upon in any further NRS. In addition there is also a specific ‘Results’ chapter contained within (Chapter 8) that provides the findings of the pilot NRS as a research project in its own right.

Four countries produced instrumented motorcycles for participation in this study: France, Greece, Italy and the UK. Each had one bike except for France, which had two. The bikes were chosen to represent the most representative type of rider from that country, thus producing bikes ranging from a 300cc scooter in Italy (intended to elicit data from scooter riders in densely-populated urban areas) up to a 1000cc sports bike in the UK (intended to elicit data from rider who use their vehicles both for commuting and for leisure rides in rural areas). All five bikes were instrumented, according to a common template agreed across all partners, with an array of sensors and video cameras intended to capture the most important defining vehicle parameters. In addition to the sensors, each participant was asked to provide subjective feedback to give an overall picture of riding style and rider behaviour. The purpose was to test a methodology intended to be able to capture data relating to incidents and near-misses, involving the participants, that could be analysed to determine the key factors and so used to help direct future safety research in this field. Each bike was given to between three and six participants, each of which had the vehicle for between four and six weeks during which time they were asked to treat it exactly as they would their normal machine. The only additional constraints were that they would need to download the data from the bike on a regular basis and to record their experiences in a travel diary.

Following the data-collection phase each partner performed a filtering exercise to identify when an event (either an incident or a near-miss) had occurred. The primary method for doing this was to identify examples in the data where sensor readings were abnormally high or low for the rider concerned. The principle behind this was that the data as a whole from each rider would be used to create a picture of the rider’s normal riding style. The extreme deviations from this style should represent occasions when they had to respond dramatically to a situation on the road or where they may have come close to losing control. The secondary method of identifying events was using rider feedback from the travel diaries.

The final stage was to examine the recorded events to determine the factors behind them. This basic principle was applied in each country, although in Greece and Italy there were significantly more events recorded which allowed for a more in depth statistical interpretation of the data.

Overall the study partners experienced many difficulties along the way, mostly to do with technical problems, but the methodology was shown to be sound and capable of producing insightful results. It is hoped that this will provide the foundation for future full-scale studies that will help direct future research and policy.

# 1. Introduction

## *1.1. Background to the study*

PTW riders are considered to be vulnerable road users since their risk rates are high, especially compared to those of passenger car drivers. There are several reasons for this, some of which have already been identified through targeted research, and others which remain to be found. The 2-BE-SAFE project aims at understanding further the reasons behind the increased crash rates using several methodologies including accidentology, simulator studies, verbal methods and video tools, conflict studies as well as naturalistic riding studies (NRS). The latter is covered by Work Package (WP) 2 of the 2-BE-SAFE project, and is the focus of this report. The WP consists of three different activities:

- Activity 2.1 – Review of previous naturalistic driving studies
- Activity 2.2 – Design of a naturalistic riding study
- Activity 2.3 – Naturalistic riding study: data collection and analysis

Within the framework of Activity 2.1, a review of previously undertaken naturalistic driving studies was conducted. Several naturalistic studies of car use have been published, but only one such study relating to motorcycle use was identified, and this is still underway, with no results as yet being made publically available. Hence, using knowledge of the methodologies of naturalistic driving studies that was acquired through Activity 2.1, and using 2-BE-SAFE partners' expertise and experience, the design of a naturalistic riding study was undertaken and completed under the scope of Activity 2.2. The output from Activity 2.2 was Deliverable 5 (D5) of the 2-BE-SAFE project and this provided the framework for a naturalistic riding study, including: definition of riding behaviours and experimental scenario design; tools to be used; data issues and appropriate procedures; conduct of the experiment; and implementation strategies to support a successful study. Activity 2.3, the naturalistic riding study itself, was conducted according to the methodological approach specified in D5. This report documents the activities and findings of Activity 2.3. . However, the final methodology plan that was finally adopted follows:

Task 1: Prepare the instrumented PTW

Task 2: Conduct a test and pilot study

Task 3: Make all necessary modifications to the instrumented PTW

Task 4: Design and print all additional material required for the study

Task 5: Resolve any issues that appeared

Task 6: Recruit study participants

Task 7: Conduct the main experiments

Task 8: Analyse the data

The specifications of the instrumented PTW in respect to the provided output parameters (e.g. speed) and their characteristics (e.g. frequency) had been defined and agreed upon prior to the implementation of the study and are noted in D5 analytically. According to these the PTW used for the study was instrumented (1).

Following the PTW instrumentation there was a testing phase and a pilot study period (2). The reason for this was mainly to check the instrumented PTW performance. Hence, throughout this period several issues with vehicle instrumentation and the expected output data that might appear could require instrumentation modification and fine-tuning (3). In addition, the downloaded data and software should also be checked in order to detect any possible problems before using them for analysis. Hence, tasks 2 and 3 were completed only after the vehicle could be safely driven and provide the predefined data in the desired manner.

Task 4 involved the preparation of the additional required material including:

- Travel diary design
- Definition of a format for weekly debriefing interviews
- Design a follow-up questionnaire presented to participants at the end of the study
- Prepare training material and briefing notes for participants.

Task 5 mainly involved solving any legal issues including instrumented PTW insurance and certification.

Task 6 involved recruiting participants according to specific participant characteristics and predefined constraints and priorities.

Task 7 involved performing the NRS, and collecting and storing the data, and Task 8 analysing the data. In most case this was done in parallel. That is for example, while the data was being collected, the data of a prior period was being analysed. Data involved both objective (recorded from the instrumentation) and subjective (travel diary, briefing interviews) data. Analysing the data also included data reduction and filtering.

## 1.2. Objectives, research questions & hypotheses

In several such studies (e.g. 100-car naturalistic driving study, Klauer et al. 2006) the aim of the study is based on specific hypotheses, that will be supported or not from data analysis and are related to driver behaviour and road safety. Such questions can be of great detail e.g. novice riders in urban intersections create more conflicts than other riders do. However, as the NRS has not been yet a standardised procedure, with standard equipment, such hypotheses were not tested at all. The most important result arising from this small-scale study was to build a methodology, define the appropriate instrumentation and the different methodological approaches for data analysis that could be used in the future for large- scale NRS where such detailed hypothesis can be tested.

Given that the methodological approach has been documented in detail in D5, it is not repeated within this document other than as background in relevant sections. Instead, this document focuses on the outcomes and findings of the study activities. However, in order to provide a basic context for the report, the key objectives and research questions defined in D5 are repeated below:

D5 set out four key objectives for the naturalistic riding study, and therefore to be addressed in Activity 2.3:

1. Validate the NRS as an observational method allowing for the provision of an experimental design that can be followed or used as a basis for naturalistic riding studies in the future.
2. Distinguish between, and hence be capable of describing, different riding patterns, from the recorded data.
3. Understand riding behaviour in two distinct situations – under “normal” conditions and where there is conflict behaviour.
4. Understand the causes behind potential accidents, and the ways in which these can be prevented either by specific rider/driver behaviour or through the implementation of road safety countermeasures ranging from conventional ones (e.g. road design) to more progressive ones (e.g. intelligent transport systems).

D5 sets out the following questions that should be answered by the research with regards to the methodology (predominantly Objective 1):

1. What are the lessons learned from the naturalistic riding study in respect to the above elements?
2. What is the most appropriate implementation time schedule for a large NRS?
3. How could the instrumentation be modified/ integrated to improve the observation of riders’ behaviours?
4. How could other elements of the study (data storage, analysis methodology etc.) be modified/ integrated to improve the observation of riders’ behaviours?
5. Was there a specific issue that was not taken into account which is a prerequisite for the successful implementation of a larger naturalistic riding study?

The following further questions relate to the analysis of the data themselves (Objectives 2, 3 and 4):

6. What rider patterns can be identified by the data? Could these patterns be correlated with specific rider profiles?
7. How can one define and distinguish between riding under “normal” conditions and riding at conflict? What are the parameters that one should record and are there specific values that

could be set to define conflicts quantitatively? This would also allow setting triggers for conflicts.

8. What are the contributing factors and dynamic scenarios involved in conflicts? – This will also provide answers to the questions: “How do riders behave and cause an accident?” “How do riders behave to avoid an imminent accident?” and “How do riders behave in order to avoid getting into an accident?”
9. What are the differences between one week of field data and one month of naturalistic riding data?
10. What are the differences among the different scenarios in the different countries?
11. What are the differences among the factors that contribute to these scenarios, in different countries?

Following on from the key objectives, D5 sets out six research hypotheses that the project should seek to address during the analysis:

1. The instrumentation does not alter PTW dynamics and rider driving behaviour.
2. The instrumentation is appropriate and all required parameters are recorded in a proper manner (no data fail, appropriate accuracy, synchronisation of the different data, etc.).
3. The data parameters and their accuracy are sufficient to provide a good quantitative and qualitative description of rider behaviour.
4. The procedure of data storage did not influence the course of the study, and was implemented efficiently.
5. The methodology for data analysis is appropriate and yields the requested output.
6. No legal or ethical issues are raised during the study and during data processing.

## *1.3. Guidance on the structure of the report*

The remainder of this report documents the findings from the 2-BE-SAFE naturalistic riding study (NRS) and is essentially a final ‘Results’ chapter following on from the previous work documented in the previous WP deliverables (D4 and D5). Each chapter within this document represents a stage in the project methodology and includes a critique of that stage in terms of the efficacy of the approach used, problems encountered and recommendations as to how the methodology could be refined and improved upon in any further NRS.

Despite each chapter within this report essentially representing a results chapter in its own right (in the context of this work being an exploratory pilot study), the analysis performed on the collected data has still yielded results that are useful outside of the pilot status of this project. The specific ‘Results’ chapter (Chapter 8) in this report pertains to these analytical results. The critique of the process of attaining these results is contained within Chapter 7 – ‘Data Analysis’.

It should be noted that the methodology used in this study was carried out as faithfully as possible to the methodology specified in D5 and so the full methodology for each stage is not always repeated in the relevant chapter. However, during the study various challenges were encountered among the project partners that sometimes required slight deviations from this methodology. Where such deviations have occurred, these are explained within this document under the relevant chapters, and indeed, a relatively full overview of the methodology used is often still provided.

# 2. Setup of the trial equipment

This chapter examines the process of procuring the necessary equipment and setting up the databikes ready for trialling. Provided below is a discussion of the procurement and preparation process in each partner country, including a review of the lessons learned during this project and recommendations for how this process could be adapted and improved in a future study.

## *2.1. Overview of planned methodology and deviations from it*

### 2.1.1. France

IFSTTAR already had two partially instrumented motorbikes, one sport tourer, a Honda VFR 800, and one roadster, a Honda CBF 1000. Both PTW are equipped with ABS (advanced braking system) and CBS (combined braking system). The equipment of these motorbikes as well as their data logger has been upgraded to fit 2-BE-SAFE requirements.

Two loggers are used: one is dedicated to the video recording, the second for sensors data (dynamics of the vehicle and actions of the rider detailed later). Both record the same GPS signal, which allows synchronizing the recordings.

The video logger is an off-the-shelf system, designed by ApproTech in Taiwan. It allows the recording of up to 4 video channels at up to 25Hz. To enhance reliability in the motorbike, it has been modified to use an SDHC memory card instead of the default hard disk. Rugged wide-angle (110° field-of-view) cameras were connected to all 4 channels, allowing recording a wide field of view of the environment (180° are covered, using a front camera and two sid e cameras fitted on the sides of the top case), as well as observing the rider him(her)self.

The data logger is a proprietary system, designed by collaboration between IFSTTAR and Paris-Sud Orsay University. The system (VIGISIM) consists of a board with 2 microcontrollers and an FPGA. One “low level” micro-controller (Star12X from FreeScale) is in charge of data acquisition, while the other “high level” micro-controller (SC13 from Beck) is in charge of data recording. The FPGA is in charge of time-stamping data. This architecture allows high frequency acquisition with very precise time-stamping (4 µs). The complete DAS (data acquisition system), including all sensors, is described below:

**Table 1 - French DAS**

<table>
<tr><th>Function / Recording parameter</th><th>Part / Sensor type</th><th>Mounting location</th><th>Installed by</th></tr>
<tr><td>Video Logger</td><td>Brigade (MDR-304)</td><td>In top case</td><td>IFSTTAR</td></tr>
<tr><td>3 x Front-facing cameras</td><td>Brigade (BE-300)</td><td>Base of windshield and sides of topcase</td><td>IFSTTAR</td></tr>
<tr><td>Rider-facing camera</td><td>Brigade (BE-300)</td><td>Over panel</td><td>IFSTTAR</td></tr>
<tr><td>Wiring and connection scheme</td><td>Custom built</td><td>Multiple</td><td>IFSTTAR</td></tr>
<tr><td>Data Logger</td><td>VIGISIM</td><td>In top case</td><td>IFSTTAR</td></tr>
<tr><td>3 axis accelerations and rotation rate (Roll/pitch/yaw) Inertial Measurement Unit</td><td>Custom built, using 3 accelerometers/gyrometers from Bosch</td><td>On gas tank</td><td>IFSTTAR</td></tr>
<tr><td>Longitudinal Speed</td><td>Honda ABS sensor</td><td>Alongside the original ABS sensor</td><td>IFSTTAR</td></tr>
<tr><td>Steering angle</td><td>Optical encoder</td><td>On top of the steering column</td><td>IFSTTAR</td></tr>
<tr><td>Brake activation</td><td rowspan="3">derivation of original motorbike signal</td><td rowspan="3">N/A</td><td rowspan="3">IFSTTAR</td></tr>
<tr><td>Throttle position</td></tr>
<tr><td>Turn signal</td></tr>
<tr><td>GPS</td><td>Sensor from video logger</td><td>In top case</td><td>IFSTTAR</td></tr>
</table>

### 2.1.2. Greece

Although an older version of the instrumented BMW F650 FUNDURO utilised in the Greek experiment was previously used in short test runs to verify the instrumentation accuracy, for the purpose of the 2-BE-SAFE experiments, several improvements had been implemented. Additions made to the motorcycle related to the instrumentation focused on:

- Throttle position
- 3-axis accelerometer
- 3-axis gyroscope (roll, pitch and yaw)
- Handle bar rotation
- Brake lever application
- Turn signal activations
- Synchronised video (forward & rider facing)
- GPS

Preparation of instrumented PTW also included receiving (buying) specific instruments. However, delays were introduced by the equipment vendors. The delays involved receiving the equipment and communication delays involving answers to problems with the instrumentation.

In addition, the instrumented bike did not “work” as intended hence modifications had to be made. In particular, issues with cabling and connections stability were observed during the testing period, with specific sensors providing no data at all. Problems related to the on/off recording button were also encountered. Vibrations, due to type of the engine (one cylinder) and mainly due to rough road surface, occurred several times with the result being gaps in recordings for the external sensors for short periods. These problems were tackled by improving/tightening the connectors. An additional problem referred to the weak GPS signal for certain short periods. However, this was due to satellite coverage of Greece, consequently, no action was taken.

For the instrumented bike to be used in the road environment several actions also had to be taken involving insuring the “modified” bike and allowing for several riders as well as certification of the modified bike.

### 2.1.3. Italy

UNIFI has used a Piaggio’s scooter – Beverly Tourer (300cc) – to perform the naturalistic data acquisitions. A scooter is an apt choice to perform these tests in Italy as the majority of riders prefer scooter style PTWs which are more adaptable for their day-to-day use.

The instruments, to be mounted on the scooter, were bought from various dealers across Europe. This was the most time consuming process and the UNIFI team performed an in-depth review of available options prior to order placement of the instruments. The list of sensors and the on-board instrumentation mounted in the final configuration are shown in the following table.

**Table 2 - Italian DAS**

| Function / Recording parameter | Part / Sensor type | Mounting location | Installed by |
|---|---|---|---|
| Video data logger | Brigade (MDR-304) | Under saddle | UNIFI |
| Front-facing camera | Brigade (BE-300) | Over headlight | UNIFI |
| Rider-facing camera | Brigade (BE-300) | Over panel | UNIFI |
| Sensor channel data logger | Instrumentation Devices (IMC CL-5016) | Rear box | UNIFI |
| Wiring and connection scheme | Custom built | Multiple | UNIFI |
| 3-axis accelerations | Xsens (MTi-G) | Under saddle | UNIFI |
| Roll/pitch/yaw | | | |
| Roll/pitch/yaw rates | | | |
| GPS | | Over rear box | |
| Front brake pressure | Leane International (AST4000) | Front wheel | UNIFI |
| Rear brake pressure | | Inside front fairing | UNIFI |
| Front wheel speed | Piaggio | Front wheel | UNIFI |
| Rear wheel speed | Piaggio (magnetic pick up) / custom built (tone wheel) | Rear wheel | UNIFI |
| Throttle position | Leane International (TPS280DP) | Under the saddle | UNIFI |
| Steering angle | Leane International (SRH280P) | Under the panel | UNIFI |
| Turn indicators and stop lights | - | - | UNIFI |

All the instrumentation work was done by the UNIFI team at the UNIFI workshop. However the deviations from the planned study timescale (i.e. a prolongation of the equipment installation) mainly occurred because of longer time needed to install the instrumentation and of the problem with the video system, which had to be replaced.

The installation of instrumentation lasted almost one year with many problems hampering the execution of the tasks. The brief list of problems encountered is listed below:

General installation: the major problem for installation was the lack of a drawing of the scooter from the OEM. A drawing of the scooter would certainly help in completing the instrumentation procedure more quickly. The brackets for the sensors (like sensor cap for steering sensor, the support for the rear and front wheel sensors) were designed and manufactured several times as there was no possibility to perform accurate measurements of the dimensions on the assembled scooter;

Video system: the initially selected video system worked correctly when connected to the power adapter. When connected to the scooter battery, and powered only by the scooter, there was an excessive power drain, which led to a general power failure of the scooter and of the acquisition system. Although the system was compact and suited to be installed on board (according to the indications of the manufacturer), the initial tests were negative. While trying to solve the problem of the power balance of the vehicle, the video acquisition system underwent a failure, most probably caused by a bad internal stabilization of the voltage, and the team decided to replace it completely;

Wiring: one of the most time-consuming sub-tasks was to create a wiring system that would allow for automatic power-up of the instrumentation with the scooter and would not be invasive for the rider. In addition several alternative options for the connectors were explored before deciding on the final solution. The presence of fairings determined an additional constraint for the whole equipment setup and especially the wiring loom. This sub-task represented a bottle-neck in the process to test the full instrumentation in the final configuration.

### 2.1.4. UK

TRL procured a Honda CBR1000RR 'Fireblade' for use in the trial, satisfying the desire to have a high-powered sports bike, representative of the majority of UK riders. TRL are very grateful for the support of North Yorkshire County Council who funded the procurement of the bike.

To instrument the bike, TRL procured a sensor array from Pi Research, a subsidiary of Cosworth Electronics. Most of the equipment was installed by a local Honda Dealership - 'Hatfields of Crowthorne', with the remainder installed on-site by TRL. The specific instrumentation used was as follows:

**Table 3 - UK DAS**

| Function / Recording parameter | Part / Sensor type | Mounting location | Installed by |
|---|---|---|---|
| Video data logger | 'Pi VIDS2' logger (x2) | Rear compartment | TRL |
| Front-facing camera | Video camera | Right-hand air intake | Honda |
| Rider-facing camera | Video camera | Wind shield | Honda |
| Sensor channel data logger | 'Pi Delta Pro' logger | Rear compartment | TRL |
| Wiring loom | Custom built | Multiple | TRL |
| 3-axis accelerations | Pi IMU (3-axis accelerometer and gyroscope) | Under tank cover, centrally aligned | TRL |
| Roll/pitch/yaw | | | |
| Front brake pressure | Sealed-gauge 2030 psi pressure sensor (x2) | Right handlebar | Honda |
| Rear brake pressure | | Brake pedal | Honda |
| Front wheel speed | Pi Sigma/Delta active wheel-speed sensor (x2) | Front wheel | Honda |
| Rear wheel speed | | Rear wheel | Honda |
| GPS | Garmin 5Hz GPS receiver | Above number plate | Honda |
| Microphone | Microphone | Under seat | Honda |
| Front suspension travel | 125mm linear potentiometer | Suspension strut | Honda |
| Engine rev | Digital signal from bike electronic management system | Bike CPU | Honda |
| Steering angle | 360˚ rotary potentiometer | Under tank cover, on steering column | TRL |
| Turn indicators | TRL custom produced | Under seat | TRL |

It was found that the installation process proved to be far more complicated than originally anticipated, with difficulties - and corresponding time delays - caused by unexpected problems with the wiring loom and several of the sensor installations. The delays caused by these difficulties caused unavoidable knock-on delays to other aspects of the trial. Some time was lost from the planned 6 months of trialling (explained further in the following chapter); although most of the delays were absorbed in the project at the expense of a full pilot period in which to test the equipment extensively in a real-world setting. This is explored further in Chapters 4 and 5.

Throughout the process of setting up the bike, the data-logger had to be updated frequently, which lead to a further complication: power drain on the bike's battery. The bike was initially set up such that to interface with the software the logging equipment would need to be powered up by having the bike ignition on. Whilst it was apparent early on that this would cause a strain on the battery it was initially believed that supplementing the battery with an external charge pack when interfacing with the logger would mitigate the problem. It was however found that this damaged the battery. This issue, and the workaround solution, is discussed in more detail in Chapter 5.

## 2.2. Lessons learned and proposed recommendations

All partners found that the setup and instrumentation of the bike took far longer than anticipated. Reasons for this included: sensors not working as anticipated and requiring replacement, connectors failing and requiring either modifications to the design or repositioning on the bike, and changes to the wiring loom caused by modifications to the setup. In addition, it was found that the turnaround time from identifying a problem to then diagnosing the issue, identifying a solution, sourcing the required materials, installing the new parts and testing took for longer than anticipated and sometimes needed to be repeated multiple times.

**Recommendation: Allow at least 12 months for instrumenting the bike. Aim to complete the installation as early as possible, with the remainder of the time set aside for rectifying unexpected complications.**

In the UK, the installation work was split between TRL, the equipment supplier and a local garage; in some cases it required the involvement of all three in order to resolve an issue. It was found that this not only took a long time, but also on occasion lead to confusion over an issue. In particular, once a sensor was installed, if it then proved to be working incorrectly it would be difficult for the TRL researchers to identify what had gone wrong in order to explain to the equipment supplier. It was also found that setting up the logging software proved to be difficult given that sensors were coming online at different times. When something didn’t work as expected this lead to further confusion over whether it was a problem with the sensor, the logging equipment or with the software configuration.

**Recommendation: If possible, installation work should be undertaken by an in-house team that are also responsible for the fine-tuning and testing. If possible the equipment supplier should be involved in the initial setup of the logging software to ensure that it is working properly.**

In order to save space and weight, motorcycle batteries are finely-tuned to provide just enough power to start the bike according to the manufacturer’s factory settings. In Italy, problems with the first video system were caused by a piece of instrumentation not designed specifically for on-board installation (problems: excessive power drain from the battery and final failure because of voltage peak at start up/shut down).

**Recommendation: Use only equipment which is specifically conceived and designed for on-board use. At the very least ensure that additional installed equipment has the minimal power consumption requirement possible and aim to get assurance from the supplier that it is suited to the proposed application.**

A further complication of power-drain was experienced in the UK due to the need to use the bike battery to power-up the logging software when the engine was not running.

**Recommendation: Ensure that there is a means to physically disconnect the system from the bike battery and reconnect to an external power supply.**

There was more than one instance experienced in which a change to a sensor location resulted in the wiring loom needing to be modified, partly caused by a trial and error approach needed in order to refine some sensor fixings.

**Recommendation: wiring should be planned concurrently to the choice of sensor location. CAD information of the assembled vehicle would improve the effectiveness of the process.**

In Italy the use of a regular test plate with the scooter, as originally included in the plan of activities, was possible only after a new complete homologation process of the scooter with the installed instrumentation. This process is expensive and extremely time consuming since it requires:

- A preliminary document from the OEM that declares the possibility to install that specific instrumentation on the vehicle;
- A series of tests to verify the performances of the scooter (e.g. electro-magnetic compatibility and handling tests) –estimated time 1 month approx.–.

For these reasons it was decided to use a test plate, which can be used by Universities for research purposes, but which restricts the set of possible riders to its employees. The nature of the study (i.e. pilot), with a limited number of riders involved, was considered compatible with this restriction without introducing any alteration to the data collection process; however in a larger study this would probably be an unacceptable restriction.

**Recommendation: In a future study the involvement of OEMs in the selection of the instrumentation and to perform the homologation process is strongly encouraged. In addition a cost-benefit approach should limit the types of vehicles used for data acquisition, in order to perform a restricted number of homologations.**

# 3. Recruitment and training of test riders

This chapter examines the process used for recruiting and training participants, including the methods for approaching recruits and the tools for selecting appropriate individuals. Provided below is a critique of the method used in the recruitment and training of test riders, including a review of the lessons learned during this project and recommendations for how this process could be adapted and improved in a future study.

## *3.1. Overview of planned methodology and deviations from it*

### 3.1.1. France

CEESAR and IFSTTAR planned that twelve riders would take part in the trial, each completing 4 weeks of riding and thus contributing to a total recording period of 6 months. To recruit volunteers, the conditions to participate to the trial were first diffused, in the form of a flyer, among the personal from CEESAR and IFSTTAR, in order to relay this message on their social network. This allowed viral propagation of the information to an unknown number of riders. In addition, the flyer was also posted on some riders newsgroups. It can be discussed whether this kind of approach is suitable and gives access to all kind of riders. We can indeed expect that this will only allow contacting riders which are part of the 'riding community', ignoring those who only chose PTW for their efficiency and convenience in congested areas. However, the instrumented motorbikes which were available, led anyway to 'real' riders, which were also more likely to participate in such a study without any financial incentive.

Seventeen potential riders contacted CEESAR. During the first telephone interview, the following information on potential riders was collected:

- Gender
- Age
- Driving Experience (Year of licence acquisition, number of kilometres covered per year by motorbike…)
- Type of motorcycle (Brand, Model, year and Engine capacity)
- Accident history last 2 years.

To participate to the trial each driver had fulfil the following conditions requested by the French insurance company (AMDM):

- Having a "A" licence (motorbike > 34 Kw) since more than 2 years
- Using motorbikes similar to those which will be lent, insurance request (Honda VFR 800 or Honda CBF 1000)
- No suspension or withdrawal of the licence in the last two years
- No accidents during the last 2 years

According to the answers given by potential riders, twelve riders were selected to the trial. Unfortunately, because of technical issues explained in the following chapters, it was not possible to proceed with twelve riders. Finally, six riders participated in the trial. Table 4 summarizes the six participants' characteristics.

**Table 4 - French participant demographics**

| | Participant1 | Participant2 | Participant3 | Participant4 | Participant5 | Participant6 |
|---|---|---|---|---|---|---|
| Gender | Male | Male | Female | Male | Male | Male |
| Age | 38 | 29 | 37 | 41 | 28 | 36 |
| Experience | 19 years (20000km/yr) | 8 years (15000km/yr) | 19 years (18000km/yr) | 17 years (7000km/yr) | 9 years (15000km/yr) | 17 years (18000 km/yr) |
| Normal bike | BMW Motorcycle (1150cc) | Honda Motorcycle (750cc) Suzuki Motorcycle (750cc) | Honda Motorcycle (750cc) | Honda Motorcycle (600cc) | Suzuki Motorcycle (1300cc) | Honda Motorcycle (600cc) |
| Accident history (last 2 years) | zero | zero | zero | zero | zero | zero |

Before handing over the motorcycle, the following documents were signed by each rider and instructions were given to them by CEESAR/IFSTTAR:

- Explanations were given about the study and the instrumentation setup of motorcycle;
- Consent form and document on terms of loan were signed by rider and CEESAR/IFSTTAR;
- Authorization to use pictures (video filming) was signed by the participant;
- Finally, riders were given the travel diary and the instructions to compile it.

### 3.1.2. Greece

Based on the 2-BE-SAFE agreed specifications on the experiments, 3 riders for a period of 6 weeks each were recruited. Male riders are over-represented in accidents and in the riding population so it was decided that all participants should be male riders.

Experience is an important factor of rider risk. Usually, there is a correlation between rider experience and rider age, with young riders usually being also inexperienced and older riders being experienced. Although young and older riders demonstrate high risk rates, it is decided to select participants that are less prone to risky behaviours, to reduce the likelihood of participants being involved in accidents. Consequently, all participants of the Greek experiment were selected to have an actual riding experience of at least 5 years and should not be older than 50 years old. The age of the actual participants ranged from 24-38 years old.

Moreover, the selected participants should ride a bike resembling that of the study vehicle, which was a BMW 650cc bike, so that they are familiar with bike characteristics and movement dynamics and hence with handling the bike. Further, they should all be frequent PTW users in order to have as much collected data as possible. Riding exposure had been determined by the riding frequency and the typical trip distance of the participant. In order to minimize the risk of participants being involved in accidents and to secure the efficient and safe conduct of experiments, it was decided not to select a rider with a high accident involvement record, At the same time, the characteristics of the selected rider should resemble those of a typical Greek rider.

Last, in terms of riding environment, PTWs in Greece are mainly used for commuting to avoid delays due to congestion rather than for leisure purposes. Hence, most of the time spent on the PTW is within the urban road network. In addition, accident statistics also indicate that more accidents happen inside urban areas than outside urban areas. For these reasons, the selected participants were chosen to be familiar with urban road environments and use PTWs for trips inside urban areas.

A predefined procedure by the project for recruiting and preparing the riders for the experiments had been undertaken. Riders were first asked to read the participant briefing note. In terms of briefing, participants were told that the aim of the study was to collect data for observing driving behaviour. The main guidance involved riding normally. However, theft of the bike or of part of its instrumentation (e.g.

video cameras) was also considered. Hence, the participant was asked to use the bike only in cases where he considered parking to be safe. This might deviate somewhat from a naturalistic study, however, vehicle theft is not uncommon and this instruction was considered necessary. Participants were also informed about the way that data would be downloaded (i.e. the time and venue for downloading).

They were also shown the travel diary; the questions and completion technique were described to them. There were also told that they would be required to participate in the weekly debriefing interviews, the context of which was explained to them.

Following that, participants were shown the bike, with each of the sensors identified and explained. Participants were offered the opportunity to ask any further questions and, once happy, asked to sign the project risk assessment, informed consent form and a declaration of receipt of the instrumented bike and associated project equipment. The handovers were conducted at UoT.

### 3.1.3. Italy

UNIFI planned to proceed with six riders for the data acquisitions, each completing four weeks of riding and thus contributing to a total recording period of six months. The limitations imposed by the use of a test plate resulted in riders being chosen from UNIFI personnel, simplifying the monitoring and data acquisition progress. (The test plate is a registration plate that has special numbering and is associated with a legal entity rather than to a vehicle, so can be moved from one vehicle to another).

The recruitment process followed the parameters identified in deliverable D5. The characteristics of the recruited riders are reported in the following table. The data show that the annual mileage of the riders is in excess of the minimal threshold (2000km/yr) and it was made in order to maximise the number of recorded data and, potentially, of relevant events.

**Table 5 - Italian participant demographics**

| | Participant1 | Participant2 | Participant3 | Participant4 | Participant5 | Participant6 |
|---|---|---|---|---|---|---|
| Gender | male | male | male | male | male | Male |
| Age | 28 | 34 | 41 | 37 | 29 | 41 |
| Experience | 12 years (5000km/yr) | 18 years (7000km/yr) | 22 years (8000km/yr) | 19 years (2000km/yr) | 8 years (10000km/yr) | 24 years (10000 km/yr) |
| Normal bike | Yamaha scooter (50cc) Kawasaki Motorcycle (250cc) | Aprilia Motorcycle (850cc) | Honda Motorcycle (150cc) | Piaggio Scooter (180cc) | Kymco Scooter (400cc) | Beverly Scooter (300cc) |
| Accident history (last 2 years) | zero | zero | zero | zero | one | zero |

The following protocol was followed for each rider before handing over the scooter:

- An authorization letter from the Head of the Department was required in order to use the scooter with the test plate;
- Explanations were given about the instrumentation setup and the usage of scooter including the limitations;
- Riders were given the travel diaries and the instructions to compile it, however none of the riders were interested to perform the interviews.
- Riders were made aware of the strategy to download the data and appreciated the fact that data downloading could be performed without their presence;
- Finally, an informed consent document was signed by both the parties (participant and the UNIFI).

### 3.1.4. UK

It was planned that four riders would take part in the trial, each completing 6 weeks of riding and thus contributing to a total recording period of 6 months. Due to purchase of the bike being funded by North Yorkshire County Council, it had initially been agreed that two of the four participants would be based in North Yorkshire. It was decided that the first two participants should be local to TRL to allow for easy access to the bike during the early data collection, and in fact the first two participants were sourced from TRL staff. A message was put out on the company intranet asking for participants who wished to take part in a motorcycle safety study. Of those who responded, two were chosen that most closely fitted the desired rider demographics of the project. The two participants in North Yorkshire were recruited using a database of riders held by North Yorkshire County Council acquired through their own rider safety initiative '95 Alive'. Each person on this database was emailed with details of the study and asked to contact TRL for further information if interested: 40 responses were received and a shortlist or the most desirable candidates created. Each was contacted for further information about riding background and availability, and two final participants selected for inclusion in the trial. As such, four riders were recruited to take part in the NRS: 2 local to TRL in Berkshire, and 2 from the area around Leeds in North Yorkshire. The four participants had the following demographics:

**Table 6 - UK participant demographics**

| | Participant 1 | Participant 2 | Participant 3 | Participant 4 |
|---|---|---|---|---|
| sex | male | male | male | male |
| age | 53 | 39 | 35 | 42 |
| experience | 36 years | 20 years | 16 years | 25 years |
| normal bike | Kawasaki ZZR1100 | Honda CBR600-FX | Suzuki SV1000S | Honda CB1300S |

It was intended that data collection would run from September-November and from March-May, with a three month break for winter. However, for the technical reasons explained in the previous chapter, it was not possible to commence data collection in September as planned. This was not initially considered to be problem as one of the local candidates expressed that he normally rode over the winter period and would be able to take part in the study during this time. Unfortunately a particularly cold winter resulted in treacherous road conditions for much of the winter period and the participant was unable to commence data collection as early as planned. As such each rider had the bike for up to four weeks as opposed to the six weeks originally planned for*.

*Note – the actual data collection period was slightly less than four weeks for participants 1 and 2 due to additional complications. Rider 1 experienced technical difficulties with the sensors that resulted in lost data, and was also ill for two weeks, during which he did not ride. An additional few days of data collection was arranged later in the trial, but the total data collection was still limited. Rider 2 was removed from the trial three weeks into his data-collection period as his preferred riding style was considered to be too risky for the purposes of the trial due to concerns of liability relating to 'duty of care'.

The two local riders recruited from TRL staff were given the option to test the bike out on the TRL test track prior to taking it away. The participants from North Yorkshire, however, were not able to visit TRL prior to the start of the study due to the large distance involved in making this journey. It was therefore necessary to conduct the full recruitment process solely through a combination of phone and email conversations. In practice this turned out to be an acceptable way of doing things and there were no problems encountered specifically arising from the use of this practice. However, allowing riders a period of adjustment in a segregated and managed environment may offer potential safety benefits, both in terms of providing the rider a practice period, and in allowing the research team to check for any bad riding habits prior to the official bike handover. It is also accepted that, whilst not a problem in this trial, there was a small risk that the participant would not still wish to take part after first seeing the bike setup. Had the rider chosen not to take part, there would have likely been a significant delay to the project while a replacement rider was sought.

Despite the recruitment process for the local and non-local riders differing slightly, the actual handover process followed the same format. Riders were first asked to read the participant briefing note, informed consent form, project risk assessment and TRL's transport policy documentation. Following this, participants were shown the bike, with each of the sensors identified and explained to them by the researcher. The logging equipment was then explained, along with instruction on the correct download procedure. Participants were offered the opportunity to ask any further questions and, once happy, asked to sign the project risk assessment, informed consent form and a declaration of receipt of the databike and associated project equipment. Two copies of each document were signed, with one copy retained by the participant and the other by TRL. The handovers were conducted at TRL for the local participants and at a convenient location of the participant's choice for the North Yorkshire participants, with the bike being transported to/from this location either by van or by the previous/next participant.

## *3.2. Lessons learned and proposed recommendations*

Partners experienced difficult decisions over the selection of participants based on the perceived riskiness of their riding. On one hand, the purpose of the study was to record incidents and near crashes, something that would be made more likely by recruiting riders known to adopt riskier riding styles or who had a history of being involved in accidents. On the other hand there were ethical considerations relating to duty of care, as well as the potential detriment to the project if a crash occurred that put the test bike out of action.

**Recommendation: There is no clear answer to this as a balance must be struck and it will be down to each project to determine what the key requirements are for the purposes of that particular study. It is something that should, however, be considered at an early stage and project coordinators must be clear about what would happen in the event of a crash. Designing a simple and inconspicuous instrumentation, which could be installed on participants' own motorbikes without any impact on motorbikes´ homologation or safety, could solve the problem. The study would have no impact on participants riding, and hence would not be liable for any potential crash. However, this study has shown how difficult it might be to develop a system simple enough to be installed easily and quickly enough to make this a practical option.**

Rider population characteristics, riding aims and riding environments differ between countries. In 2-BE-SAFE the study participants of the different countries did not have the same characteristics. For example in some countries urban areas were of interest whereas in the UK rural or interurban areas were of interest.

**Recommendation: Unless the study has a big budget and is performed during a long enough period allowing for a large participant sample, it is most important to have participants that are typical from each country than participants with similar characteristics between countries who might not be typical riders for some of the countries.**

All the riders involved in the study expressed that they were interested to contribute to the research tasks. However, many of them wanted minimal interference with their everyday life and some refused to participate in interviews.

**Recommendation: In order to increase the cooperation level in the use of verbal tools, financial compensation for additional tasks imposed on the participant through being involved in the study could be considered.**

Both electronic and paper versions of the travel diaries and instructions were given to the riders. All the riders compiled the travel diaries in electronic form.

**Recommendation: in a larger scale study the possibility of an implementation of the travel diaries in formats compatible with handheld devices should be explored.**

# 4. Piloting

This chapter examines the piloting of the equipment and the study processes, prior to the first involvement of the main study participants. Provided below is a critique of the method used in the piloting process, including a review of the lessons learned during this project and recommendations for how this process could be adapted and improved in a future study.

## *4.1. Overview of planned methodology and deviations from it*

### 4.1.1. France

The sensors and VIGISIM data logger had already been successfully used in the VFR800 in very severe experiments (recording dynamics of extreme riding and fall events, reproduced by a stuntman). As a result, they were considered as very reliable. However, the experimental conditions in which they were used (manual triggering of recording, short data acquisition) were very different from a naturalistic driving experiment (automatic triggering of data acquisition, long periods of data acquisition). Late availabilities of the motorbikes for the integration of features necessary for 2-BE-SAFE (autonomous operation, video-logging), left little time for a proper piloting and final troubleshooting of the DAS. An IFSTTAR researcher used both motorbikes for short periods of time before delivery to the riders, with good results. However, the driving patterns in that period didn't allow identification of power supply problems which happened later in the experiment, and the short duration of the piloting didn't allow identifying long-term reliability issues (such as disconnection of plugs or ejection of memory cards due to vibration). The fact that the data visualization software wasn't ready at that stage also prevented identification of some synchronization problems between data and video.

Since participants appointments were already made, that the project timescale didn't allow significant shifts, but also because the study as a whole was considered as a pilot study for a larger future study, it was decided to push as fast as possible to start the actual experiment, in order to identify as much problems as possible in a really naturalistic environment. This proved to be a costly mistake: troubleshooting had to be made at remote places, and some participants had flat batteries problems, which resulted in them being unable to use the motorbike.

### 4.1.2. Greece

The enhanced motorcycle had been tested for instrumentation verification and data quality issues using one rider for a period of 4 weeks. The scope of the pilot runs was twofold: first to detect and correct any installation or sensors malfunctioning problems and, second, to evaluate whether the recorded data maintain certain levels of quality.

Regarding the installation and functioning of sensors, the main issue that was detected involved the pairing of different devices attributed to bugs in the firmware. This resulted in a lag of the recorded data when switching the engine on. After communicating with the manufacturers, the problem was fixed by updating the firmware of the data logger that corrected all the bugs.

As for the data quality issues, attention was given to the evaluation of the data downloading process. Particularly, the availability (e.g. is the data collection system accessible? etc) and process ability (e.g. are the sensors in a convenient format?) were tested. Moreover, a preliminary analysis of the collected data was undertaken in order to evaluate the quality of the signals produced, as well as their appropriateness for the purpose of the analysis in the 2-BE-SAFE framework. Quality issues considered involve the Completeness (extent to which the expected attributes of data are provided), accuracy (data reflect real world state), credibility (extent to which the data is regarded as true and credible). In general, apart from the GPS data for which, due to frequent loss of signal, the quality was questionable, no critical data issues were faced.

### 4.1.3. Italy

Prior to actual data acquisitions, all the sensors (except GPS position) were calibrated and each sensor functioning was verified at the UNIFI workshop. Especially the orientation of rider facing camera and front facing camera (i.e., the horizontal distance of the first ground point was chosen to be less than 4m from the front facing camera) were thoroughly examined. During the preliminary test trials, the scooter performed the set of test decided in task 4.1 to validate the instrumentation and the 3-days trial in data acquisition configuration. The full test was repeated twice since after the first pilot the problems with the first video system and the rear tone wheel were evidenced.

The final piloting was performed in December 2010, after all the problems were solved. Its positive completion allowed the scooter to be given to participant1 for actual test trials.

### 4.1.4. UK

As explained in Chapter 2, technical difficulties in setting up the databike resulted in delays to the project. In order to minimise the impact on the project schedule it was deemed necessary to commence the data collection phase before all the equipment had been fully tested in a proper pilot experiment. That is not to say that all the equipment went out untested as some of the earlier-installed sensors were tested on-site, but there were some sensors that were not fully calibrated when the bike initially went out. Part of the participant 1 data-collection period was therefore spent fine-tuning a few of the sensors based on the results seen after each daily download. The following sensors were not fully-operational upon the bike being handed over to the first participant:

- Turn-indicator signal
- Front-facing video camera
- Steering angle
- Engine rev

The front facing video camera had been giving problems for some time and this continued to be the case, despite efforts to get it working. In the end feedback from the supplier was received that the logging unit would need to be returned for assessment and repair (it would later be revealed that a catastrophic failure of the video logging unit had occurred and that it would not be serviceable for the remainder of the project). Following the removal of the front-facing camera logging unit from the bike the decision was taken to swap the feeds for the rider-facing and front-facing such that the front-facing data would be recorded at the expense of the rider-facing. In retrospect it turned out that this was indeed the favourable option as it proved to be impossible to analyse the journeys in which there was no front-facing camera feed due to the inability to apply any context to the other sensor channels being recorded.

The engine rev. sensor is another one that was never fully configured throughout the trial due to an inability to determine the cause of the faulty signal. For some time it was believed that the data would be retrievable once a functional correction could be identified and applied retrospectively to the data, but this proved not to be the case. As such the engine rev and rider-facing camera data were missing from the final datasets. All other channels were included.

## *4.2. Lessons learned and proposed recommendations*

It was highlighted that, even if a sensor was initially seen to be working correctly, this would not always remain so as other sensors were integrated and came online. It seemed that problems with one sensor could lead to knock-on effects causing problems with another.

**Recommendation: Ensure that there is enough time to get every sensor installed and checked before sending the bike out for full testing.**

Sometimes sensors were checked with the bike in situ and apparently shown to be working. However once the bike was used in real riding it became clear that the calibration of the sensor was off.

**Recommendation: Ensure that each sensor is checked and validated in a real riding situation in which the recorded values can be confirmed as accurate and realistic.**

Similarly, some sensors shown initially to be working, later failed due to vibration and the general rigours of being installed on a motorcycle.

**Recommendation: all connection should incorporate a physical lock between mating parts that ensure a connection cannot work loose over time. In the case of wiring between bridges that have reciprocal moving parts, enough wire length should be used to allow a smooth movement that will not cause fatigue failure in the wire. Wires and sensors should also be securely fixed in place to make sure they cannot work free and become exposed, even under extreme usage.**

In the UK study it was not possible to run a full pilot as time pressures required the bike to be sent out to the first participant at the earliest opportunity. This carried mixed pros and cons as it allowed for some data to be collected, but at the same time made it slightly more awkward to fix the sensors that were not yet working properly. In the case of this study it was possible to get access to the bike during most days as the participant was a TRL employee who could bring the bike to the workshop when he was attending the TRL site, but if a member of the public was participating this would not have been possible.

**Recommendation: This again comes back to leaving ample time to troubleshoot issues, but it is important to ensure that the kit is working before it is sent out. Even when it is working, it should be considered how easy it would be to gain access to the databike once it has been sent out in case something does fail on the bike and needs to be worked on. Participants based closest to the research organisation's premises should be the first to be used in the study.**

In France, one of the databikes used was an existing databike that had been used successfully in a previous project and was thus considered to have been proven already as reliable. However it had been used under different trial conditions and, in the NRS, developed several problems relating to battery leakage leading to loss of data (video or motorbike dynamics).

**Recommendation: Each databike used should be tested and piloted under conditions as representative as possible of the main trial conditions. In particular, even during the pilot, the equipped bike should ideally be tested by several riders, with different riding styles and travel patterns, and who should test the data-download procedures in a field setting.**

It was later found that some difficulties were experienced due to the video and sensor data not synchronising.

**Recommendation: The full data-visualisation process should be tested during the pilot stage, not just the download process.**

# 5. Data collection and storage

This chapter examines the tasks of recording data onto bike-mounted storage devices, and of capturing subjective rider accounts of their actions and experiences during the study. It also covers the process of downloading the data from the bike and transferring it to a secure storage location. Provided below is a critique of the method used in the data collection process, including a review of the lessons learned during this project and recommendations for how this process could be adapted and improved in a future study.

## *5.1. Overview of planned methodology and deviations from it*

### 5.1.1. France

Data collection was performed by CEESAR and IFSTTAR using the two instrumented motorbikes (VFR800 and CBF1000). Depending on participants' location, motorbikes handover was done either at CEESAR, North West of Paris or at IFSTTAR, South of Paris. Data pickup was done weekly at the same places, or if that was too complicated, at the rider's home or workplace. At that moment, riders were interviewed, in order to clarify the depiction of the self-reported events. After pickup, data was transferred on a NAS with RAID 5 redundancy. At that stage, correspondence between numeric and video data had to be done manually, which would not be applicable to a larger scale study.

The initial plan allowed collection of data for 12 recruited drivers, during six month duration, each driver using the motorbike for one month. Unfortunately, the late start of the experiment resulted in first participants having to ride during winter. Climate conditions (snow) made riding impossible for some weeks, during December 2011 and January 2011, resulting in delays.

In addition to that, technical problems, more specifically battery drain, led to immobilization of the motorbikes, and hence a halt in data acquisition for participants 2 and 3.

The constrain of having to finish the experiment before summer 2011, and the drop-outs of later participants caused by the recurring delays to the initially appointed experiment period, resulted in being able to only collect data for 6 different riders.

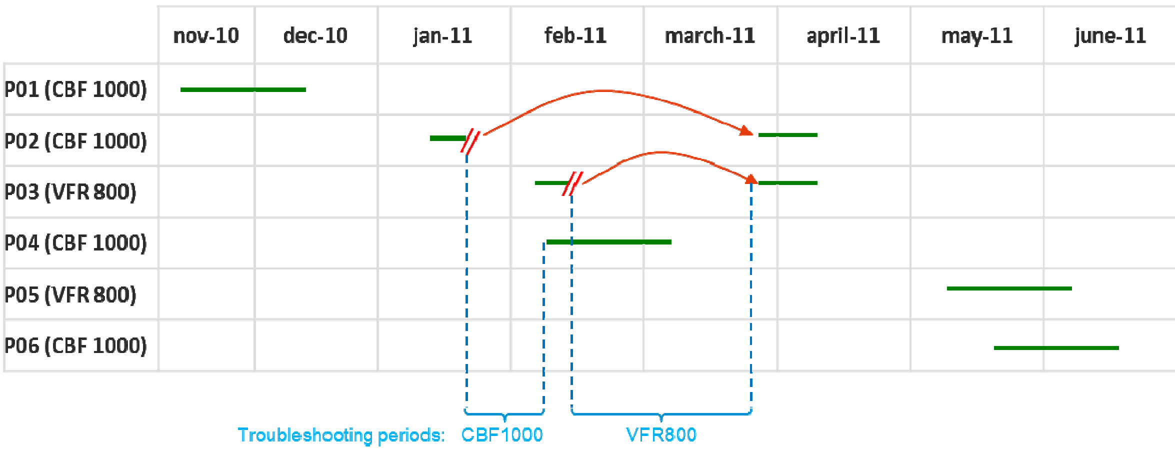



**Figure 1 - French data-collection timescales**

Although battery drain (and resulting failure to start the motorbike) was solved early on, several technical problems continued to cripple objective data collection. The issues which were met are listed in Table 7:

**Table 7 - Log of French DAS issues**

| Failure | Causes | Consequences | Solutions or workaround |
|---|---|---|---|
| Battery drain | Over-consumption of DAS.<br><br>DAS does not always switch off after engine stop. | Inability to start motorbike.<br><br>DAS failure, switching on and off, and corrupting storage. | Asking rider to recharge batteries and/or change them, using provided charger and spare batteries.<br><br>Adding a power-on LED indicator so that the rider can check if the system is properly shut down.<br><br>Design of a new power supply system (could not be done before end of experiment). |
| Signals loss | Ground loop problems<br><br>Disconnection of DAS components because of vibrations | Degradation or loss of signals. | Isolating camera supports solved ground loops issues.<br><br>Plugs were strengthened in order to withstand vibrations. Silent blocs / dampening material were added were necessary. |
| Data files loss | Dismantling of memory cards because of vibrations.<br><br>Compact flash burnt (cause unknown).<br><br>DAS reboots (attributed to battery drain, see above). | No data or partial data (either video and/or numeric data, multiple short partial acquisitions in one trip). | Check that memory cards were fully inserted, better dampening of data loggers.<br><br>Solve battery drain issues. |

The resultant objective data recorded is shown in Table 8:

**Table 8 - Overview of French objective data-collection**

| Participant Id | Motorbike | Participation dates | Self-reported trips | Sensors/GPS | Video | Incidents |
|---|---|---|---|---|---|---|
| *P01* | Honda CBF1000 | 15.11.2010 to 13.12.2010 | 33 trips | 7 files<br>1h | 17 files,<br>6:30h | 3 reported<br>2 validated |
| *P02* | Honda CBF1000 | 13.01.2011 to 21.01.2011 and 29.03.2011 to 14.04.2011 | 34 trips | 34 files,<br>31h | 37 files,<br>22:13h | 0 reported<br>1 found |
| *P03* | Honda VFR800 | 03.02.2011 to 10.02.2011<br>and<br>30.04.2011 to 13.05.2011 | 33 trips | 18 files,<br>6h | 132 files,<br>6h | 4 reported<br>2 validated |
| *P04* | Honda CBF1000 | 08.02.2011 to 15.03.2011 | 47 trips | 57 files,<br>18h | 30 files,<br>9:55h | 2 reported<br>2 validated |
| *P05* | Honda VFR800 | 05.05.2011 to<br>08.06.2011 | 64 trips | 95 files,<br>29h | 182 files (only 62 can be used),<br>20h | 7 reported<br>1 validated<br>(video missing for the others) |
| *P06* | Honda CBF1000 | 23.05.2011 to 24.06.2011 | 35 trips | 73 files,<br>1h | 128 files,<br>1h. Only 5 very short videos can be used. | 10 reported<br>1 validated<br>(video missing for the others) |

### 5.1.2. Greece

The instrumented motorcycle is equipped with a data logging system. This system gathers and stores 100Hz riding parameters' data from all sensors, as well as from the video cameras. The data logger's capacity is 16h HD video or 889 h of data recording. The recorded data were downloaded daily from the flash memory to an external High Capacity Hard Drive (HD) that was given to the rider. By the end of each week the recorded data were transferred from the rider's HD to a central recording unit (with backup facilities), which is attached to the Laboratory's Computing System. The recording unit was available (under authorisation) to all, but all the backup data were strictly available only to Laboratory's director (Prof Eliou). The duration of the transferring procedure (from rider's HD to the main recording unit) was about 10-15 minutes, depending on the volume of the recorded data). Deviations from the above-mentioned procedure were observed only during bad weather conditions, or due to a rider's unavailability to be at the Laboratory by the end of a certain week. During these periods, the transfer from the rider's HD to the main recording unit was done every 10 or 15 days. During the experiment, no problems due to material failure (HD or flash crash) were observed.

The diaries were completed, in draft mode, at the end of each journey, and in formal mode (electronic) when the rider was at home. Riders were also contacted weekly for a debriefing interview, in order to locate, in accordance to the travel diaries contents, any possible points of interest for further discussion.

Finally in collaboration with NTUA, the recorded data for each separate rider were recorded on an external HD and delivered to NTUA for processing, accompanied with the relevant diaries.

The structure of the data logging system was easy and flexible. Data was downloaded every week to secure storage systems in the UoT premises and encompassed the video recording for each run, as well as compressed information on the riding parameters under investigation every 10-3 sec. The data was codified based on the date the run took place, as well as the start time. The data were able to be easily visually observed and processed, or extracted to an ascii file for further analysis via a piece of commercial software properly calibrated based on the needs of the Greek experiment.

### 5.1.3. Italy

In compliance with the guidelines of the study (ref. deliverable D5), the data were downloaded weekly. The data download was performed removing the memory cards from the DAS and the video acquisition system, downloading the data on a notebook and finally copying the data to the repository with RAID system for data protection. The data integrity and the anomalies in the data acquisition were verified immediately after the download.

The possibility to use a compact format for the videos, although a proprietary one, facilitated the data download and storage. Also the data from the sensors were recorded in a proprietary format, which proved to be very efficient since more than one rider's data could have been stored on a 2GB compact flash card.

The data collection process for all the riders was scheduled in the period October 2010 - April 2011. However the issues reported in chapter 2.1.3 caused a delayed start in December 2010. As anticipated in the previous chapter (section 4.1.3), the data collection process was interrupted by a set of failures, which for their nature it was not possible to detect during the piloting. A comprehensive overview of the data collection phase is reported in the figure below.

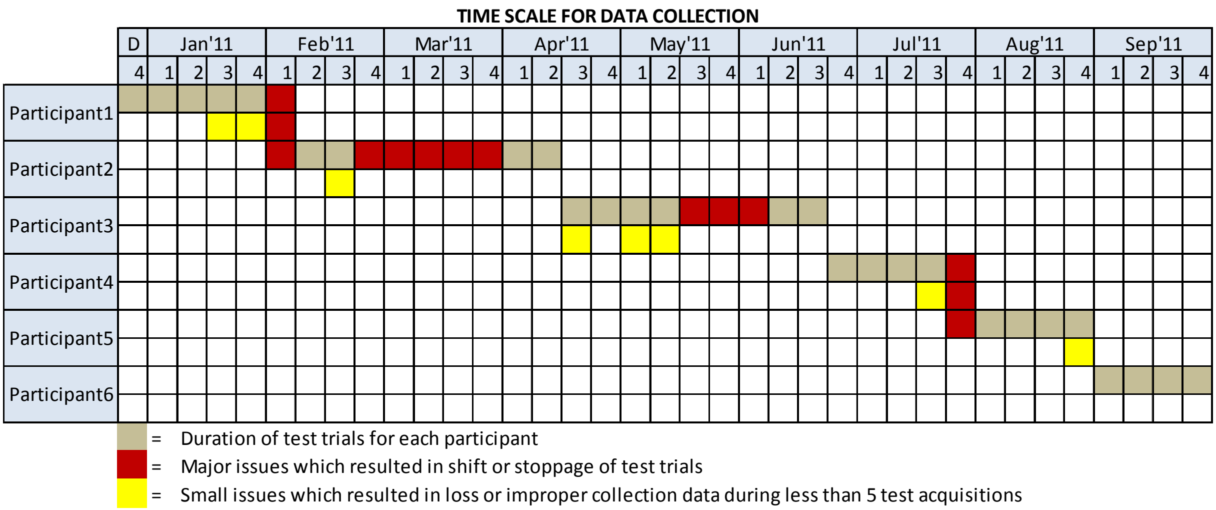



**Figure 2 - Italian data-collection timescales**

In the period of data acquisition of participant #1 the following problems arose:

- Steering sensor: after two weeks of data collection the continuous friction between the steering sensor and the inner part of the dashboard generated a shift between two parts of the steering sensor. This resulted in a measured offset of 30 degrees. The initial solution lasted one week, and a malfunctioning was detected because of a new 15 degrees shift. A protective cap was installed in the period between participant #1 and #2 and it fixed definitively the problem;
- Rear wheel speed sensor: the sensor distance from the tone wheel increased from the nominal installation value (because of excessive vibrations and flexibility of the support bracket) and it resulted in loss of rear wheel speed sensor data. However, the problem was

temporarily resolved with a new installation with decreased initial distance between the sensor and the tone wheel, in order not to interrupt the data acquisition process, since a permanent solution required a new design and manufacturing of the sensor support.

During the period between participant #1 and participant #2, UNIFI improved the instrumentations setup with:

- Design and installation of a metallic cap was mounted on the steering sensor to protect it from other moving parts: this solution solved the problem with the steering sensor permanently;
- Redesign, manufacturing and installation of a new bracket for the rear wheel speed sensors and simultaneous installation of a new and more robust sensor.

In the period of data acquisition of participant #2 the following problems arose:

- in the first week, there was an issue with data acquisition system: the system never started (as it was auto-start) even after the engine was turned on. Several trials were made both after a full, long lasting charge of the scooter battery, as well as with the power adapter. The results were all negative and the acquisition system was sent for support to the manufacturer (the repair took over one month).

In the period of data acquisition of participant #3 the following problems arose:

- During the first week, the rider-facing camera didn't give any output. It was an issue of loose connection, caused by loosening of the camera connector to the video acquisition system, which have no possibility of a physical lock. The lock was implemented using a thermal-shrinking sheathing which, applied also to the other video channel, solved permanently the problem;
- During the third week a turn light indicator stopped functioning. The scooter was taken to the official Piaggio workshop but the problem showed up again after a few days;
- During the fourth week the sensor of front tone wheel stopped progressively to work because the wire got cut as a consequence of a too tight installation, which caused a fatigue strain on the wire itself. It was replaced with an analogous sensor and the wiring was modified.

In the period of data acquisition of participant #4 there were no problems with the data acquisition system. However data acquisition was stopped for one week at the end of July since it was necessary to perform a periodical servicing to the scooter.

In the period of data acquisition of participant #5 the following problems arose:

- The power cables of the wheel speed sensors came loose, most probably because of the vibrations induced by the riding style of the participant #5. Only a couple of data acquisitions were lost;
- The plastic cover of the RS232 CAN connector of the inertial platform broke and resulted in on-off data acquisition. The cover was replaced with a new RS232 cover and the stability of the connection was restored;
- The power supply cable for the acquisition system was broken because of strain in the cable (probably because of movement of the system caused by vibrations) and it was resolved in a few days.

In the period of data acquisition of participant #6 the following problems arose:

- The rear wheel speed sensor was not working. After a check of the cables, the problem was labelled as failure of the sensor. Since the wheel speed sensor data was optional, it was decided to proceed with the data acquisition in order not to postpone the end of the data acquisition campaign;
- A bolt came loose (front mud guard) and the whole front fairing had to be removed in order to fix it.

### 5.1.4. UK

As mentioned in Chapter 2, the bike was initially setup such that to download data, or otherwise interface with the data-logging software, the bike ignition needed to be on in order to provide power to the system. It was found that the bike battery was not able to support such work for more than a few minutes at a time and that any extended work on the bike would either run the battery flat or require an additional 'jump-start' pack to be connected to the battery. During the initial bike setup and early data-collection period it was often necessary to have additional power going to the bike for extended periods and the battery regularly alternated between conditions of being highly charged and heavily depleted. Ultimately this caused the battery to fail and required a new battery to be installed. To prevent this recurring the system was modified such that an external power supply could be connected directly to the logging unit rather that the unit taking power from the battery, thus allowing work to be undertaken on the system with the ignition off. This proved to be extremely useful and also had the added benefit of allowing the system to be manually disconnected if necessary to allow the bike to be ridden without data being logged and thus mitigate the issue of corruption caused by overwriting (discussed later in this chapter).

A further technical problem was encountered in the form of a blown fuse in the sensor logger, which arose during the period that Participant 1 had the bike and continued for some of the time that Participant 2 had it. The blown fuse had the effect of corrupting data from some, but not all, of the sensor feeds, which is the main reason it went unrectified for an extended period of time. One of the symptoms was that the voltage going to the box was recorded as being abnormally high, and the problem was initially believed to relate to the supply from the battery. It was only once the data had been sent for analysis to the equipment supplier that the problem was diagnosed, and fixing it required a replacement logger to be sent out, which again took time. The problem with the logger also masked a problem that arose with the rear brake pressure sensor. Having initially been working fine, the sensor started giving erroneous readings. This was believed to be one of the corrupted sensor channels but turned out to be a problem with the sensor itself that could only be fixed once the bike was able to be taken in to the Honda dealership. The problem was ultimately fixed by bleeding the sensor, which relies on oil pressure in its operation.

Due to using internal TRL riders for the first two participants, it was possible to have access to the bike during each working day. The participant would drop the bike off at the back of the building in the morning, available for researchers to work on the bike. It would be returned to the drop-off point in time for the participant to pick it up again at the end of the day. The time in between was then available to allow data to be downloaded and modifications made when necessary/possible to keep the bike running smoothly. This proved to be invaluable as, having set the bike up to record the various sensor channels at appropriate sampling frequencies, it had previously been revealed that the storage media installed on the bike were only sufficient to record about 2.25 hours of data (and only 1.75 of video). The initial plan had been to download data on a weekly basis but in order to prevent losing large amounts of data, it would instead have to be downloaded daily. This procedure was followed for both of the first two participants, with data collected each day that the participant travelled to the TRL main site.

Initially it had been intended for the a researcher to conduct all the data downloads from the bike, but for the second two participants based up in North Yorkshire it was clearly not practical for a researcher to make the 500km round trip each day to do this. As such it was necessary to train the participants to conduct the download themselves at the end of each day. They were also required to upload the data regularly onto a secure server to which a researcher would have remote access in order to check that there were no problems with the data recording. This added to the workload required of the participants but fortunately two were found that were willing to undertake the additional tasks; although it was found that the data upload could be particularly onerous, with slow upload speeds often resulting in the process taking several hours at a time.

By downloading daily the limitation of the available storage capacity was largely negated, but on occasion participants would either venture out on a particularly long leisure ride that exceeded this time limit, or would forget/be unable to download at the end of a day, and so 'max out' the storage. In such a situation it was previously anticipated that each system would simply begin to overwrite the existing data and so the earlier part of the journey would be lost. In fact it was found that the video logger would simply stop recording, whereas the sensor logger would overwrite. Journeys (or accumulated journeys) between approximately 1.75 hours and 2.25 hours would therefore simply have the latter portion of video missing, more of an inconvenience than anything else. Once the 2.25 hours threshold was exceeded and the sensor logger began to overwrite however, it was found that this would corrupt the synchronisation between the two recording systems and the video data for the whole journey would be lost. Fortunately this happened rarely, but it did require an additional instruction be given to participants that if their journey (or accumulated journeys) exceeded 2 hours, they were to pull over and disconnect the logging equipment, thus terminating the recording but preserving the data recorded up to that point. The ability to disconnect the equipment was a fortunate by-product of the modifications made in response to the earlier problems with the battery, described in Section 2.1.4 and in this Section. Without this ability large portions of data might have been lost when participants exceeded the logging capacity.

In addition to the electronic data collection, riders were also asked to keep a travel diary in which they would record any riding experiences they considered to be of note. Riders were also contacted weekly for a debriefing interview during which the contents of the travel diary could be discussed and points of interest elaborated on. This process worked very well, with riders generally recording a fairly high level of detail. However it was found that the threshold for what participants perceived to be noteworthy did vary to quite a high degree between riders. It was particularly noted that the first rider did not report having any incidents and the second rider only reported having two, both of which were considered to be significant by the research team; whereas the latter two riders both included much less significant events in their reports (many of which could be regarded as fairly typical riding experiences) and therefore made entries on most days.

## *5.2. Lessons learned and proposed recommendations*

Weekly debriefing interviews did not provide a lot of additional or useful information. Most of the interesting things were noted in the travel diary. Some participants were not as willing to participate in this procedure as they felt they would spend time without providing any additional information that would be of interest.

**Recommendation: The weekly debriefing interviews should either be redesigned or not used at all.**

There were gaps of a few weeks in data collection due to participant illness and due to bad weather conditions (November – December 2010).

**Recommendation: Deviations from the time-scale should be taken into account when planning the data collection period.**

In the absence of a remote monitoring system, the only way to check that the logging system was working correctly was to download the data and to check it for erroneous readings. Although conducted daily in the UK, in most places it was conducted weekly and this proved to strike an acceptable balance between minimising the risk of lost data and minimising the workload for the participant.

**Recommendation: Either retain the weekly download protocol or introduce a remote monitoring function.**

In the UK the large distances between TRL and the homes of Participants 3 and 4 meant that the data needed to be uploaded to a FTP site each week. Variable connection speeds meant that on occasion this upload could take several hours.

**Recommendation: If participants are to be based prohibitively far from the research organisation, either ensure that the participant has access to a fast upload connection that can be left running for several hours at a time, or that they are provided with a memory stick that can be posted securely to the research organisation and then returned each week.**

The need in the UK for data to be downloaded daily proved to be a hindrance, both for TRL and for the participants.

**Recommendation: When acquiring the logging equipment, ensure that there is sufficient storage space to hold at least 1 week’s worth of data (bearing in mind possible long social rides as well as the usual commuting activities).**

# 6. Data reduction / filtering

This chapter examines the task of identifying interesting and relevant data for analysis, and of coding the data appropriately to allow for cross-partner analyses. Provided below is a critique of the method used in the data reduction process, including a review of the lessons learned during this project and recommendations for how this process could be adapted and improved in a future study.

## 6.1. Overview of planned methodology and deviations from it

Given that this was an exploratory research study, it was not known what would need to be looked for in the data in order to identify incidents and near-crash events. Whilst various sensors were recording riding parameters believed to be relevant, there were no known thresholds above which a particular sensor would be regarded as giving an ‘extreme’ reading. It was decided that each rider should in effect define their own thresholds by looking at each rider’s data in their entirety and identifying those readings at the extreme ends of the spectrum. Different partners tried different methods of doing this, but the underlying principle was the same for all, namely:

- Identify examples of extreme data-points
- Use this to identify a section of video where a riding ‘event’ may have occurred
- Check the video to determine if anything of note occurred
- If so, mark as an incident or near crash for coding and further analysis

The theory behind this being that the extreme sensor readings should relate to the harsher, more abrupt or ‘panicky’ control inputs to the bike and that these in turn should relate to the more critical situations. It was also anticipated that the more extreme readings might represent the bike being pushed closer to the limits of its handling performance and thus the point of failure.

### 6.1.1. France

Although many parameters were recorded, the exploitation of data in France focused first on using IMU measurements (3 axis acceleration and rotation rates) to try to identify non-ordinary riding behaviours. This is justified by the fact that succeeding in finding efficient algorithms to detect interesting events from that alone, would allow later studies to use much simpler data acquisitions systems, where adaptation to a specific motorbike wouldn’t be an issue (more direct measurements such as steering angle or wheel speed necessitate a specific adaptation for each motorbike). Moreover, it is expected that the dynamic nature of the motorbike leads any action from the rider to measurable alteration of the dynamic variables, meaning strong correlation of actions and dynamic variables, and hence redundancy making using both potentially unnecessary.

Accelerations and rotation rates were first decoded and conditioned in order to remove offsets. Then, a median filter (5 values wide, for signals originally sampled at 1 kHz) was applied. Finally, at each time-step the Euclidian distance to null values of accelerations and rotations rates was calculated:

$$D\gamma = \sqrt{{\gamma_x}^2 + {\gamma_y}^2 + {\gamma_z}^2}\ ;\ D\rho = \sqrt{{\rho_x}^2 + {\rho_y}^2 + {\rho_z}^2}$$

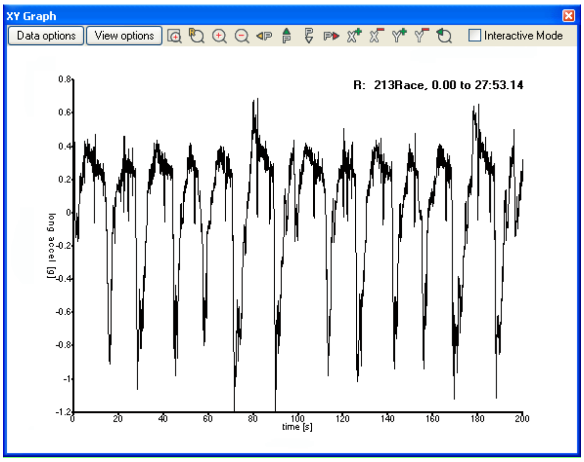
Where $\gamma$ represents acceleration and $\rho$ represents rotation rate.

Both parameters were used independently, which may be a limit of the approach (a multivariate analysis could be more appropriate). $D\gamma$ and $D\rho$ were calculated at each time-steps first for a few trips of several different riders. Using all values, their distribution was determined, and thresholds allowing selection of 0.1% of extreme values were determined. The two parameters were then determined for all time-steps in every trip. When the values reached the threshold, the corresponding trip id & timestamp were saved in a single table, as well as values of the parameters. The resulting table was ordered by rider, then parameters values. As a result, the most extreme measurements for each rider were detected, and the corresponding video record could be observed, in order to assess the relevance of the detection.

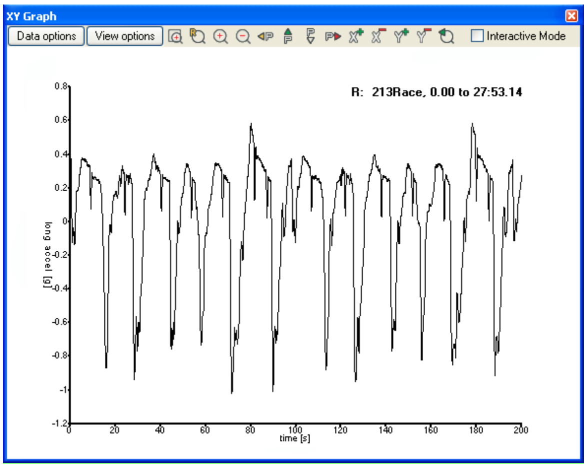
### 6.1.2. Greece

#### *6.1.2.1. Preparing the data*

During processing, the data from analogue signals (3D Accelerometer) were subjected to filtering in order to avoid unwanted noise mostly due to vibrations. The most useful result of the filtering procedure was on the Acceleration profiles (Acceleration/Time) for each Run. The filtering procedure does not produce any delays in signal recording and mainly it consists of creating an average value for the recorded parameter, taking into account a critical number of recorded values before and after. Figure 3 depicts the time-series of longitudinal acceleration for a period of 200sec before and after filtering.




Unfiltered




Filtered

**Figure 3: Comparison of unfiltered and filtered data**

The range for each signal is seen below:

- For analogue signals
  - Throttle: 0 to 100
  - Brake rear: 0 to 100
  - Steering: -100 to 100
- For digital signals
  - Blinker R 0_on 100_off
  - Blinker L 0_on 100_off
  - Brake activity Front 0_on 100_off
  - Brake activity Rear 0_on 100_off

#### *6.1.2.2. Identifying events*

A key problem in naturalistic riding studies is to define which riding situation may be considered as critical or risky. Interestingly, in all relevant approaches documented so far, typical driving parameters' thresholds are established, and based on those values criticalities are extracted and further analyzed. This technique lacks consistency with the fact that each driver/rider has its personal stock of values, ideas, beliefs and practices, reflecting rigorously on its behaviour on the road, such as the braking, overtaking and so on, that may not converge to a typical rider's behaviour. In this context, the question that emerges is whether the high resolution naturalistic riding data which is in nature multivariate and noisy can be used to define a self-contained personalized rider's profile. Another problem may result from having to process a large amount of data. The 2-BE-SAFE framework that uses a standard 100Hz frequency of data collection is a typical example of such a problem. The joint examination and analysis of months of video and sensor data may become unfeasible.

The methodology developed and implemented in the Greek experiment for data reduction and filtering is based on the assumption that the emerging incidents are detected not by the exceedance of a specific parameter's threshold value (e.g. speed, deceleration etc), but by the exceedance of a specific multivariate threshold value based on more than one riding parameter and attempts to detect the incidents that may result to critical riding situations of high risk based exclusively on high resolution naturalistic riding data without observing the videos. The data exploited concern information on wheel speed, acceleration, throttle, steering, rear braking and so on. A comprehensive methodological shell is proposed in order to distinguish between regular and irregular riding behaviour. "Irregularities" in riding behaviour are consistently expressed as outlying values in a multivariate consideration of the available riding parameters. The detected irregularities are those values that diverge from the centroid of the jointly considered riding variables and define critical riding situations that may further be associated to typical riding events

A robust statistical approach is implemented in order to detect the time a deviation from the mean riding behaviour occurs that may signify the onset of a critical riding situation (incident). The outlier detection is based on a multivariate set of riding parameters that are jointly considered. A statistical testing strategy will act complementary to the outlier detection methodology; different models in terms of input data considered will be evaluated with respect to their ability to detect critical situations.

Although, intuitively, naturalistic data can be used to analyze transportation safety and driving behaviour in various ways, their spatial and temporal characteristics is a multiplier of the complexity of any analyses – in both concept and computational intensity - that may be employed. Riding data collected in extremely high resolutions (e.g. 100Hz) often contain outliers. The goal of the proposed methodology is to detect the outliers and then construct a classifier to characterize the parameters that affect the riding style. Outlier detection is a critical step in data mining aiming at describing the abnormal data behaviour as reflected in the data that deviates from the natural data variability (Hodge and Austin 2004). According to Barnett and Lewis (1994), an outlier is an observation (or subset of observations) which appears to be inconsistent with the remainder of that set of data. Outlier detection has been applied in many fields such as chemical engineering and data mining; some specific fields of research include fraud detection, activity monitoring, structural defect detection, fault diagnosis, medical condition monitoring, motion segmentation etc. (Hodge and Austin 2004).

In the specific study, an outlier is defined as an observation for a specific time interval that the rider for some reason drastically alters its riding behaviour due to an external or internal stimulus. There exist both univariate and multivariate approaches to outlier detection. In complex and highly volatile phenomena such as the evolution of the riding variables, the multivariate consideration is imperative, as, for a specific time interval, although one or more variables may be considered as outliers, the whole riding behaviour defined by the joint consideration of all variables may not be a multivariate outlier. In the specific study a simple and flexible methodology based on the Mahalanobis distance is applied; in contrast to the Euclidean distance, the Mahalanobis distance takes into account the correlation structure of the data as well as the individual scales (Barnett and Lewis 1994). The Mahalanobis distance $d_i$ defined as (Barnett and Lewis 1994):

$$d_i = \sqrt{\left(x_i - \hat{\mu}\right) S^{-1} \left(x_i - \hat{\mu}\right)}\ , \qquad (1)$$

where, $X_i = (x_{i1},...,x_{ip}),\ i = 1,...,n$ be the multivariate space of p riding parameters that independently come from a multivariate normal distribution $X = N(\mu,\sigma^2)$, where $\mu$ is the mean and $\sigma$ is the covariance matrix, $\hat{\mu}$ and $S^{-1}$ are the sample mean and covariance matrix respectively. The Mahalanobis distance can be approximated by an F-distribution $\left[ p(n-l)(n+l)/n(n-p) \right] F_{p,n-p}$; at a significance level α, a determination as to whether a new observation $X_i$ can be considered as outlier – critical incident – or not can be made based on the following formula: $d_i \leq \left[ p(n-l)(n+l)/n(n-p) \right] F_{p,n-p}$ .

The described methodology suffers from the masking effect and the swamping effect (Barnett and Lewis 1994). An outlier is said to mask a second one that is close by if the latter can be considered an outlier by itself, but not if it is considered along with the first one. Equivalently after the deletion of one outlier, the other instance may emerge as an outlier. An outlier swamps another instance if the latter can be considered an outlier only under the presence of the first one. To deal with these effects a robust estimator of the Mahalanobis distance is recommended that leaves out each observation in turn and calculates its scaled distance from the centre using the rest of the data; this is known as the jack-knifed distance. Jack-knifing is a process where the multivariate distance for each observation/object is calculated using means, variances, and covariances that did not consider (i.e., not influenced by) the given observation.

In 2-BE-SAFE the most important signals that are being monitored are given in Table 9.

**Table 9: The list of monitored variables and their description.**

| Variable | Description |
|---|---|
| Longitudinal acceleration [g]<br>Lateral acceleration [g]<br>Vertical acceleration [g] | linear acceleration |
| Speed [kph] | longitudinal speed |
| Yaw rate [deg/s]<br>Pitch rate [deg/s]<br>Roll rate [deg/s] | roll, yaw and pitch rates |
| Throttle [%] | throttle position |
| Brake Rear [%] | brake pressure rear |
| Steering [%] | steering angle |
| Brake activity Front [0/100] | brake activation front |
| Brake activity Rear [0/100] | brake activation rear |
| Wheel Speed [km/h] | Speed of the rear wheel |

The signals reported in Table 9 will be evaluated with respect to their ability to detect extraordinary PTW driving behaviour.

The proposed methodology for data filtering is applied to the available riding variables in order to detect the outliers and distinguish between regular riding behaviour and changes to irregular riding style. Periods of irregular behaviour will be detected as the deviation from the mean values of the distance metric reported in the Section 8.1.2 (Equation 1). A typical example of a detected incident can be seen in Figure 4.

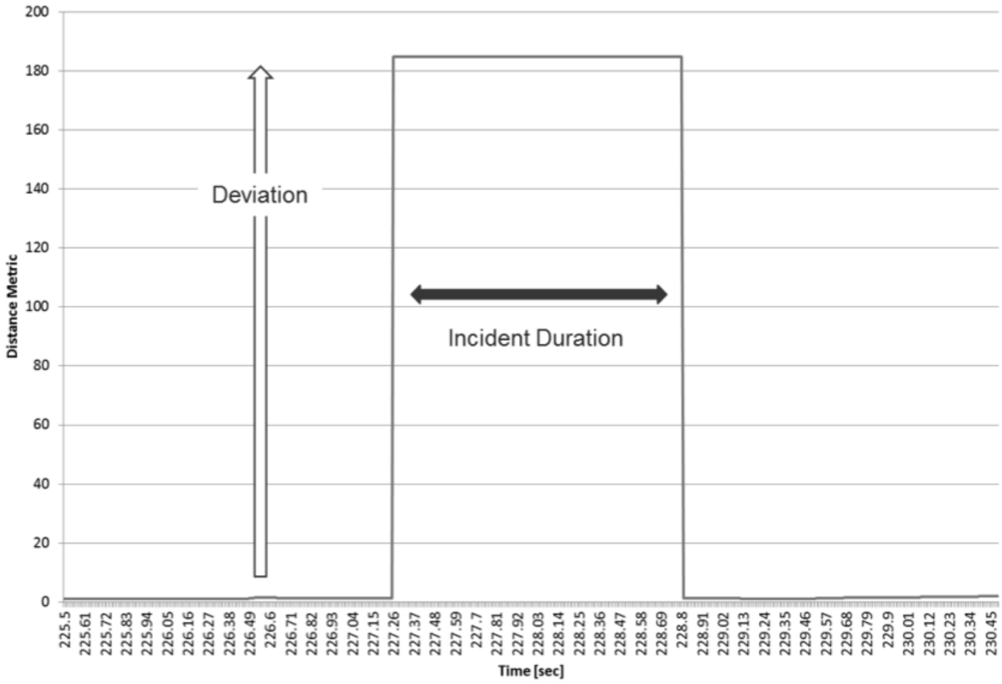



**Figure 4: An example of a detected incident using the Mahalanobis distance metric.**

The first step of the analysis is to assess on the number of variables that should be taken into consideration. The second step of the analysis is to associate the observed outlying behaviour to specific riding situations that could be characterized as critical. A look at Table 1 reveals two groups of available variables. The first is related to the mechanical characteristics and includes braking (front/rear brake activation and rear brake pressure), yaw rate, pitch rate and roll rate, throttle, steering and wheel speed. The second group refers to the traffic related variables such as linear acceleration components and speed. This distinction is made in order to differentiate those parameters that are directly related to rider's reactions from those that may be considered as outcome of others, such as acceleration.

On the basis of the above, it was decided that three distinct outlier detection models with respect to the different input space are further evaluated:

- Model 1: steering, throttle, brake activation and wheel speed.
- Model 2: linear acceleration and speed.
- Model 3: All available variables.

The criterion for selecting the optimum input space for the outlier detection methodology is to produce the less data intensive model that will be able to detect all *significant* shifts from regular to irregular riding patterns. Significance is judged by an F-distribution. The proposed approach requires defining which input data should be considered in the process of incident detection. In this paper, different models with different input spaces will be considered and the optimum input space will be identified using as criterion to produce the less data intensive model that will be able to detect all *significant* shifts from regular to irregular riding patterns. Statistical difference between models will be judged based on classical statistics and conditional entropy, an information theoretic criterion that quantifies the uncertainty of a variable Y conditional on the variable X taking a certain value x provided by the following equation (Shcreiber 1999):

$$H_r(\mathbf{Y} \mid \mathbf{X}) = -\sum_{x \in X, y \in Y} p(x,y) \log \frac{p(x,y)}{p(x)} \qquad (2)$$

The three models are first compared on the basis of the distance metric (Equation 1) and its temporal structure based on the Wilcoxon signed rank test (Washington et al. 2010) that revealed different temporal evolution of the distance metric between the three different models. The difference between Model 1 and the other two Models with respect to the evolution of the riding patterns as depicted on the joint consideration of the related riding parameters is significant, whereas – according to the t-statistic – Model 2 does not significantly differ from Model 3.

Regarding the classification $c_i$ of the riding patterns to regular or extreme/outlying patterns, a comparative study is established based on the conditional entropy. Results show that the conditional entropy for Model 2 and Model 3 knowing Model 1 ($H_r(c_{\text{Model2}} | c_{\text{Model1}})$ and $H_r(c_{\text{Model3}} | c_{\text{Model1}})$) equals to 0.021 and 0.025 respectively. These small values of conditional entropy indicate that the knowledge for the type of riding pattern coming from Model 2 and 3 when the classification from Model 1 is known does not provide any further information.

The three models are further compared based on the detected outliers that they produce using the F-distribution test. An example of the results of Model 1 on a 15 minute trip is seen in Figure 5 that depicts the distance metric (Equation 1) time series using as multivariate input space the time –series of the mechanical related variables; any distance metric value above the 5% threshold value signifies an outlier or a critical irregular riding behaviour. As can be observed, the proposed methodology distinguishes between irregular and regular riding behaviour and may reveal the specific time interval where a shift to irregular behaviour may occur, as well as its duration. Moreover, the larger the metric distance the more extreme the riding behaviour of the PTW user is, the more abrupt is the change to its riding style.

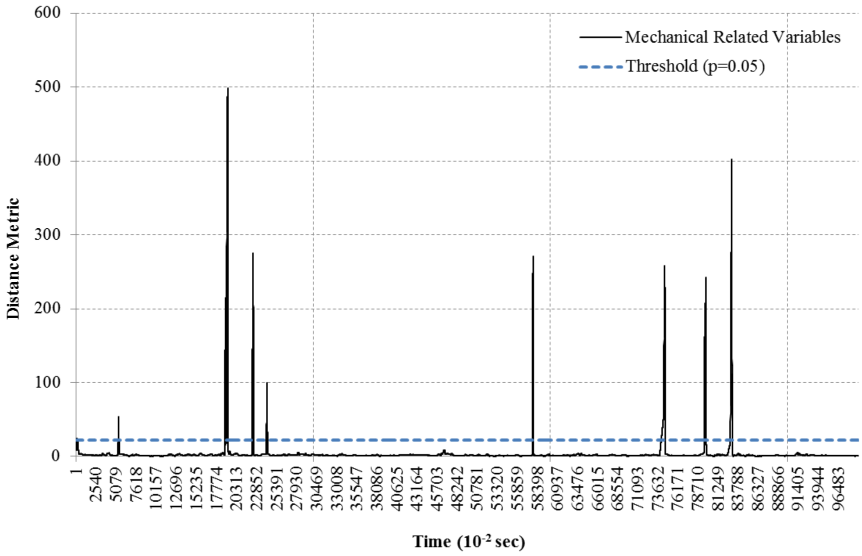



**Figure 5: Distance metric time series using as multivariate input space the time –series of the mechanical related variables (Model 1). Any distance metric value above the 5% threshold value signifies an irregular behaviour (outlier).**

Comparing the detected outliers from all three models, it is found that the larger the number of variables considered in the input space of the algorithm, the lesser the ability of the methodology to discern irregular from regular riding behaviour and detect critical incidents degrades with the increase of the input space. This is probably due to the fact that certain variables are correlated (e.g. rear brake activation and break pressure, acceleration and throttle position). Moreover, it seems that correlations between variables mask (smooth out) the dynamics of riding behaviour. This is clearly observed in Figure 6 where the distance metric of the time series of all available variables is depicted; a critical incident is cancelled out when using the entire set of riding variables instead of the ones that are directly connected to the mechanical characteristics of the PTW.

The finding that the variables that are related to direct mechanical characteristics of the PTW are more influential to the process of detection can be attributed to the fact that speeding or accelerating/decelerating is the direct outcome of changes in throttle and brake activation. Furthermore, speeding or accelerating/decelerated may be the effect of more than one combination of the mechanical-related characteristics, such as steering, throttle and/or braking.

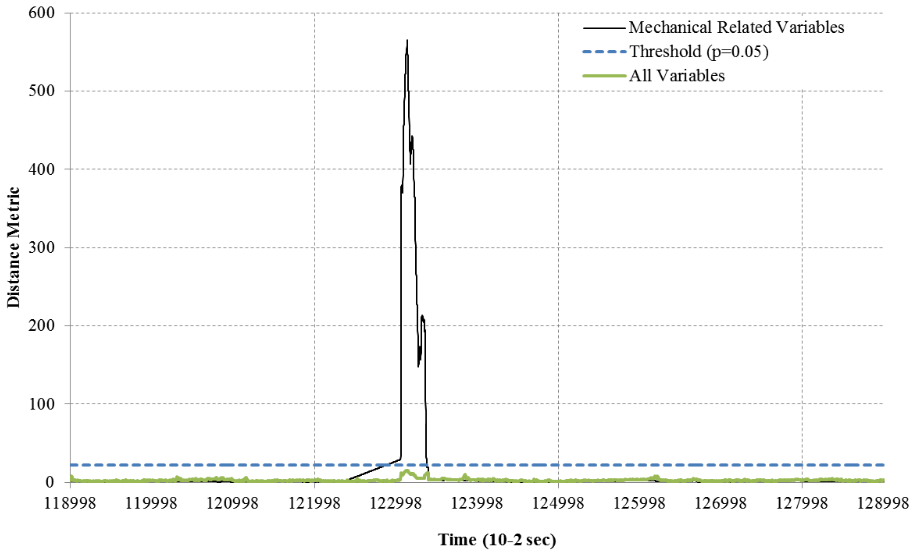



**Figure 6: A single riding situation as detected by the distance metric time series using as multivariate input space the time –series of the mechanical related variables and all available variables. Any distance metric value above the 5% threshold value signifies an irregular behaviour.**

Outliers detected using the mechanical parameters are further evaluated by observing the respective videos. All outliers detected point to a change – regardless of being smooth or abrupt - in the riding style. Among the situations detected are:

- Moped braking and moving on the right to avoid opposing vehicle,
- Braking due to pedestrians in high grade, waiting at an intersection to enter main traffic,
- Moped moving on the left to avoid fixed object,
- Entering sharp turn when interacting with opposite lane's traffic,
- Braking and moving on the right after having overtaken vehicles (vehicles are in front of the moped as well),
- Overtaking more than one vehicle,
- Moped moving to the left to avoid stationary object.

Summarizing, the proposed approach to data reduction / filtering is a simple and a simple and flexible methodology to detect incidents from massive datasets without taking the time to examine video, a procedure that is time consuming and less efficient in revealing the riding parameters change in the emergence of an incident. The proposed method is validated in various trips and all outliers detected can be considered as incidents. Findings from the algorithmic calibration show that the use of fewer parameters than measured is adequate. This does not mean that we should not measure the rest of the parameters due to their possible explanatory power in defining risk. Further, the traffic related parameters (acceleration, speed) were not influential to the detection of incidents. It is to note that the methodology is consistent to the complexity or rider's behaviour as it does not limit is generalization power to typical threshold values of riding parameters, but produces custom-made riding profiles and irregular riding patterns allowing the thresholds of extreme riding behaviour to vary among riders based on their personal stock of values, ideas, beliefs and practices.

### 6.1.3. Italy

#### *6.1.3.1. UNIFI data processing*

A preliminary step to the data analysis is their characterization, since it allows the understanding of the possible problems faced to process the data set. For this reason, before exposing the methodology used for the identification of the events, the following section is about a general characterization of the data.

General characterization of the acquired data

The experimental campaign involved 6 riders for a total of 279 acquisitions and 2375km travelled distance. A general overview of the data clearly show differences in the usage patterns of the involved riders (Table 10), as it can be deduced from 25$^{th}$ and 75$^{th}$ percentile duration of the journeys.

**Table 10: Data acquisition status**

| | # acquisitions | km ridden | Duration (s) 25th percentile | Duration (s) 75th percentile |
|---|---|---|---|---|
| Participant1 | 66 | 350 | 511 | 777 |
| Participant2 | 12 | 175 | 222 | 806 |
| Participant3 | 97 | 600 | 409 | 917 |
| Participant4 | 22 | 350 | 332 | 1537 |
| Participant5 | 36 | 600 | 747 | 1551 |
| Participant6 | 46 | 200 | 270 | 658 |
| Total | 279 | 2375 | | |

Significant percentage of GPS signal was lost mainly because of the time required to connect at start up (Table 11). This characteristic was amplified by the short average duration of the trips of some riders. In fact the time for GPS signals to be available usually varied from 500 to 600 seconds (especially in the period from December to February).

**Table 11: Data acquisition status for all participants (% GPS signal lost)**

| | # acquisitions | % GPS signal lost |
|---|---|---|
| Participant1 | 66 | 79.2 |
| Participant2 | 12 | 78.3 |
| Participant3 | 97 | 24.9 |
| Participant4 | 22 | 37.5 |
| Participant5 | 36 | 25.3 |
| Participant6 | 46 | 55.0 |

In addition the following percentages of data were lost because of the problems cited in chapter 5:

Participant1: problem with steering sensor shift, but no data was lost; 7.6% PTW state data was lost because of human error (didn't plug-in the power supply for PTW state).

Participant2: significant amount of data was lost due to failure of the data acquisition system. Apart from the problem with the PTW state signal (43.9% data lost), GPS signal was generally lost in 78.3% also because of cold starts (Table 12).

**Table 12: Participant2 data acquisition status (% data lost)**

| Participant2 | % data lost |
|---|---|
| Pressure sensors, wheel speeds, steering, throttle | 21.2 |
| PTW state | 43.9 |

Participant3: also the percentage GPS signal lost was less than a 25% and video loss from rider facing camera was observed in 21.2% due to a loose connection (Table 13).

**Table 13: Participant3 data acquisition status (% data lost)**

| Participant3 | % data lost |
|---|---|
| Rider facing video | 21.2 |
| PTW state | 14.1 |
| Front wheel speed | 9.1 |

Participant4: there was rarely any problem with the data acquisition. Only in 7,7% data loss occurred for PTW state as a result of loose connection; however, 37.5% GPS signal was lost because of the above mentioned problem.

Participant5: in the last phase of the data acquisitions, the power cable for the DAS got unplugged due to excessive vibrations. This fact caused 14.9% data loss of all the signals (Table 14).

**Table 14: Participant5 data acquisition status (% data lost)**

| Participant5 | % data lost |
|---|---|
| Steering angle, throttle position, pressure sensors, PTW state | 14.9 |
| Front wheel speed | 21.3 |
| Rear wheel speed | 36.2 |

Participant6: 100% rear wheel speed sensor data was lost. In fact, from the beginning of data acquisitions, the rear wheel speed sensor data was not working; in addition 55% GPS signal was lost because of loose connection and cold start.

<u>Method for event identification</u>

The Italian team decided to implement the definition of the threshold values to detect candidate relevant events and, afterwards, to screen the data in search of the events via an ad hoc software. Since, as stated in chapter 5, the collected data were saved in a proprietary compressed format of the DAS, a preliminary step of data conversion to ASCII format was necessary.

Previous accidentology studies have identified as pre-impact manoeuvres braking and swerving. Thus these manoeuvres were taken as a reference for the selection of the signals which could prove useful to detect relevant events. One additional signal (i.e. horn activation) was included since its use could be associated generally to a conflict with another road user.

The selected signals are potentially redundant for the detection of the events, but the exploratory nature of the present study allows the inclusion of redundant checks, which will be analysed at a later stage to verify their performances. In addition at this stage the multiple detection of an event according to different criteria is an additional potential indication of the relevance of that event. The full list of criteria is:

- Criterion 1: Horn
- Criterion 2: Front Wheel Lock
- Criterion 3: Rear Wheel Lock
- Criterion 4: Brake Pressure Front
- Criterion 5: Brake Pressure Rear
- Criterion 6: Longitudinal Deceleration
- Criterion 7: Gyro Z
- Criterion 8: Pitch

All the data with valid signals were processed. The availability of GPS data was not a criteria for exclusion of specific datasets since a constant loss of GPS data was present at the beginning of each acquisition during all the experimental campaign because of a slow connection of the GPS module to the satellites. This decision was motivated by the fact that the GPS data are mainly used to provide geographical reference and are not key information for the identification of the events. In addition, for the specific experimental setup used in Florence, the velocity signal could be derived also from the two tone wheels and not only from GPS, which allowed a complete characterization of the event also in absence of GPS connection.

The developed methodology is meant to be applied to the valid signals without any condensation of the acquired data (e.g. averaging or summing them over a specific time interval) and without any distinction between urban or extra-urban environment. The data condensation was an option, since the data were sampled at 100Hz and the quantity of raw data was considerable, but a preliminary analysis of the data series showed that the events happened on a relatively short time scale and thus condensation could have led to loss of information. Another characteristic of the method is the automatic redefinition of the threshold values for each rider, in order to take into account the different riding styles. The threshold values were defined univocally for all riders as a percentile value of the data acquired on a specific signal, but for each rider the corresponding physical value was determined based on the initial 10% of data. The threshold values were applied to screen the acquired data and look for relevant events.

The percentile values for each signal were determined from a visual pre-analysis of the signals followed by a trial and error approach to decrease the number of false relevant events without affecting the true positive events (i.e. incidents and near-missed). In detail the reduction process of the data went through the following steps:

- Definition of the percentile value to be used to determine the threshold for each signal;
- Calculation of the physical threshold value for the rider currently processed;
- Screening of the data to identify candidate events;
- Review of the candidate events using video footage and sampled data;
- (Only at the beginning of the data analysis process) calculation of the percentage of relevant events out of the candidate ones and, if necessary, modification of the percentile values and re-initialization of the cycle from point 2;
- In case the event was an incident or near-missed, the data were extracted and saved (60s before the event and 30s after) according to the data reduction scheme defined in task 2.3 of work-package 2. The event was also characterized (i.e. fully reduced) and included in a database structure, common to all partners, which was also defined in the data reduction scheme.

The screening procedure, after the initial phase of definition of the percentile values, identified 2813 candidate events, distributed over the criteria as shown in Figure 7.

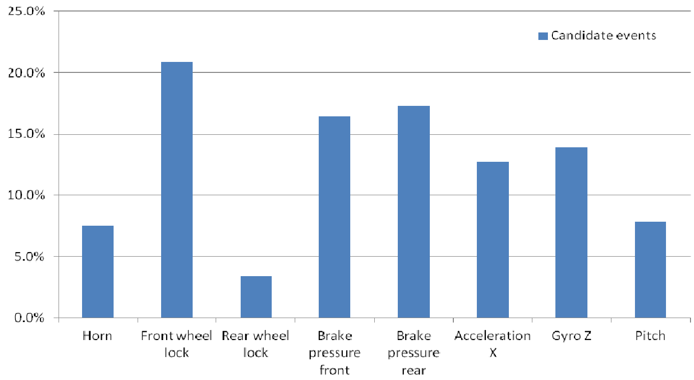



**Figure 7: Percentage distribution of candidate events for various criteria**

After an in-depth analysis of the candidate events, the true events were identified and categorized into two main conflict types: near missed-events and incidents. Globally 79 true events were identified, which have a distribution over the various criteria shown in Figure 8. In Figure 9, the total number of true events (incidents and near-missed) per kilometre ridden for each participant is depicted.

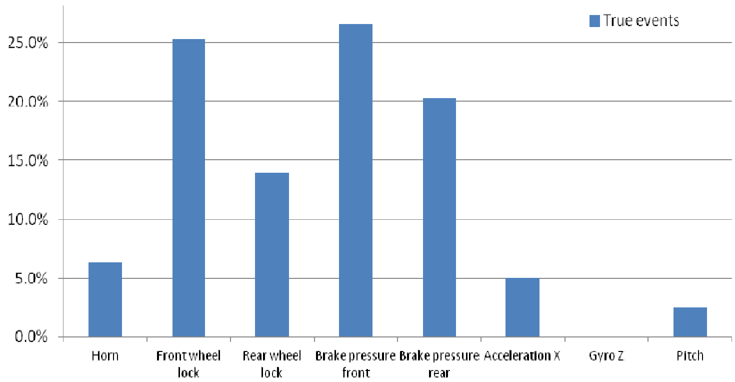



**Figure 8: Percentage distribution of true events for various criteria**

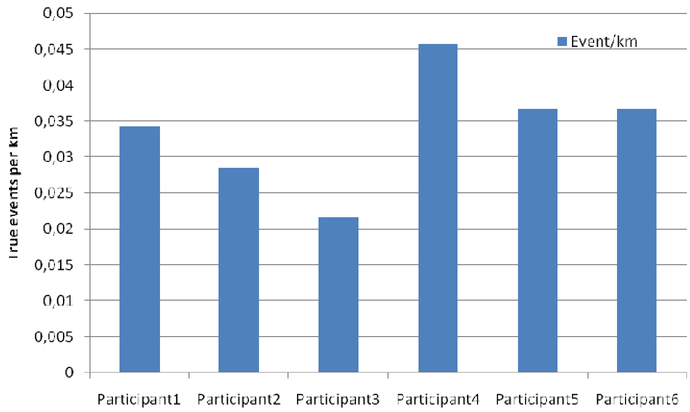



**Figure 9: Number of true events per kilometre**

The total number of near missed events that were identified is 6. The number of near missed events for each participant is reported in Figure 10, while in Figure 11 the near missed events per kilometre ridden for each participant is shown.

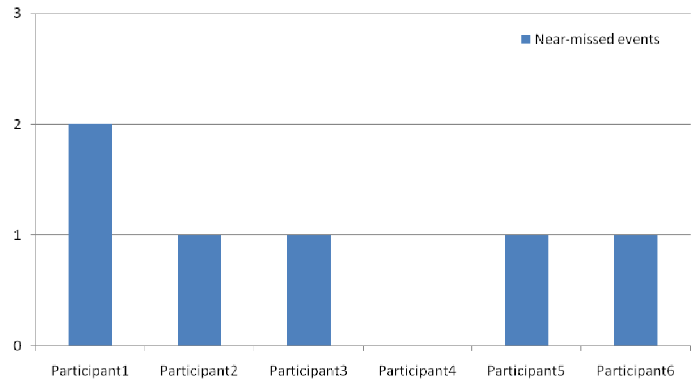



**Figure 10: Total number of near missed events**

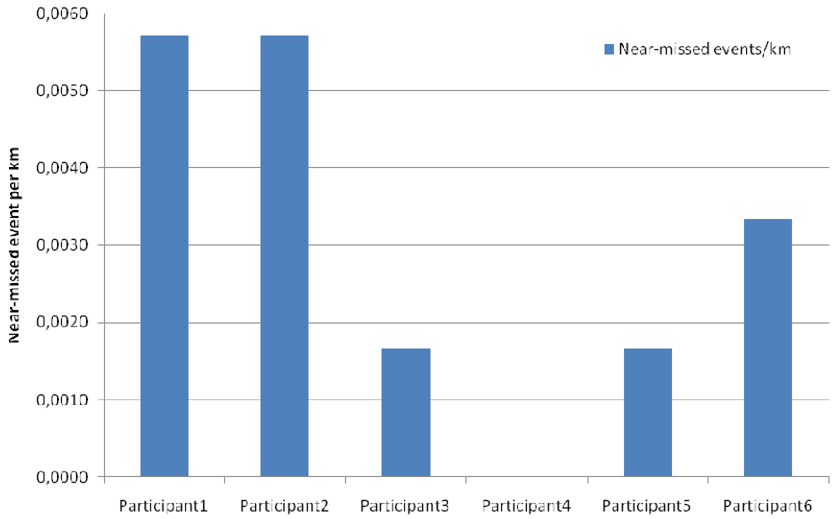



**Figure 11: Number of near-missed events per kilometre**

Although the method proved succesfull to identify the events, it is important to perform an assessment of the selected criteria. The goal is to analyse the number and type of multiple detections occured for a particular true event (incident and near missed) using the above mentioned criteria.

In Figure 12, the percentage distribution of the kind of detection has been depicted. In 22.8% of the analyzed conflicts, single events were detected. Almost 90% of the single events that were detected were primarily detected by wheel lock up and brake pressures (Figure 13). 43% of the analyzed conflicts were identified through a double detection (Figure 12) and nearly 95% of the double detections involved wheel lock up and brake pressures (Figure 14). 34.2% of the analyzed conflicts had a triple detection (Figure 12). Nearly 75% of the triple detections involved again wheel lock up and brake pressures (Figure 15). However, for all the detections (single and multiple), 86% of the events were mainly detected using wheel lock up and brake pressure criteria (Figure 16).

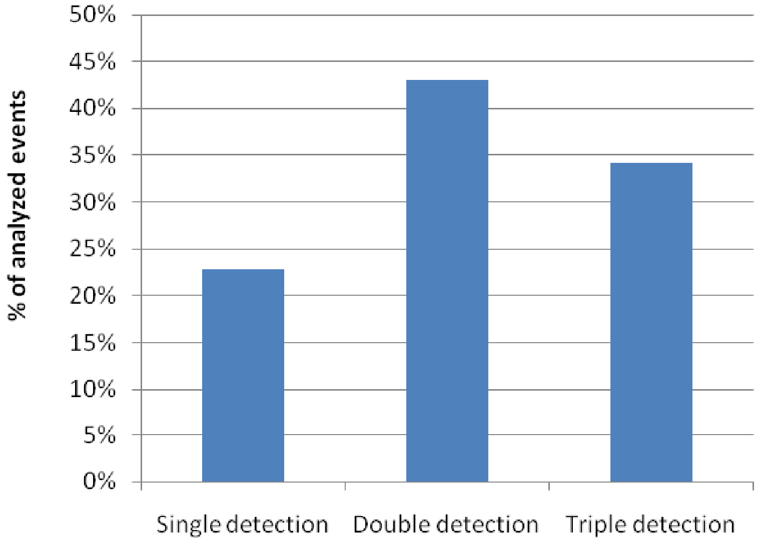



**Figure 12: Percentage of single and multiple events detected**

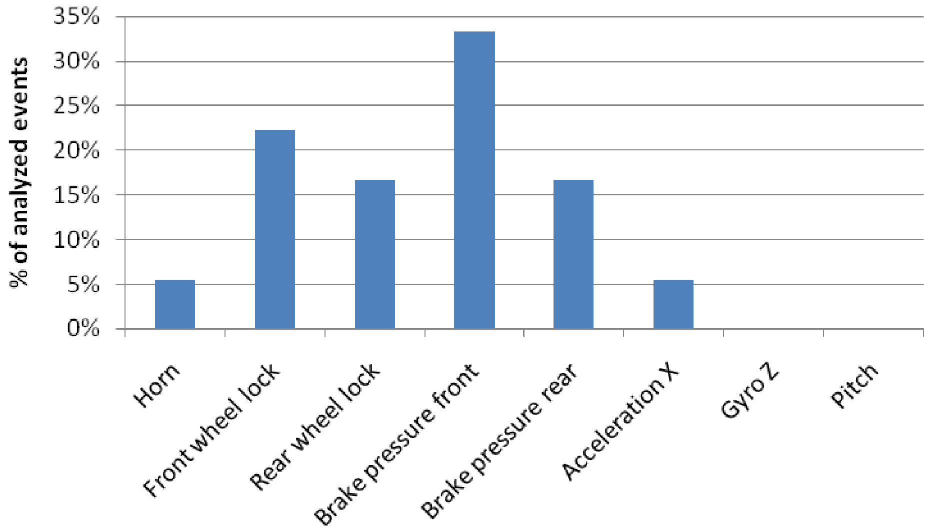



**Figure 13: Percentage distribution of various criteria for single detection of events**

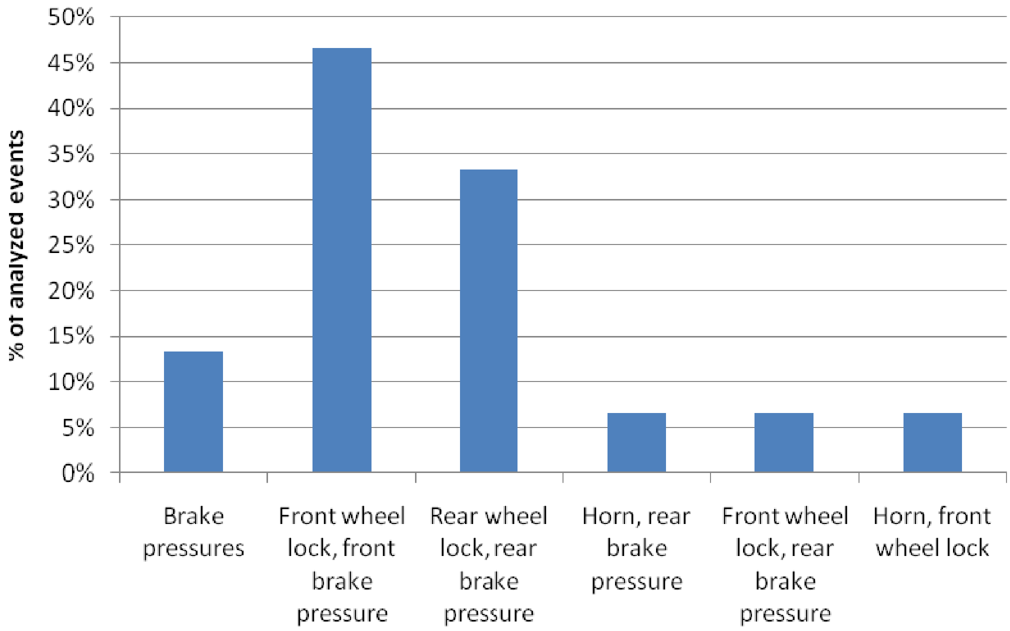



**Figure 14: Percentage distribution of various criteria for double detection of events**

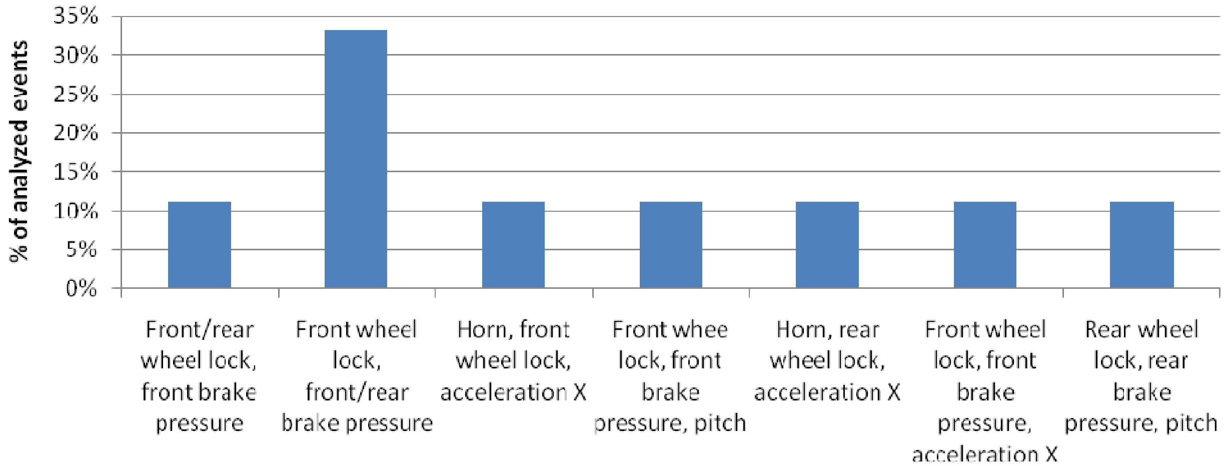



**Figure 15: Percentage distribution of various criteria for triple detection of events**

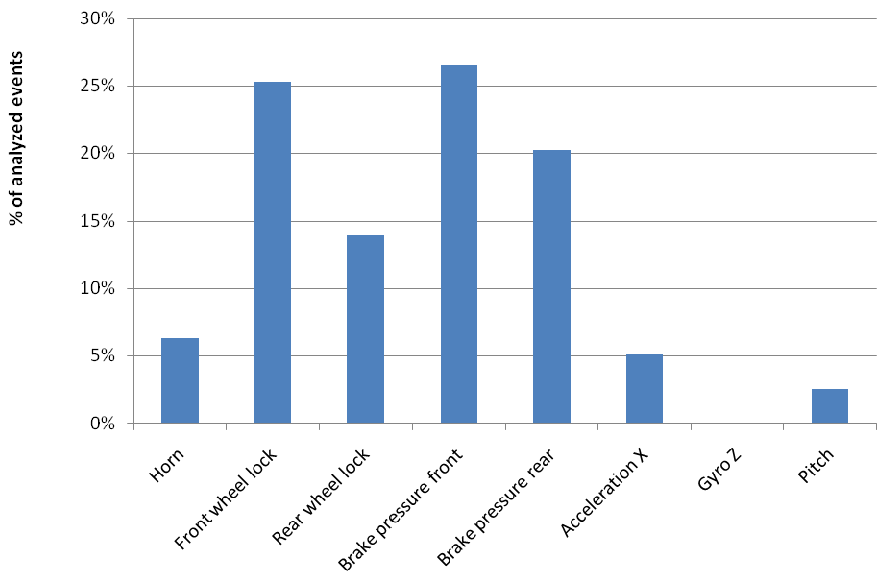



**Figure 16: Percentage distribution of various criteria**

**Table 15: Criterion assessment for near-missed events**

| | NME1 | NME2 | NME3 | NME4 | NME5 | NME6 |
|---|---|---|---|---|---|---|
| Horn | | | | | | |
| Front wheel lock | X | X | | X | X | X |
| Rear wheel lock | X | | | | | |
| Brake pressure front | X | X | X | X | X | X |
| Brake pressure rear | | | X | X | X | X |
| Acceleration X | | | | | | |
| Gyro Z | | | | | | |
| Pitch | | | | | | |

With reference to near-missed events (NME) there was always (at least) a multiple detection (Table 15) among the wheel lock and the pressure brake criteria. Indeed these four criteria were the only ones triggered during the near-missed events. The latter statement is an indication for future studies although it is not appropriate to draw any general conclusion about the relative importance of criteria from such a small set of events.

### 6.1.4. UK

#### *6.1.4.1. Identifying extreme data-points*

In the UK it was decided that the task of identifying the examples of extreme data-points would be done by essentially ranking each data-point for a given sensor channel and then selecting a given percentage of points at the top (or bottom, depending on the sensor) of this ranking. The advantage of using this method is that a set percentage of data-points could be specified for inclusion for each sensor channel, and therefore the threshold set such that an appropriate amount of data could be selected for analysis given the time available.

Before a ranking of data-points could be compiled, the data first had to be condensed. Given that each rider had up to 25 hours plus of accumulated data, and that many data channels were collected at a sampling rate of 100Hz, it meant that there could be more than 9,000,000 data-points needed to be ranked for each sensor channel, and even selecting just the most extreme 0.1% would still result in possibly 9,000 individual data-points to check against the video data. This would become unmanageable in terms of data manipulation, but would also take far too long. It was also deemed to be unnecessary given that the purpose of this stage of the work was simply to identify which parts of the video to scrutinize for a possible incident and looking at individual 1/100ths of a second would be unnecessarily precise.

In order to condense the data into a more manageable format, a program was developed that took the exported datasets for each individual rider journey and simplified these into 5-second segments, such that 500 rows of data were reduced to 1 (note, 5 seconds was chosen as a compromise between achieving the biggest compression of data possible and minimising the chance of two individual rider events occurring closely together becoming indistinct). The simplification worked by taking the maximum value recorded during that 5-second period, the minimum value recorded and finally a mean of all the values, thus keeping the important information intact. This condensed data for each journey was then combined and exported to an excel spreadsheet in the form of a pivot table. The table had all the journeys for that rider combined, with a row for each 5-second period described above. The columns were formed of the individual sensor channels, each one further split into the three values for maximum, minimum and average of each 5-second period. Some further columns were also added at this stage, such as a measure of the difference in wheel speed readings between the front and rear sensors (note, the max, min and average values for this parameter were based on the differences at each 1/100$^{th}$ of a second, not the condensed front and rear wheel speed data). The video data were also systematically reviewed to identify the light conditions, weather conditions and road type in each 5-second period and a column added for each. i.e. each 5-second period was coded according to:

- Light conditions: daylight or night
- Weather conditions: wet or dry
- Road type: rural, urban or duel-carriageway

A macro feature was written that allowed for all the values in any selected column to be ranked and then the most extreme x% transferred to another table that gave the trip number and time so that it could be checked against the video data. It was decided that selecting the most extreme 0.1% of values would provide a suitable number of events to look at in the time available. The table could also be filtered to exclude possible confounding data-points (e.g. brake pressure data was filtered to exclude times when the bike was stationary) or to focus on a particular set of riding conditions, such as when the road surface was wet.

Not all of the sensor channels were related to rider control inputs that might indicate a possible incident. For example, knowing that a rider is travelling quicker than normal does not suggest an incident may have occurred, simply that he has chosen to ride quickly at that point; similarly it is not meaningful to categorise any given GPS coordinate as ‘extreme’. 13 parameters were interrogated in the data for examples of ‘extreme’ events (shown in Table 16), some of which relate to different measures of the same rider control input.

**Table 16 - Parameters investigated for 'extreme' events and the associated control inputs**

| parameter | Control input |
|---|---|
| High front brake pressure | Braking harshly |
| High front suspension travel | |
| Low value in y-axis accelerometer | |
| Low front suspension travel | Accelerating harshly |
| High value in y-axis accelerometer | |
| High value in x-axis accelerometer | Turning right sharply / heavily |
| Low value in gyroscope roll | |
| Low value in x-axis accelerometer | Turning left sharply / heavily |
| High value in gyroscope roll | |
| High value in z-axis accelerometer | High g-force |
| Low value in z-axis accelerometer | Low g-force |
| High positive wheel speed difference | Locking or spinning up a wheel |
| High Negative wheel speed difference | |

The full dataset for each rider was interrogated against each of the 13 parameters, picking out the top (or bottom) 0.1% of all 5-second periods for each. Following this the same process was repeated three times but with the dataset restricted to show only wet conditions, urban road type and rural road type, again picking out the top or bottom 0.1%.

This process produced a total of 876 5-second periods in the data to check for possible significant events. In practice this figure included a large amount of double counting through the same rider actions being picked up across multiple sensors (e.g. a harsh braking event being detected by high brake pressure, suspension travel and low accelerometer value); or through the same action being picked up in, say, the wet analysis and also the urban analysis. A single action could also produce extreme sensor readings spanning over two consecutive 5-second periods, also resulting effectively in a double-count. With duplicates removed there remained 524 potential individual events to check in the data. Also to be checked were the 28 potential incidents flagged up by the riders in their travel diaries and interviews. Naturally there was some overlap between these two sets of data, although perhaps less than expected. In fact there were only 7 potential incidents flagged up by riders that corresponded to a 5-second period flagged up by the extreme sensor-value analysis. This means there were 21 potential events flagged by riders that the sensor analysis failed to identify. With the sensor and rider sources combined there were thus 545 potential individual events to be looked at.

#### *6.1.4.2. Identifying events of note from the extreme data-points*

Each of the 545 potential events was checked to determine if anything noteworthy had occurred. This was achieved by watching the video from roughly a minute before the trigger until the researcher was satisfied that either the event in question was resolved or that no event had in fact occurred. In practice the researcher would usually be required to watch the video through several times in order to be sure that he had a suitably complete understanding of the situation. The researcher would then indicate whether or not anything of note had occurred (i.e. either an incident or a near-crash). Once all the 545 potential events had been looked at in this way, there were 20 that were categorised as being at least an incident and so were taken forward for further analysis. As will be seen in Chapter 8, the majority of these came from rider reports rather than the sensor analysis.

## *6.2. Lessons learned and proposed recommendations*

All methodologies for data filtering presented in Section 6.1 acknowledge that extreme riding behaviour that occurs with the emergence of a critical riding situation varies among riders due to differences regarding their personal stock of values, ideas, beliefs and practices. The methodologies presented so far are based on the above concept and aim at defining custom-made threshold values of riding parameters to detect critical riding situations. These methodologies range from univariate (UK, France and Italy) that reveal thresholds of extreme riding behaviour based on a single riding parameter to multivariate (Greece) that are based on the joint consideration of more than one riding parameter.

**Recommendation: A consistent methodological framework for comparing the presented methodologies using various types of PTW drivers and under various types of road and traffic environments should be developed and adopted in future studies.**

In the UK and France it was found that the sensor analysis was not effective at identifying incidents flagged up as such by the participants. As will be seen later in Sections 8.1 and 8.4 this is largely due to the fact that for many incidents, the rider's control inputs were well within the normal range for the rider, with the incident only becoming apparent with the addition of contextual video data, e.g. the proximity of another vehicle.

**Recommendation: In some similar car-based studies a button has been fitted that allows participants to time-stamp in the data anything they perceive to be an incident of other noteworthy event. Such an approach would be of significant value in future PTW studies.**

As an extension of the above point, it is interesting to note that in Greece and Italy the sensor analysis seemed to be more effective at picking up events. It is possible that this relates the fact that there was more slow-speed city riding in these countries and that in the higher-speed conditions an aggressive rider input may actually have contributed to, rather than prevented, a serious incident.

**Recommendation: Where high-speed riding is expected to be prominent, possibly consider a greater emphasis on the use of rider reports to identify events.**

Findings from the Greek experiment also indicated that the use of fewer parameters than measured is adequate for revealing irregular riding patterns. This outcome may have significant implications for the instrumentation of PTWs during naturalistic studies. However, the use of fewer sensors to detect incidents does not necessarily mean that we should not measure the rest of the parameters, as they may still prove usefully in providing additional context in defining risk. Further, the traffic related parameters (acceleration, speed) were not influential to the detection of incidents.

**Recommendation: Evaluate these findings using data from different European countries, various road segments and weather conditions. Reveal the possible information loss in defining risk when using fewer parameters than those used in this study.**

On many occasions it would have been useful to know the distance to the vehicle in front, the speed at which the vehicle was travelling and additionally, from those, the time-to-collision to the vehicle in front.

**Recommendation: Longitudinal and lateral distance/speed sensors should be tested and, in the case that the accuracy of the provided data and analysis results is acceptable, it would be worth using such sensors for naturalistic riding studies.**

In order to have comparable results between the different studies that were performed in the different countries the terms "incident" and "conflict" had to be defined. However, this is not straightforward. The level of risk that can be considered to define these two situations may differ from country to country as driving mentality, attitudes and behaviour also differ.

**Recommendation: One has to choose between having the exact same situations attributed with the same risk values (so results might be comparable, but not realistic in terms of actual riding behaviour); or to try and define these terms with different risk levels from country to country which however can be comparable in terms of how the rider would perceive and react to the situation, and the respective result (i.e. near-miss, damage only accident etc).**

A critical distinction should be made between irregular and risky behaviour. Evidently, the situations detected may be considered as incidents where a rider is engaged to an unusual - far from the mean - riding behaviour and, thus, may be candidate riding situations with high accident risk. The detected set of incidents may vary with regards to the accident risk they encompass. A meaningful result as to which of the observed situations are associated with more extreme/ irregular riding behaviours cannot be extracted. Moreover, as the available dataset did not encompass any crashes, the deviations from the mean riding style may not characterize direct accident risk. The situations revealed may be considered as potential situations with increased probability of having a "near-miss".

**Recommendation: Whilst this study has made progress, further research is needed for uncovering the determinants of risky riding under critical incidents.**

# 7. Data analysis

This chapter examines the task of analysing the various data sources. Provided below is a critique of the method used in the data analysis process, including a review of the lessons learned during this project and recommendations for how this process could be adapted and improved in a future study.

## *7.1. Overview of planned methodology and deviations from it*

### 7.1.1. France

The method to detect potentially interesting events has been presented in 6.1.1, and should have been combined with self-reported incidents in order to create the database of all safety-relevant events which have been encountered in the study. Unfortunately, the very high occurrence of trip sections with either video or sensor data missing made it hard to transfer that into an efficient method. Moreover, first results of that approach showed it to be currently too sensitive to measurement glitches. This means that refinements and extensive testing are necessary to get acceptable results. Given the time constrains in the project and the necessity to provide scientifically relevant information about the incidents encountered, it was chosen to focus on video analysis of all the driving activity. As a result, all 65 hours of recording were screened twice by two different road-safety researchers at CEESAR, which led to interesting results.

First, riders tend to declare as incident any misbehaviour of car drivers, even though they are without any consequence to their own riding. Conversely, we observed regularly, especially for some riders, forbidden and often dangerous behaviour, such as splitting lanes, speeding, and for one driver, near-systematic passing at red light. Of course, riders didn't report their own transgressions, as it never led to an incident. More generally, only minor incidents have been observed, and all of them, minus one, had been reported by the riders. In all those events, riders' reaction and motorcycle dynamic stayed within ordinary riding range, meaning we could not have detected them from the sensors only. Although this could probably not be generalized to near-crashes, which didn't occur in the study, it shows the necessity to rely on the rider, either through the diary or using a button connected to the DAS, to get direct knowledge of safety-relevant events.

All relevant events which were identified are described in chapter 8.1, enriched with stills from video, aerial view and estimation of causes. The explanations from the rider's point of view are given, thanks to the interviews.

### 7.1.2. Greece

In all relevant approaches documented so far, some shortcomings regarding the detection and identification of reactions of PTW riders can be found. All studies implement typical fixed driving/riding parameters' thresholds – regardless of the type of rider and the type of area or other roadway of rider characteristics- and, based on those values, the incidents are extracted and further analyzed. This technique lacks consistency with the fact that each driver/rider has its personal stock of values, ideas, beliefs and practices, reflecting rigorously on its behaviour on the road, such as the braking, overtaking and so on, that may not converge to a "typical rider's behaviour". This leads to a different definition of the notion "incident" for each driver. Furthermore, the use of fixed thresholds to identify critical incidents severely biases the riding behaviour that may be associated with the occurrence of a specific incident. Moreover, until now little is known on the manner in which a rider reacts to the emergence of a critical incident. More specifically, there is no knowledge coming from data collected on the interrelations between braking, speeding and manoeuvring under different riding or roadway conditions.

The analyses conducted in the framework of the Greek naturalistic riding experiment aim at treating the following two questions:

1. Is there a way to automatically detect riding situations (incidents) using solely data and without seeing the video?
2. How these situations are related to specific riding characteristics?

To treat the first question, a statistical approach to detect critical incidents from a multivariate set of riding parameters that define the riding characteristics of a specific rider has been proposed as a data reduction/filtering technique; incidents are defined as those situations that the rider's actions deviate from its mean riding behaviour. The mean behaviour and its deviation are defined in relation to changes of the braking, wheel speed, steering and throttle. Although, causalities could not be established, this methodology is a first attempt to automatically detect irregularities and critical incidents from a vast amount of complex and high resolution naturalistic riding data.

The second question is related to identifying criticalities in riding behaviour and to link them to specific riding situations (incidents). This question is treated in two steps. First, it is assumed that, at the emergence of an incident, the rider performs a far from typical (mean) riding action that is followed by a set of sequential actions during the incident in order to avoid crash. For this step, a clustering approach is undertaken in order to reveal the critical rider's actions at the beginning and during the occurrence of an incident. In the second step, the revealed actions are further associated to specific riding situations, for example overtaking, avoiding a stationary obstacle and so on, taking into consideration the uncertainties arisen from the manner the rider will react to each situation. Both methodological steps are modelled using Bayesian Networks (BNs). A Bayesian network $BN = \langle K, L, \mathbf{\Theta} \rangle$ is a directed acyclic graph $\langle K, L \rangle$ of $k \in K$ nodes that represent the $x_i$ random variables of the network. Nodes are connected by links $l \in L$ that describe the probabilistic relationship between interconnected nodes; this relationship is quantified using a conditional probability distribution $\theta_i \in \mathbf{\Theta}$ for each node $k_i$ (Friedman et al. 1997): $\theta_{x_i|\Pi_{x_i}} = P_B(x_i \,|\, \Pi_{x_i})$, where $\Pi_{x_i} \in \Pi_{X_i}$, where $\Pi_{X_t}$ stands for the set of parents of $X_i$ in the network. Independency between variables is denoted by the lack of a link. A BN defines a unique joint probability distribution over X given by:

$$P_B(x_1,...,x_n) = \prod_{i=1}^{n} P_B\left(x_i \,\middle|\, \Pi_{x_i}\right) = \prod_{i=1}^{n} \theta_{i|\Pi_i}\left(x_i \,\middle|\, \Pi_{x_i}\right) \qquad (2)$$

BNs are powerful in handling incomplete data and uncertain phenomena. Moreover, due to their probabilistic nature, they can easily integrate both qualitative information and quantitative information in modelling. BNs have been successfully applied to traffic analysis and forecasting incident detection.

The BN can act as a classifier; given the characteristics $x_i \in \mathbf{X}$ as inputs (for example the riding parameters) and a set of classes Z (for example the riding situations), a new unclassified observation S can be assigned to a class by the rule:

$$classify(x_1,...,x_n) = \arg\max_n \, p(z) \prod_{i=1}^{n} p\left(x_i \,\middle|\, z\right) \qquad (3)$$

A BN can be also used as a clustering model. Clustering is a task to partition the objects in the dataset D into clusters of similar objects. By using BN, each object with attributes x may be classified to its most probable cluster (class) $k^*$, based on the estimated parameters $\theta_i$, by using a membership probability as a score (unsupervised classification):

$$k^* = \underset{1 \le k \le K}{\arg\max} \; p\left(k \,\middle|\, \mathbf{x}, \hat{\boldsymbol{\theta}}\right) = \underset{1 \le k \le K}{\arg\max} \; p\left(k, \mathbf{x} \,\middle|\, \hat{\boldsymbol{\theta}}\right) \qquad (1)$$

Parameters are learnt via an Expectation-Maximization algorithm. The amount of information flow between two nodes $x_i$ and $x_j$ can be measured by mutual information. The mutual information $I\left(x_i, x_j\right)$ between variables $x_i$ and $x_j$ measures the expected information gained about xj, after observing the value of the variable xi:

$$I\left(x_i, x_j\right) = \sum_{x_i \in X, x_j \in X} P\left(x_i, x_j\right) \log \frac{P\left(x_i, x_j\right)}{P\left(x_i\right) P\left(x_j\right)} \qquad (2)$$

The mutual information between two nodes can tell us if the two nodes are dependent and if so, how close their relationship is. The information flow with respect to the set of "evidence" variables (condition-set), in this case the Class membership Z $I\left(x_i, x_j \,\middle|\, z\right)$ is given by conditional mutual information:

$$I\left(x_i, x_j \middle| z\right) = \sum_{x_i \in X, x_j \in X, z \in Z} P\left(x_i, x_j, z\right) \log \frac{P\left(x_i, x_j \middle| z\right)}{P\left(x_i \middle| z\right) P\left(x_j \middle| z\right)} \tag{3}$$

The learning procedure is based on quantifying the amount of information stored in each link of the network. First, an initial structure of the BN is developed and then the relationships are learnt. Structure evolves (nodes dependencies and strength) according to the mutual information.

### 7.1.3. Italy

#### *7.1.3.1. UNIFI data processing*

The data analysis was performed using in-house developed software. Specifically three programs were developed, which performed the following tasks:

- Calculation of the rider physical thresholds;
- Automatic screening of the data to determine the candidate events;
- Visualization of data relative to candidate events.

The last one was specifically conceived to review the data, except the videos which were in a proprietary format. Although it was possible to export the videos in AVI format, the process was not efficient in terms of time, if performed on all the videos, and thus a separate piece of software, provided by the manufacturer of the video recording unit, had to be used. The use of two different programs, for the videos and other data, which had to be synchronized manually, slowed down the analysis process.

Each candidate event was reviewed by video analysis in order to identify the true events. The rationale behind the classification of the candidate events into incident or near-missed was:

- Each candidate event was classified as incident if the event involved an evasive reaction by the rider in the risky condition. The rider was in complete control during the whole incident.
- Each candidate was classified as near missed if the event involved an abrupt reaction by the rider in the risky condition. The rider usually performed hard manoeuvres (hard braking or swerving) and in most situations almost reaching the limits of the PTW capabilities.

### 7.1.4. UK

20 events (i.e. either incidents or near-crashes) were identified during the data reduction/filtering process. Each of these 20 events was then analysed in detail to determine the key factors relating to that event using the cross-partner coding template created earlier in the project. Each event was initially coded by one researcher and then double-checked by another researcher to help reduce the coding errors. It was also at this stage that a decision was made as to whether an event fell into the incident or near-crash category. Ultimately eight were categorised as a near-crash with the remaining 12 as incidents.

It had initially been hoped that a sufficient number of events would be identified in the data to allow for events to be grouped into categories of event-type and that the contributing factors could be analysed to determine the relative frequency of contributing factors related to different environmental and infrastructure conditions. However it became clear that with only 20 events available for analysis, statistical analysis would be of limited power. Instead a discursive analytical approach was adopted in which each event was studied to identify each of the contributing factors and to determine how the event unfolded, such that a chain of events could be established. This method was intended to provide an insight into what sort of factors were seen to be of particular relevance to an event, including what were deemed to be the root causes, and some understanding of how factors relate to each other as an event unfolds.

## *7.2. Lessons learned and proposed recommendations*

The initial idea of analysing data in order to confirm or reject specific research questions, as noted in Section 1.2, was not implemented. However, in such studies that take place in different countries with different riding mentalities, attitudes and behaviour, the questions could not be the same between the different countries.

**Recommendation: Having the exact same analysis performed between different countries does not always provide accurate and comparable results.**

The reduction and analysis of the eye glance is hard, and in most cases also impossible, because of the reflection on the helmet visor. This problem is present both during daytime and night time.

**Recommendation: eye glance is not a reliable parameter to be included in the characterization of the events.**

The analysis of the events was found to be significantly harder where there was no automatic synchronization of the video and sensor data.

**Recommendation: in the planning stage of the naturalistic riding consider attentively the availability of fully integrated software to review the data.**

In Greece, and to a lesser extent in Italy, the large numbers of identified events allowed for useful statistical analysis to be performed. In the UK and France there were not sufficient numbers to do such an analysis and a different approach had to be taken.

**Recommendation: If the intended analysis is to involve detailed statistical interrogation to find patterns and frequencies that can be correlated to the population as a whole, large numbers of events will be required. This study has shown that, depending on the type of riding being observed, these may not appear regularly in the data.**

In many cases, and in the UK and France especially, rider feedback was far more effective at identifying events that the sensor analysis. It also provided vital additional context with regards to the rider’s state of mind and what he was thinking that is impossible to gather from the sensor data alone.

**Recommendation: Whilst the sensor data was important to add detail to the understanding of each event, the importance of rider feedback and subjective opinion cannot be overstated. The importance of the travel diaries should be stressed to each participant and the potential value of a button on the bike for the rider to log an event at the time it occurs should be explored fully.**

# 8. Results

This chapter presents the findings from the analyses conducted on the data collected during the NRS, which provide not only a reference against which to review the efficacy of the analysis methodology used, but also an indication of what sort of results a larger NRS might produce as well as a set of findings in their own right based on the behaviours of test riders observed during this NRS. The findings are assessed against the project objectives and research hypotheses described in the introduction (Chapter1) of this report.

## 8.1. France

**Event 1**

Event identification

| | |
|---|---|
| Participant number | 1 |
| Date & Time | 06/12/2010 – 08:36 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The event took place at an intersection in the urban area. The rider failed to anticipate the give way to vehicle coming from the right. He braked to avoid collision with the car. The aerial photograph and the picture from street view show the location at which the event occurred.

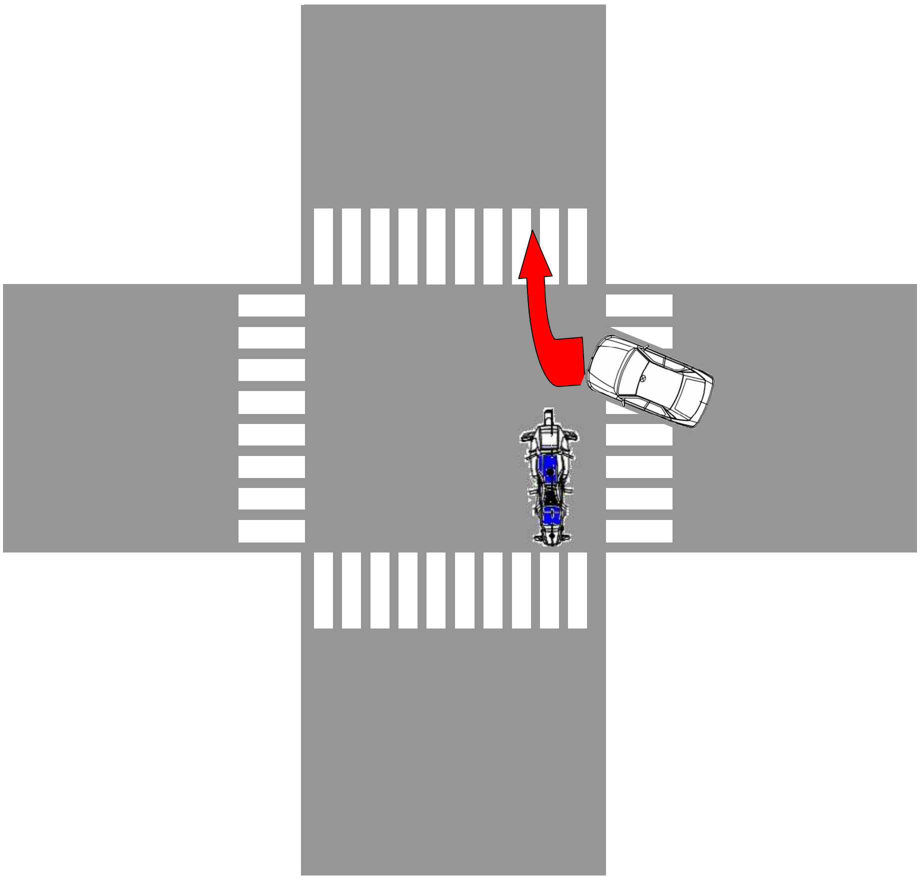
Pre – event situation

The rider is travelling through a urban area and following a car. He is approaching an intersection with give way for the vehicle coming from right. The hedge on the right obstructs rider vision. According to the travel diary and the video, it’s snowing and raining, and the condition of surface is wet. The rider reported also in his feedback that he was distracted and lost in thought.

Start of event

The rider sees at the last moment the vehicle coming from the right.

Climax of event



Right - facing camera

The rider brakes suddenly and the car coming from the right stops also.

Resolution of event

The rider gives way to the car and the car turns in front of the rider.

Discussion

The cause of this incident can be attributed to the rider error to check the give way to the vehicle coming from the right. The rider reported in his feedback that he travels every day on this road and he knows this intersection. The rider's inattention or distraction, vision obstruction with the hedge and the weather conditions are the factors which have contributed to the incident.

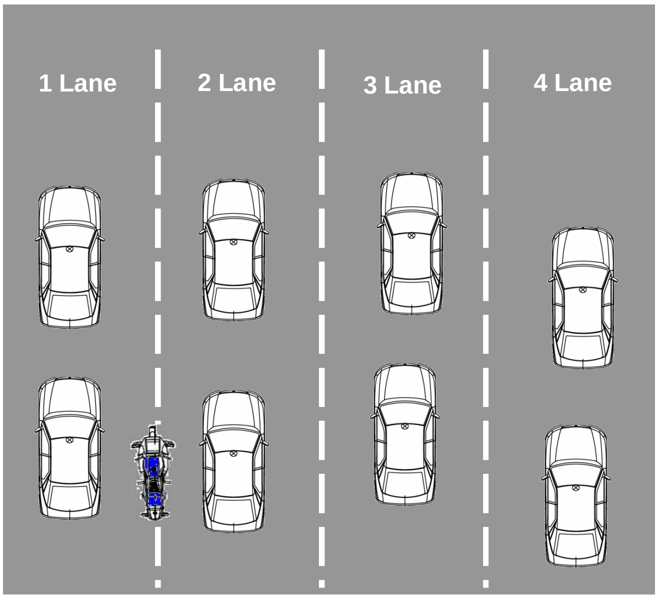
**Event 2**

Event identification

| | |
|---|---|
| Participant number | 1 |
| Date & Time | 07/12/2010 – 08:56 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

On the highway, the rider passed between lanes (between first and second lane), when a car coming from the right merged in to the left lane (first lane). The rider swerved to left to avoid the collision. The following picture shows the road configuration and the rider position.




Pre – event situation

The rider is splitting between the first and the second lanes on the highway. The flow is unstable with temporary stoppages. The rider is following another motorbike rider.

Start of event

Front– facing camera

Right – facing camera

First the car which is on the third lane on the highway changes lane to move to the second one and then it begins to merge in to the first lane.

Climax of event

The car driver sees at the last moment the presence of the rider and he switches off the turn signal. The rider swerves to left, where the gap is wider, to avoid the collision with the car.

Resolution of event

The car stays on the second lane and the rider finishes swerving. The rider continues to overtake the vehicles between lanes one and two.

Discussion

The cause of this incident can be attributed both to the rider and to the car driver.

The car driver failed to check the blind – spot before to change lane. He started to put the turn signal and then switched it off, because he saw the rider presence at the last moment. As a result, it was difficult for the rider to anticipate the car driver manoeuvre. According to the interview with the rider on this conflict, he reported that he thought that the car driver would stay on the second lane.

Conversely, splitting lanes faster than other traffic, whereas the flow is unstable, was a rather inappropriate behaviour from the rider.

**Event 3**

| | |
|---|---|
| Participant number | 2 |
| Date & Time | 17/01/2011 – 06:58 |
| Event severity | Incident |
| Trigger | Video |

<u>Overview of event</u>

The rider is travelling on secondary road. The car coming from the right lane merged in to the left lane and cut off rider's path. The rider braked in order to give way to the car. The aerial photograph and the picture from street view show the location at which the event occurred.


<u>Pre – event situation</u>

Coming out of tunnel, the rider is travelling in the left lane. According to the travel diary he was in a rush and distracted. The weather condition is good, but it's dark.

Start of event

At the last moment the car which is on the right road is changing to left lane. The car driver is switching on the turn signal at the last moment to warn the rider.

Climax of event

The car driver is accelerating to insert in the left lane and the rider is braking and slowing in order to give way to the car.

Resolution of event

The rider gives way to the car and car driver finishes changing the lane.

Discussion

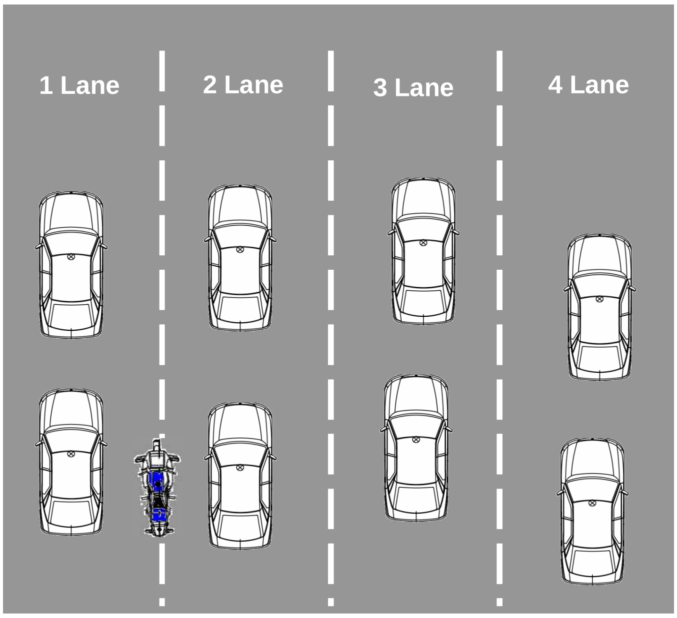
The car driver failed to check the blind – spot before changing lane and started his manoeuvre. At the last moment the driver identified the rider's presence. This situation supposes that the rider was surprised by car manoeuvre, because he flashed his headlights to alert the car driver that his manoeuvre was dangerous. Another important point we can notice is the presence of a "A" sticker (i.e. "Learner", or novice driver) on the back of the car.

**Event 4**

| | |
|---|---|
| Participant number | 03 |
| Date & Time | 02/05/2011 – 17:48 |
| Event severity | Incident |
| Trigger | Video |

Overview of event

The event took place on the highway. The rider overtook between the first and the second lanes when a car which was on the first lane changed to the second lane. The rider braked to give way to the car. The following picture shows the road configuration and the position of the rider.




Pre – event situation

The rider is splitting between the first and the second lanes on the highway. According to the travel diary, the weather is rainy and cloudy. The flow is unstable.

<u>Start of event</u>

The car on the first lane is starting to change the lane, in order to go to second lane. The rider is still overtaking between first and second lanes.

<u>Climax of event</u>

The rider is slowing and swerving to the first lane. The car is continuing to change the lane.

Resolution of event

The car is finishing changing lane. The rider, after swerving, is coming back in the middle of the first and second lanes.

Discussion

In this event, the car driver probably misjudged the rider speed and thought he had the time to change lane.

**Event 5**

| | |
|---|---|
| Participant number | 03 |
| Date & Time | 07/05/2011 – 14:44 |
| Event severity | Incident |
| Trigger | Rider report |

<u>Overview of event</u>

The rider is travelling on the beltway (around Paris) when the car travelling on the left lane, changed to the right lane without warning the rider with his turn signal. The aerial photograph and the picture from street view show the location at which the event occurred.

<u>Pre – event situation</u>

The rider is travelling on the beltway and approaching a curve.

Start of event

The car which is travelling on the left lane is changing to the right lane without warning the rider with his turn signal.

Climax of event

The rider slows down, but remains between the lanes. The car continues the manoeuvre.

Resolution of event

The car finishes changing lane and the rider continues splitting between lanes.

Discussion

The principal cause of this conflict is that the driver failed to check the blind – spot and did not warn the other vehicles his intention to change de the lane. What we can suppose also probably the car driver didn't see the rider presence.

**Event 6**

| | |
|---|---|
| Participant number | 04 |
| Date & Time | 21/02/2011 – 10:06 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The incident happened in the urban area. The rider is travelling when the car which was in the perpendicular parking started to reverse. The rider braked and gave way to the car. The aerial photograph and the picture from street view show the location at which the event occurred. The rider was travelling to the North West.

Pre – event situation

The rider is travelling in the urban area.  He is coming up to the perpendicular parking. According to the travel diary the rider is in a hurry.

Start of event

The car which is in the perpendicular parking started to reverse in order to leave the parking. The car driver doesn't see the rider's presence. The way how the car was parked, the driver could not see the rider's approach.

Climax of event

The rider brakes. The car driver stops the manoeuvre, because he sees at the last moment the rider's presence.

Resolution of event

The car is finishes his manoeuvre and the rider continues his travel.

Discussion

The cause of this event can be attributed to a car driver error, failing to check before to reverse.

**Event 7**

| | |
|---|---|
| Participant number | 05 |
| Date & Time | 09/05/2011 – 14:37 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider is travelling on the secondary road. He overtook by right because of the traffic jam. The car which was on the left changed the lane to the right. The aerial photograph and the picture of street view show the location at which the event occurred.

Pre – event situation

The flow is unstable. On the one way road, the rider is splitting between parked vehicles on the right and the moving vehicles on the left. The rider approaches a tunnel. The flow is unstable with temporary stoppages.

Start of event

In the tunnel, lanes are narrowing (two lanes become one lane). The car in the left lane is beginning to pull in to the middle of the two lanes. The bus is halted in the tunnel on the right side of the road.

Climax of event

The rider is swerving to right to avoid the collision.

Resolution of event

Thanks to a gap in the right lane, the rider is able to avoid collision and moves away from the vehicle.

Discussion

The main cause of this incident is that the car driver did not see the rider. Despite the signs on the road indicating the narrowing of the road, the car driver decided to change the lane.

**Event 8**

| | |
|---|---|
| Participant number | 04 |
| Date & Time | 15/03/2011 – 12:16 |
| Event severity | Incident |
| Trigger | Video |

Overview of event

The event took place at the junction. The rider is travelling on the secondary road in the urban area. The rider accelerated away from the traffic lights at the junction and turned to the left. He didn't give way to the vehicle coming from his right. The aerial photograph and the picture of street view show the location at which the event occurred.

Pre – event situation

The rider is accelerating away from the traffic lights at the junction. And at the same moment the traffic light is also green for the vehicles coming from in front.

Start of event

The rider is turning to the left. At the moment according to his feedback, he is searching gas station.

Climax of event

Front – facing camera

Right – facing camera

The rider is failing to give way to the vehicle.

Resolution of event

The rider is accelerating to avoid the collision with the car.

Discussion

The cause of this incident is that the rider was distracted by searching a gas station.

### 8.2. Greece

The initial conditions at the occurrence of an incident refer to a single action that is undertaken by the PTW rider as an immediate reaction to a stimulus, whereas the conditions during the evolution of an incident may encompass more than one action undertaken by the rider in order to prevent an accident. In the latter case the sequence of rider's actions may play an important role. For each incident phase – beginning and during the incident - a BN clustering model is constructed in order to reveal groups of critical riding actions with respect to the riding characteristics defined by steering, braking, throttle and wheel speed. By critical, we mean the different actions that the rider engages at the beginning and during a critical incident. The trained BNs are able to produce clusters with 68% and 72% purity respectively; the relative high purity signifies that all clusters produced contain mainly cases from a sole class of actions and not from multiple classes of riding actions.

Results are summarized in Table 2 and Table 3 for the beginning and during an observed incident respectively. The profile of each cluster is established based on the binary relative significance, meaning the ratio between the mutual information brought by each variable and the greater mutual information; $\frac{\text{mutual information}_i}{\max\{\text{mutual information}_i\}}$, $i=1,2,...,n$ where n is the number of variables describing riding. Moreover, for each influencing variable, its modal value, meaning the most probable value with respect to the response variable and its observed state; this modal value comes with its probability.

As seen in Table 2, the clustering revealed three distinct groups of riding actions associated with the prevailing conditions at the occurrence of an incident. In each group of actions, the independent variables are ranked in a different manner, indicating that variables' influence in the various groups of actions is different. The group S1, encompassing the 59% of sample actions, reveals that the rider, at the beginning of an incident, activates the rear brake in medium speed, executing a minor manoeuvre. In this group, the most influential variable are the rear and front brake activation, followed by throttle and steering; wheel speed seems to be least influential.

In the S2 group (22% of sample), the rank order is different; front brake activation is the prevailing variable, in terms of influence to the knowledge of the dependent variable's state (S2), followed by wheel speed, throttle and rear brake activation; in the second group of actions at the beginning of the incident, steering is the least influential variable. Actions belonging to the S2 group show that the rider most likely will use the front brake in low speed, again by executing a minor manoeuvre. Finally, there is a third group S3 (19% of cases) where throttle ranks first in terms of influence to the target variable S3, followed by rear brake activation, steering and wheel speed; the front brake activation is not significant. Actions belonging to the S3 group characterize accelerations in high speed where the rider executes a minor manoeuvre; brakes are not activated. A more thorough look at the results show that, although S1 and S2 cannot be easily intuitively assigned to specific riding situations, S3 seems to be a characteristic action met in overtaking, as the rider suddenly accelerates in high speed and executes a minor manoeuvre.

**Table 17: Results from clustering for the initial conditions at the occurrence of an incident.**

| Node | Binary mutual information (%) | Binary relative significance | Modal Value[1] | |
|---|---|---|---|---|
| S1 (58.78%) | | | | |
| Rear Brake Activation (0/100) | 55.05% | 1.00 | 100 | 100% |
| Front Brake Activation (0/100) | 41.51% | 0.75 | 0 | 100% |
| Throttle (%) | 21.32% | 0.39 | <=2.47 (1/4) | 81% |
| Steering (%) | 15.81% | 0.29 | <=0.42 (3/4) | 81% |
| Wheel Speed (kph) | 4.35% | 0.08 | <=49.743 (2/4) | 33% |
| S2 (21.56%) | | | | |
| Front Brake Activation (0/100) | 73.12% | 1.00 | 100 | 100% |
| Wheel Speed (kph) | 23.47% | 0.32 | <=33.45 (1/4) | 57% |
| Throttle (%) | 18.31% | 0.25 | <=2.47 (1/4) | 100% |
| Rear Brake Activation (0/100) | 7.61% | 0.10 | 0 | 57% |
| Steering (%) | 4.64% | 0.07 | <=0.42 (3/4) | 57% |
| S3 (18.66%) | | | | |
| Throttle (%) | 79.25% | 1.00 | <=16.69 (3/4) | 50% |
| Rear Brake Activation (0/100) | 27.39% | 0.34 | 0 | 83% |
| Steering (%) | 14.78% | 0.19 | <=0.42 (3/4) | 50% |
| Wheel Speed (kph) | 11.45% | 0.14 | >65.91 (4/4) | 50% |
| Front Brake Activation (0/100) | 0.78% | 0.01 | 0 | 67% |

[1] Values in the parentheses are the ranges of variable discretization the modal value belongs to.

Similarly, rider's actions during an incident can be clustered into three groups (Table 3). The first group C1 encompassing the highest percentage of cases (44%) is more influenced by steering, rear brake activation, throttle and wheel speed rather than the front brake activation. This means that C1 encompasses actions during which the rider executes a minor manoeuvre, while brakes are activated in medium speeds. In the second group C2 (37% of cases), as in the case of C1, steering is again critical, but wheel speed is more influential than braking. Moreover, front brake rather than real brake is more influential. C2 describes actions there the rider executes a minor manoeuvre in very low speed when both brakes are activated. Finally, C3 is strongly related to throttle and the non-activation of both brakes, whereas wheel speed and steering is less influential. This means C3 involves actions where the rider accelerates in medium speed.

Interestingly, although Si set of actions uniquely appear in each incident (each incident have one appearing Si action), an incident will most likely involve more than two actions Ci actions during its evolution. The manner S1 and Ci are related, as well as the manner a sequence of actions Ci during an incident may be formed with respect to the type of incident will be further investigated in the next section.

**Table 18: Results from clustering for the riding actions during a detected incident.**

| Node | Binary mutual information (%) | Binary relative significance | Modal Value[1] | |
|---|---|---|---|---|
| C1 (43.65%) | | | | |
| Steering (%) | 24.32% | 1.00 | <=1.84 (3/4) | 86% |
| Rear Brake Activation (0/100) | 21.53% | 0.89 | 100 | 96% |
| Throttle (%) | 15.13% | 0.62 | <=5.56 (1/2) | 99% |
| Wheel Speed (kph) | 11.45% | 0.47 | <=55.61 (3/4) | 47% |
| Front Brake Activation (0/100) | 0.60% | 0.03 | 100 | 71% |
| C2 (36.98%) | | | | |
| Steering (%) | 73.21% | 1.00 | <=-0.94 (2/4) | 52% |
| Wheel Speed (kph) | 54.71% | 0.75 | <=19.12 (1/4) | 53% |
| Front Brake Activation (0/100) | 19.69% | 0.27 | 100 | 95% |
| Throttle (%) | 13.24% | 0.18 | <=5.56 (1/2) | 100% |
| Rear Brake Activation (0/100) | 0.94% | 0.01 | 100 | 77% |
| C3 (19.37%) | | | | |
| Throttle (%) | 78.40% | 1.00 | >5.56 (2/2) | 91% |
| Rear Brake Activation (0/100) | 61.63% | 0.79 | 0 | 100% |
| Front Brake Activation (0/100) | 51.62% | 0.66 | 0 | 99% |
| Wheel Speed (kph) | 37.13% | 0.47 | <=55.61 (3/4) | 91% |
| Steering (%) | 22.76% | 0.29 | <=1.84 (3/4) | 98% |

[1] Values in the parentheses are the ranges of variable discretization the modal value belongs to.

A Bayesian classifier is developed in order to relate each riding action at the beginning of an incident to the specific incident categories, as well as the actions to follow during the incident. Table 4 shows the data specifications with respect to the dependent variable and independent variables. As can be observed, the dependent variable is an incident categorization and is general enough to encompass a significant amount of situations met by PTW riders on roads. The dependent variable results from observing all detected incidents through video recordings. As independent variables, apart from the action taken at the beginning of the incident (Start), four other variables are considered. The first three are binary variables {0,1} and refer to whether the action C1, C2 or C3 has been observed during the incident. The fourth variable quantifies the number of actions a rider may do during a specific incident.

**Table 19: Data specification for the BN classifier.**

| Independent | Dependent |
|---|---|
| Start (S1, S2, S3) | Incident Category |
| Nr of actions (1, 2,…) | Stationary obstacle, |
| Action C1 (0 if no, 1 if yes) | Moving obstacle, |
| Action C2 (0 if no, 1 if yes) | Overtake, |
| Action C3 (0 if no, 1 if yes) | Opposing Traffic. |

The Bayesian classifier developed can use the associated data (steering, throttle, front/rear brake activation and speed) for the prediction incident type with relative high precision (function of the number of correct predictions of the target variable) of 82%. Results on the discovered associations are seen in Table 5; in incidents involving moving obstacles or opposing traffic the rider, at the beginning of the incident, will most likely activate the rear brake in medium speed, executing a minor manoeuvre (S1). The riders will then conduct on average 2 actions to avoid a crash, with the prevailing action being C2, which is to activate both brakes and conduct a minor manoeuvre in very low speed.

**Table 20: Results from associating the type of the incident with specific riding actions at the occurrence and during the incident.**

| Node | Binary relative significance | Modal Value | | Node | Binary relative significance | Modal Value | |
|---|---|---|---|---|---|---|---|
| Moving Obstacle (28.57%) | | | | Opposing Traffic (28.57%) | | | |
| Start | 1 | S1 | 90% | Start | 1 | S1 | 90% |
| Actions | 0.542 | 2 | 40% | C1 | 0.843 | 0 | 100% |
| C3 | 0.067 | 0 | 90% | Actions | 0.768 | 1 | 70% |
| C2 | 0.014 | 1 | 70% | C2 | 0.180 | 1 | 80% |
| C1 | 0.008 | 0 | 80% | C3 | 0.074 | 0 | 90% |
| Stationary Obstacle (28.57%) | | | | Overtake (14.29%) | | | |
| Start | 1 | S2 | 60% | Start | 1 | S3 | 80% |
| Actions | 0.518 | 2 | 70% | C3 | 0.591 | 1 | 80% |
| C1 | 0.336 | 0 | 50% | Actions | 0.326 | 3 | 60% |
| C3 | 0.280 | 0 | 100% | C2 | 0.078 | 0 | 60% |
| C2 | 0.012 | 1 | 60% | C1 | 0.001 | 0 | 80% |

In the case of incidents involving stationary objects, the most probable initial action is the front brake activation in low speed (S2); the rider will most probably activate both brakes and conduct a minor manoeuvre in very low speed (C2) during the course of the incident. Finally, overtakes are strongly related to the initial action S3, that is accelerating at high speed, while conducting a minor manoeuvre. During the incident, there is a high probability of accelerating and executing 3 actions with the prevailing action being the acceleration (C3).

Summarizing, risk hindering in the behaviour of riders is a common consideration in PTW safety. Until now, riders' behaviour has been systematically studied through survey questionnaires and police reports, methods that may be biased, lacking critical information or encompassing errors and inaccuracies due to perception. Although current technological advances have foster the conducting of naturalistic experiment that may provide very detailed information on the manner a rider behave on the road, little is still known on the manner a rider reacts to the emergence of a critical incident. The present paper proposes a methodology based on Bayesian Networks for identifying the riding behaviours that arise at the emergence of a critical incident based on high resolution monitored riding data (100Hz) consisting of information on wheel speed, throttle, steering, brake activation and associate them with typical types of incident such as incident involving a moving or stationary obstacle, overtake and incident involving traffic in the opposite direction of travel.

Based on previous results which have shown that deviations from the mean riding behaviour may efficiently be related to incidents with different levels of criticality with respect to rider's risk, different behavioural patterns describing actions that govern the manner a rider reacts to external stimuli are revealed both for the onset of incident and during its duration. These patterns are mainly described by the interrelations between the riding variables that are related to the mechanical characteristics of the PTW, such as front and rear braking activation, throttle position, steering angle and wheel speed. Furthermore, the proposed methodology efficiently relates the observed patterns with four rough riding situations/incidents that are characterized by different initial actions and by different likelihood of actions undertaken by the rider during the incident. These four riding patterns relate to the occurrence of moving or stationary obstacle, overtaking and the opposing traffic.

The proposed methodology is purely probabilistic and compatible with the uncertainty hindering in the rider's behaviour. The revealed riding patterns may be explicitly distinguished. The latter associated with the fact that a very broad categorization of observed incidents has been proposed, results to a flexible characterization of riding behaviours at the emergence and during an incident. Further research is needed on the variability of the observed behavioural patterns across different riders and different riding settings.

## *8.3. Italy*

### 8.3.1. UNIFI data processing

In this section the results will be presented of the analysis of the events (incidents and near-missed) identified with the method explained in chapters 8 and 9. All the identified events involved multiple road users, which most probably is a consequence of the data acquisition performed mainly in the urban area of Florence, Italy. The following results could trigger instinctive comparison with existing accidentology data. However the comparison is not scientifically correct as the current project had not the resources to create a database of events capable to derive conclusions supported by a statistical significance. Thus the results will be presented as pure observation of the behaviours, without performing any further correlation with other data sets.

In Figure 17, the percentage distribution of the conflict type observed is shown. Approximately 60% of the events involved conflicts with lead vehicle, while conflicts with merging vehicle is only the second scenario with 18% of the events.

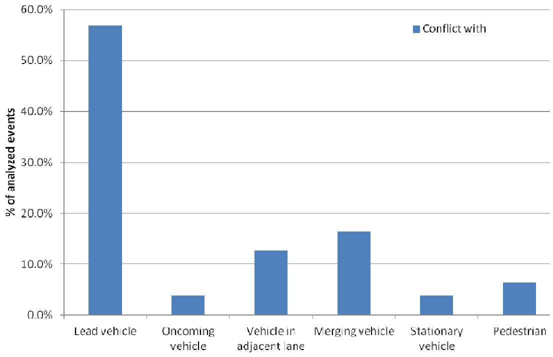



**Figure 17: Type of conflicts**

In 70% of the pre-event behaviour Figure 18 the rider was travelling at constant speed and in only 2% of the cases the rider was braking. This distribution may suggest that the riders were not perceiving any risk.

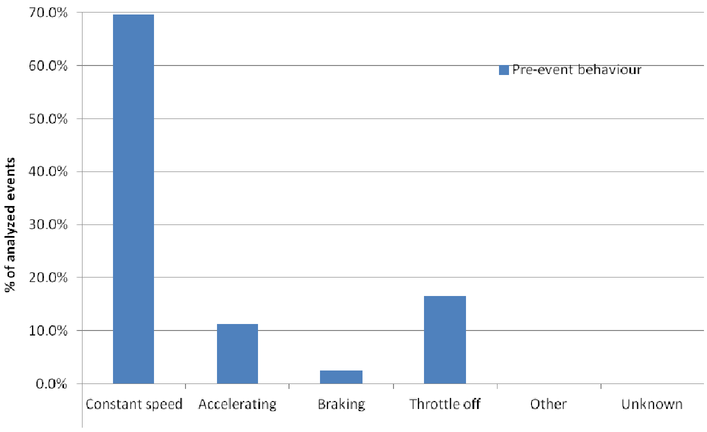



**Figure 18: Pre-event behaviour**

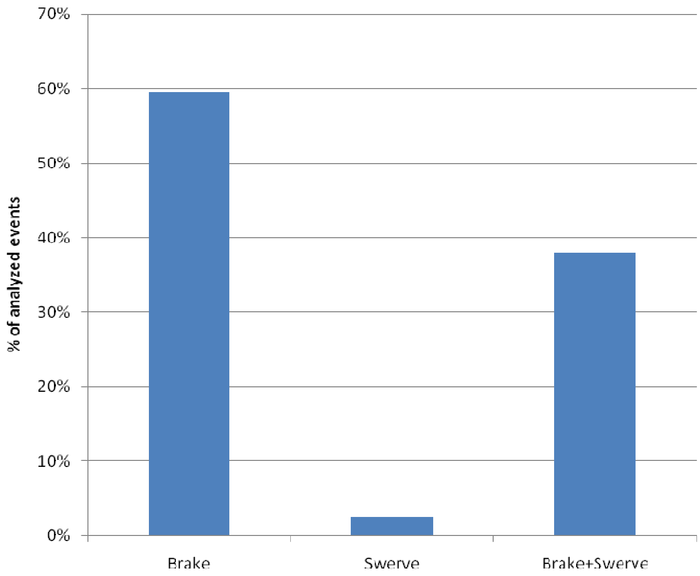



**Figure 19: Percentage distribution of event avoidance manoeuvres**

In Figure 19, the percentage distribution of event avoidance manoeuvres performed by the participants is depicted. In 60% of the events, rider performed just braking. However, in 98% of the events, rider performed braking along with swerve. Pure swerve manoeuvre was persent in just 2% of the events. The breakdown of the event avoidance manoeuvres is described in Figure 20 and Figure 21.

Among the events with a braking action (i.e. pure braking or braking and swerve), in 40% of the cases the braking action led to, at least, the lock-up of one wheel (Figure 20). These results suggest that the braking behaviour could and should be improved, since it is logical to expect a poor behaviour even in more dangerous situations.

In approximately 40% of the cases the riders swerved to avoid the dangerous situations (Figure 21). In 22.8% of the cases riders swerved left and in 17.7% of the cases riders swerved right. However, in the cases where riders performed swerve manoeuvre, the decision to swerve either right or left was 100% correct.

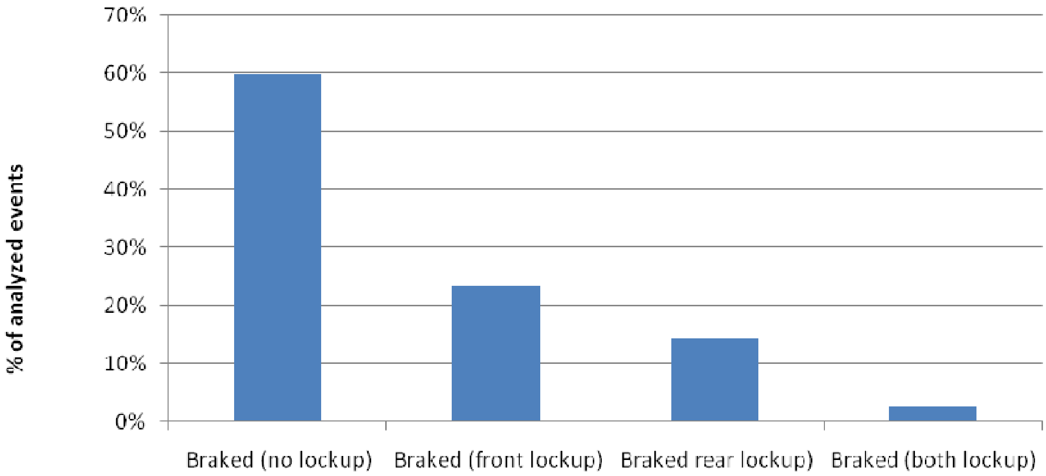



**Figure 20: Event avoidance manoeuvre - braking behaviour**

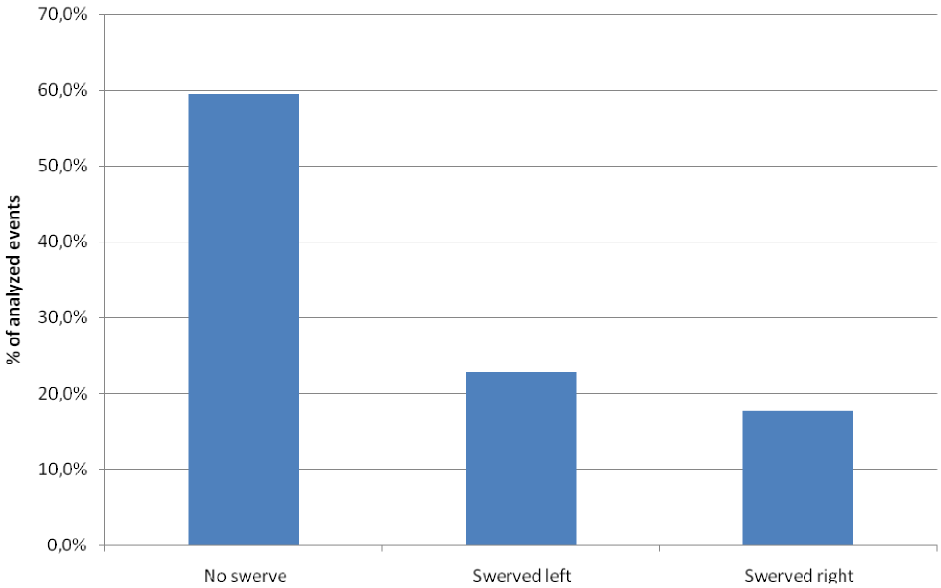



**Figure 21: Event avoidance manoeuvre - steering action**

In addition to the previous analysis the collected and reduced data allow to completely characterize the scenario. In Table 21, a list of event configurations for all the events is shown: 60% of the events occurred when either PTW was almost impacting the rear of other vehicle or PTW and other vehicle were travelling in the same direction and there was side swipe situation.

In the case of near-missed events the detected configurations are (Figure 22):

- PTW & other vehicle (OV) in opposite direction, OV turns in front of PTW (1 near-missed event)
- PTW impacting rear of OV (4 near-missed events)
- Other PTW events (sideswipe caused by a door opening of a parked car) (1 near-missed event)

**Table 21: Event configuration for all the events (incidents and near-missed events)**

| Event Configuration | percentage |
|---|---|
| PTW into OV possible impact at intersections; paths perpendicular | 2.3% |
| OV turning left in front of PTW, PTW perpendicular to OV path | 2.3% |
| OV turning right in front of PTW. PTW perpendicular to OV path | 9.1% |
| PTW & OV in opp. dir., OV turns in front of PTW | 15.9% |
| PTW possibly impacting rear of OV | 31.8% |
| Sideswipe, OV and PTW travelling in same directions | 27.3% |
| PTW possibly impacting pedestrian | 4.5% |
| Other PTW possible events | 6.8% |

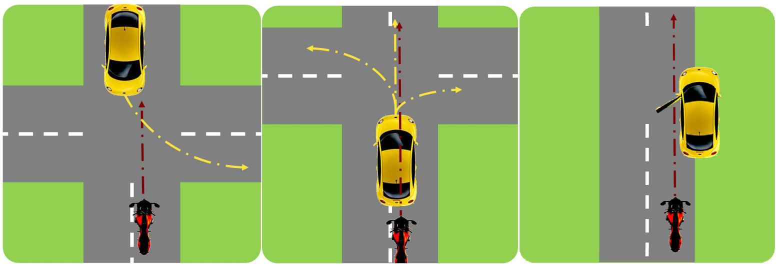


**Figure 22: Frequent event configurations for near-missed events**

### 8.3.2. CIDAUT data processing

CIDAUT performed additional analysis of three Italian riders (rider 02, rider 04 and rider 06). These analyses will detail how the rider behaviour has behaved (from a risky point of view) and if this behaviour has led to a conflict (with or without an accident associated).

A failure mode and effects analysis (FMEA) was also performed. An FMEA analysis can be described as a systemized group of activities intended to: recognize and evaluate the potential failure of a product/process and its effects, identify actions which could eliminate or reduce the chance of the potential failure occurring, and document the process. It is complementary to the process of defining what a design or process must do to satisfy the customer. In the case of road safety, a FMEA analysis will help to understand the motivations of the onset of the dangerous situations the riders have had during their action.

The output from both these sets of analysis can be found in Appendix 1.

### 8.4. UK

The output from the UK analysis is similar to that from the French data. Each of the 20 events has been broken down into the four stages of: pre-event situation, start of event, climax of event and resolution of event. A discursive analysis of the event variables and the contributory factors is then presented, structured around the four-stage classification. Due to the greater number of events seen in the UK data the analysis takes up too much space to be presented within this chapter in its entirety and, as such, only the eight near-crash events are shown here. In fact the distinction between a near-crash and an incident was often blurred and fairly subjective, however it provides a useful means of making a distinction to identify the perhaps more interesting events here. The full analysis of all 20 events can be found in Appendix 2 at the end of this report.

**Event 1**

Event identification

| | |
|---|---|
| Participant number | 1 |
| Date & Time | 23/03/2011 – 07:42 |
| Event severity | Near-crash |
| Trigger | High front brake pressure |

Overview of event

The rider accelerated away from the traffic lights onto a roundabout, preparing to take first exit. However, the car in front braked and the rider only just braked in time to prevent going into the back of it. The aerial photograph below shows the location at which the event occurred. The rider approached the roundabout via the slip road from the NW, exiting via the first exit to the NE.

Pre-event situation

The rider approaches a set of traffic lights controlling the flow of cars onto a roundabout. The traffic lights are currently at red, causing a queue of vehicles, and the rider filters through the stationary vehicles, ultimately pulling up behind the lead vehicle. However, there is not sufficient room for the rider to pull in completely behind the lead vehicle and so he must take station to the left hand side of the lane. The rider is in the middle lane of three entering the roundabout and there are two available for the exit the rider intends to take. The left lane must turn left but the middle (rider's) lane can either turn left or continue ahead. The rider wishes to turn left.

Start of event

The traffic lights change to green, allowing traffic to enter the roundabout. The rider follows closely behind the lead vehicle, possibly so as to ensure his place ahead of the following vehicle, although it seems more likely that it is in an attempt to get ahead of the lorry in the left-hand lane. Either way the rider has committed himself to a position too close to the vehicle ahead.

Climax of event

The lead vehicle is continuing around the roundabout and the rider is either expecting the car to continue moving ahead smoothly or is simply concentrating on the lorry to the left rather than looking ahead. Either way, when a van cuts in front of the lead vehicle and causes the driver to brake slightly, the rider is apparently caught by surprise. In the video, the front of the bike is seen to dip jerkily as the rider takes evasive action to prevent going into the back of the lead vehicle, seemingly by braking heavily.

Resolution of event

The rider cuts to the left of the lead vehicle and continues unharmed, taking the exit as planned.

Discussion

The primary cause of the event was the unexpected braking of the lead vehicle, exacerbated by the fact that the rider was following too closely. Why the braking of the lead vehicle caught the rider so by surprise is not clear, but it seems probable that it was because he was attempting to get in front of the lorry in the left-hand lane and was concentrating on this rather than what was happening ahead. In the build-up to the incident it is noteworthy that the rider, having filtered through the stationary traffic, was unable to gain a dominant position at the lights, instead being forced off to the left. It may be because of this that the rider felt the need to pull away from the lights quickly and thus ended up too close to the lead vehicle. As such the positioning of the rider at the lights may have been a contributing factor.

The incident was detected through the sensor analysis due to a heavy application of the front brakes. The threshold detection value for Participant 1 was 64.7 psi and in this case the actual front brake pressure was 71.6 psi, the second highest value seen in all of Participant 1's data. However, somewhat confusingly the data-trace shows that the rider began applying the front brake almost immediately upon pulling away and that in fact the peak braking occurred before the car in front braked. This would imply that the rider did anticipate the car's actions but does not explain why he still came so close to hitting the car, nor the jerky bike movements seen in the video following the car braking. It is possible that there is a slight discrepancy in the time coding between the sensor data and the video data but this could not be determined confidently.

**Event 2**

Event identification

| | |
|---|---|
| Participant number | 2 |
| Date & Time | 01/03/2011 – 09:13 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider accelerated onto a motorway at speed. Having come off the slip lane the rider pulled across to the outside lane to overtake traffic. As the rider did so a car driver in the middle lane started to pull across to the outside lane in front of the rider, seemingly unaware of the rider's presence. The rider rode through a narrowing gap between the car and the central reserve whilst travelling at 110 mph. The aerial photograph below shows the location at which the event occurred. The rider joined the motorway via the slip road from the E. The event occurred shortly before the over-bridge with the rider heading SW.

<u>Pre-event situation</u>

The rider is pulling onto the main carriageway from the slip road. At this point the rider is travelling at roughly 120 mph.

<u>Start of event</u>

The rider has pulled across to the middle lane and is continuing to move across to the outside lane to overtake the cars in front. At this point the rider is travelling at roughly 115 mph.

Climax of event

The rider is now attempting to overtake the car in front using the outside lane. However the car is itself now pulling into the outside lane, seemingly unaware of the presence of the rider. It is not clear whether the rider could brake and fall-in behind the lead car or if he has no choice but to overtake, however the rider decides to overtake. At this point the rider is still travelling at roughly 115 mph.

Resolution of event

The rider cuts through the narrowing gap between the car and the central reserve, still travelling at over 110 mph, and emerges into a clear lane, in control of the vehicle. It is difficult to tell from the video but there is a suggestion that at the last moment the car driver identifies the rider and starts to pull back slightly towards the middle lane. The whole sequence from entering the motorway to passing the lead vehicle takes less than 5 seconds.

Discussion

The primary cause of the conflict was that the rider attempted to overtake at the same time as the vehicle being passed was pulling into the outside lane. It appears as though the driver was simply unaware of the riders presence, which rather than being an observational fault of the driver is almost certainly the result of the both the speed at which the rider was travelling and the rapid transition from the slip road to the outside lane, clearly placing the rider at fault. It is also noteworthy that the vehicle in question was a sports car with probably limited rear visibility, making it even more important for the rider to properly make his presence known. Given how quickly the entire sequence unfolds it is perhaps not surprising that the rider makes few control inputs to the bike, however it is interesting to note that the rider performs the overtake at a fairly constant speed (i.e. does not brake nor try to accelerate through the gap). This suggests the rider did not panic and instead maintained focus, which may have helped prevent an otherwise much more serious outcome. It is also interesting to note that, despite the serious situation unfolding, the sensors were not able to detect anything of note and the detection of the event was through rider feedback alone. In fact, the rider's control inputs throughout the sequence was entirely within the normal range for that rider, with no harsh acceleration, braking or steering inputs.

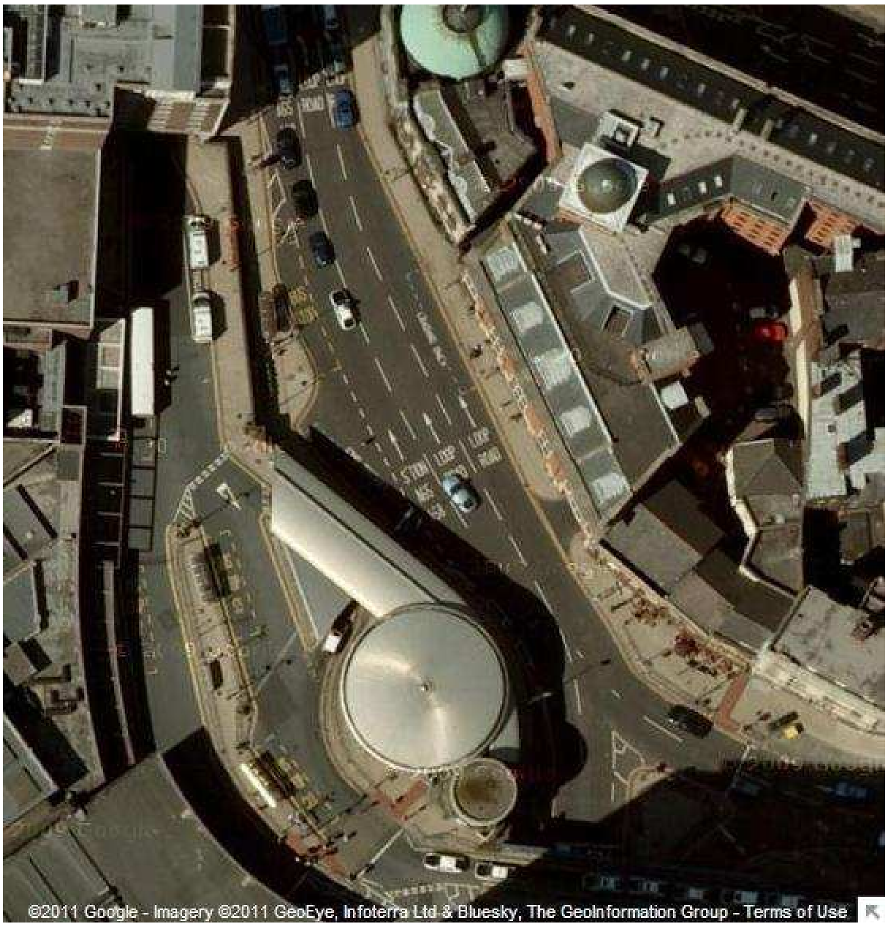
**Event 4**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 28/03/2011 – 07:49 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider was caught in traffic and went to overtake, but failed to check his blind-spot. He pulled out in front of another PTW that was also overtaking and had to quickly move back left to avoid a collision. The aerial photograph below shows the location at which the event occurred. The rider entered from the S, heading N. (note that the road layout has changed slightly since this picture was taken, with the road now marked with 2 lanes rather than the 3 shown.



<u>Pre-event situation</u>

The rider is following a car in front that comes to a standstill at the back of line of traffic waiting for a set of traffic lights ahead to change.

<u>Start of event</u>

Rather than deciding to overtake as soon as he comes up behind the lead vehicle, the rider seems to 'dither' and ends up getting very close. The rider decides to pull out to overtake the line of cars, but his proximity to the car in front means he ends up swinging the bike further out to the right than perhaps would otherwise have been necessary. The rider also reported in his feedback that he failed to check his blind-spot before doing so.

Climax of event

The rider notices another PTW approaching from behind, also intending to overtake the queue of cars. The rider pulls back left sharply to avoid riding into the other PTW.

Resolution of event

The rider manages to leave enough room and the other PTW rider squeezes past. Both PTWs then continue ahead to the front of the queue.

Discussion

The cause of this event can be attributed to a rider error in failing to check the blind-spot before moving off, exacerbated by the fact that the rider did not act decisively upon approaching the lead vehicle which resulted in him making a wider manoeuvre than required and may have made it more difficult for the following motorcycle rider to anticipate what he would do. Any resulting crash would have been fairly low-speed in this case, but contact was seemingly only narrowly avoided. As with the previous two events, there were no sensor readings that indicated a potential event in the data. Rider feedback was instead required.

**Event 9**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 08/04/2011 – 16:27 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider is waiting at a traffic-light-controlled junction. The lights change and the rider moves off, however a car entering from a side road to the left has jumped the lights and cuts in front of the rider, who is forced to brake heavily to avoid a collision. The aerial photograph below shows the location at which the event occurred. The rider approached from the N, heading S; the driver jumping the lights approached from the E, heading N.

Pre-event situation

The rider approaches the same junction referenced in Event 8. As usual he filters down the right-hand side of the queue of cars to a stop at the front of the queue, waiting in the cross-hatched area. The traffic signals cycle through various phases, with the last phase allowing traffic to enter from the side road to the left and turn right, as shown in the image above.

Start of event

The queue of traffic turning right has cleared and the lights change ahead of the rider. Knowing the junction well the rider sets off immediately, probably aiming to get ahead of the car alongside him to his left.

Climax of event

A car entering from the left has jumped the lights and suddenly turns out from the side road, directly into the path of the rider (the car is in fact visible prior to making the turn but is partially obscured by the railings. It is also fair to assume the rider would likely not be concentrating on traffic entering from the side road once the traffic lights had changed to green). He is forced to apply the brakes heavily to avoid a head-on collision.

Resolution of event

Fortunately the rider reaches no more than about 6 mph before applying the brakes and is able to bring the bike to a stop safely. There is sufficient room for the turning car to pass by without a collision.

Discussion

The cause of this event was the car entering from the left against the lights. This particular situation involved risk to the other car drivers in the queue as well as the rider, however the risk to the rider was elevated for a number of reasons: firstly, the rider is naturally more exposed than a car driver; secondly, the rider was further over to the right, due to filtering past the queue of vehicles, and so was closer to the path of the turning car; and thirdly, the greater available acceleration to the rider than that of the car driver to his left would allow him to set off from the lights quicker and so get closer to the path of the turning car.

The sensor analysis failed to identify the event from the braking for two reasons: Firstly, the front brake pressure only reached 23.6 psi (the threshold detection level for Rider 3 was 56.0 psi); and secondly, even if the brake value had been above the threshold level, it would not have registered due to the low speed at which the event occurred. In the early stages of the analysis it was discovered that all the braking events flagged up were from when the rider was stationary (e.g. waiting at traffic lights). In order to remove these false-positives, brake pressure data was filtered to remove values recorded at speeds less than 10 mph. Thus this event would have been filtered regardless of the brake pressure value recorded. It is also worth mentioning that the maximum value of 23.6 psi is also slightly dubious as this value remains fixed for approximately 2 seconds through the period when the video indicates braking reached its maximum, raising the possibility that the sensor may have frozen at the critical moment.

**Event 11**

<u>Event identification</u>

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 17/04/2011 – 09:56 |
| Event severity | Near-crash |
| Trigger | Rider report |

<u>Overview of event</u>

The rider was attempting to overtake two vehicles on a country road, but found he had misjudged the speed of an oncoming vehicle and had to move back in between the two vehicles. The aerial photograph below shows the location at which the event occurred. The rider was travelling N.

Pre-event situation

The rider approaches two vehicles travelling fairly closely together on a country road.

Start of event

The rider is travelling quicker than the two lead vehicles and decides to overtake immediately, pulling out into the opposing lane.

Climax of event

The rider intends to pass both vehicles in a single manoeuvre, but as he approaches the lead vehicle he realises that the oncoming car is closing the gap more quickly than he anticipated and he is instead forced to apply the brakes and move back left behind the lead vehicle.

Resolution of event

The oncoming vehicle passes safely and the rider is able to complete the overtake manoeuvre, continuing past the lead vehicle.

Discussion

The rider reported that he misjudged the speed of the oncoming vehicle rather than not see it. The slight dip in the road is likely to have hidden the oncoming car from him when he first started the overtake and so it seems that he then identified it but decided to continue past both vehicles. The gap between the two lead vehicles was sufficiently large that the rider was able to pull in behind the front one without too much difficulty, but had he pushed ahead with the overtake a head-on collision would have been a distinct possibility.

**Event 14**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 23/04/2011 – 07:58 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider was making a right-hand turn through a bend when the back wheel momentarily lost traction and kicked out. The tyre almost immediately regained traction and kicked the bike up into a brief wobble. The aerial photograph below shows the location at which the event occurred. The rider was heading N.

Pre-event situation

The rider approaches a right-hand bend. At the start of the bend there is a transition in road surface, with the bend itself having had a newer surface applied fairly recently. The rider stated that he was aware of the new surface and that it might be slippery, and that he approached the corner slowly because of this. The rider was travelling at approximately 34 mph, was lightly applying the front brake and no rear brake at the point the above picture was taken.

Start of event

As the rider is roughly halfway around the bend the back wheel momentarily loses traction; enough time for the wheel to slide out slightly to the left and with a noticeable increase in the lean angle of the bike.

Climax of event

Almost immediately the rear tyre regains traction and the bike begins to right itself. The wobble caused is only minimal but there is a noticeable reduction in the lean angle.

Resolution of event

The rider quickly regains control and is able to continue through the bend along roughly the intended line. The rider exits the bend in full control of the bike.

Discussion

The pictures above show that the physical effect on the bike was minimal, with only a slight variation in the lean angle of the bike throughout the incident. This belies the fact that the rider came very close to experiencing a single-vehicle crash, either through losing the rear wheel entirely or through being 'high-sided' when the rear wheel regained traction. This is in spite of the fact that the rider stated that he was aware of the potential for slipping on the new road surface and specifically entered the bend slower than he normally would have. Interestingly there was no indication in the wheel-speed data of a mismatch between front and rear (which would be inactive of either a wheel-spin or a lock-up). This supports the rider's statement that he was neither accelerating nor braking when the event occurred; either one of which could potentially initiate a loss of wheel traction.

**Event 15**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 23/04/2011 – 08:14 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

A van overtook the rider but cut back in far too quickly, nearly clipping the rider. The aerial photograph below shows the location at which the event occurred. The rider was heading E.

Pre-event situation

The rider has just passed through a country village. The rider is seen here passing the transition from the 30 mph zone to a 40 mph zone. As he passes the signs the rider is travelling at approximately 42 mph.

Start of event

Soon after passing the signs the rider realises that a van is coming up closely on his right-hand side and begins to move over to the left of the lane.

Climax of event

The van is then seen to cut in sharply in front of the rider, narrowly missing clipping the bike.

Resolution of event

The van makes it past without contact

Discussion

At the point where the overtake occurred the rider was travelling at roughly 45 mph – above the speed limit – yet the van driver still decided to overtake. Not far ahead the limit changes to national speed limit (60 mph) and it seems likely that the van driver knew this. It is not known for sure what caused the van driver to pass with such little clearance, although the video shows another car passing in the opposite direction approximately 3.5 seconds later that may have caused the van driver to panic slightly, although the road at this point is straight and open and so the driver would almost certainly have been able to see the car approaching before he started to overtake. There is also the possibility, although speculation, that the driver purposely ‘cut the rider up’ as an act of aggressive driving.

**Event 20**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 15/05/2011 – 09:20 |
| Event severity | Near crash |
| Trigger | Rider report |

Overview of event

The rider pulled out to overtake a van without properly checking that the way was clear and nearly crashed into an oncoming car, just managing to pull back in at the last moment. The aerial photograph below shows the location at which the event occurred. The rider was travelling NE.

Pre-event situation

The rider is on a social ride with another biker. The other bike has passed a van in front and the rider is looking to do the same. He has positioned himself close to the centreline in order to identify a gap in oncoming traffic.

Start of event

It is not clear why the rider does not maintain his position near the centreline. However, having believed he has identified a suitable gap the rider has moved across to the left of the lane. As the 4x4 passes the rider leans right to begin his planned overtake, despite being unsighted at the time.

Climax of event

As the rider pulls out he realises that there is in fact another vehicle coming. The rider quickly leans the bike over to the left, but this is not sufficient to bring the bike back over the centreline.

Resolution of event

The rider is still riding to the right of the centreline when the oncoming vehicle passes, narrowly missing him (fortunately the car driver has moved across in an attempt to leave as much room as possible). The rider then continues past the van.

Discussion

The above sequence is probably the closest to a serious crash that any of the riders came during the study. The cause of the event was that the rider pulled out into an inappropriate gap, but this was exacerbated by the fact that the rider swung across right as quickly as he did. It is not clear why the rider moved over so far left in the lane prior to the overtake, but it meant that he not only crossed the centreline too swiftly, but also that he was unsighted to oncoming traffic for several seconds prior to starting the overtake. The fact that he was riding with a companion may have been an influencing factor, making the need to pass the van quickly seem more pronounced. Being on a social ride may also have made the rider feel more like he wanted to promote the feeling of having fun on the bike, which may also help to explain the wide, sweeping manoeuvre.

# 9. Conclusions

This chapter provides an overall assessment of Activity 2.3 of the 2-BE-SAFE project against the objectives, research questions and hypothesis formulated in D5 and presented in Section 1.2 of this document.

## *9.1. Objectives*

**Objective 1: Validate the NRS as an observational method allowing for the provision of an experimental design that can be followed or used as a basis for naturalistic riding studies in the future.**

Ultimately the NRS carried out under Activity 2.3, and forming the research work documented within this deliverable, resulted in data being collected allowing analysis to be performed and providing an insight into the factors that may contribute to various types of PTW conflict situations. With the additional lessons learned along the way, and the corresponding recommendations to mitigate some of the difficulties experienced, it is considered by the study partners that the methodology can be confidently applied in future NRSs.

**Objective 2: Distinguish between, and hence be capable of describing, different riding patterns, from the recorded data.**

Given the limited number of incidents and near-crash situations observed during the study it has not been possible to define different riding patterns explicitly related to risky riding situations. However, at a high level the data have clearly shown that different riders, both between countries and within countries, have different approaches to riding. This is partly shown by both the frequency and type of incidents that each were seen to be involved in during the study; but perhaps the most clear-cut way of differentiating in riding styles was made possible by the relatively novel method pursued in this study of determining the thresholds above which an event would be flagged up in the data, tailored to that individual rider. It is possible to make an objective distinction between riding styles of participants based on where the threshold for event detection fell. For example one might compare a rider for which 120 psi braking pressure would be required to flag up a potential event to a rider for which the corresponding value would be 90 psi and immediately be able to make an assumption about the differences in typical braking styles of the two riders. By looking at each of the sensor traces in this way an objective means of comparing riding styles should present itself. This is perhaps an approach that may be able to be developed in future NRSs. Moreover, probabilistic methodological tools have been developed and applied that enable a measure of deviation from the mean riding behaviour to be defined, specifically tailored to each rider and based on the joint consideration of all sensor signals, to identify specific riding patterns that occur at the emergence and during certain typical incidents, such as incidents involving a moving or stationary obstacle, overtakes and incidents involving traffic in the opposite direction of travel. The entire methodological approach to define riding patterns tailored to individual riders and assign specific patterns to specific incident types is transferable and may be implemented in future NRSs.

**Objective 3: Understand riding behaviour in two distinct situations – under "normal" conditions and where there is conflict behaviour.**

This implies first that we should be able to distinguish between normal riding and riding at conflict. This was proven to be a rather challenging objective for several reasons: First, there is no standardised parameter that can be calculated from recorded data and which implies a conflict. Such a parameter in driving studies is the time-to-collision parameter, for which sensors recording distance/speed between the investigated vehicle and the adjacent ones need to be recorded. Where Naturalistic Studies involve passenger cars rather than PTWs such sensors can be easily mounted, the recorded data are easier to analyse due to car movement within a lane, and there are more or less set values of time-to-collision according to which the investigated event is a conflict. On the other hand, in this study such sensors did not form part of the instrumented equipment; however even if they did, because PTW movement, especially in urban areas, involves lane splitting and filtering they would not provide data that could be easily analysed, as it would include a large amount of noise.

In addition, the instrumentation did not include a "conflict button" which would indicate when the rider perceived to be facing a risky situation. Such information was provided from the travel data questionnaire, however a button would be more efficient and perhaps more reliable. Last, the number of conflicts was not as high in all countries hence the required analysis was not possible, due to the small sample.

To tackle these issues, the problem of distinguishing between normal and irregular riding has been treated from a statistical perspective. The concept behind the modelling carried out in the present NRS is to create an automated manner to distinguish between normal and irregular riding and detect PTW riding incidents and near-misses. “Irregularities” in riding behaviour are consistently expressed as outlying values in either a univariate or a multivariate consideration of the available riding parameters. The proposed statistical measures of deviation from the mean riding behaviour have been found to be efficient in distinguishing between these normal and irregular riding and - with the proper algorithmic calibration – are capable of detecting critical riding situations. Nevertheless, a straightforward link between the emergence of irregular riding patterns and the level of risk could not be established.

**Objective 4: Understand the causes behind potential accidents, and the ways in which these can be prevented either by specific rider/driver behaviour or through the implementation of road safety countermeasures ranging from conventional ones (e.g. road design) to more progressive ones (e.g. intelligent transport systems).**

As with Objectives 2 and 3, the ability to address this objective directly was hampered by the relatively low numbers of incidents and, particularly, near-crashes observed. For example in the UK and France there was little scope for extrapolating the incidents seen in the study to make assumptions about the relative frequency of incidents in the wider population (although the incidents that were recorded have provided an insight as to how those particular types of events started, developed and unfolded and revealed some of the contributory factors that can be looked at in further research). However in the Italian and Greek data it has been possible to interpret a deeper meaning from the data, with respect to how the findings may be related to the wider population, and begin to assess why common incident types happen, and why some progress into more serious situations. Given that this was a relatively small-scale pilot study this gives a promising indication of the potential of a much larger study.

## *9.2. Research questions*

**Question 1: What are the lessons learned from the naturalistic riding study in respect to the objectives?**

As has been demonstrated throughout this document, there have been many lessons learned along the way, in each aspect of the methodology. Ultimately the study suggested that future studies could be confident of achieving similar objectives.

**Question 2: What is the most appropriate implementation time schedule for a large NRS?**

Perhaps one of the key lessons learned during this study is that the time allocated for setting up the bikes and generally for getting the groundwork in place to commence the data-collection phase was insufficient due to many unexpected technical and logistical difficulties, although with lessons learned from this study, futures ones would hopefully go more smoothly. With this in mind it is recommended that at least 12 months should be set aside for instrumenting a bike in future studies (including the design, procurement and installation and testing). Beyond this the remainder of the study was largely carried out according to schedule. In terms of the length of time each rider should be involved, there needs to be a balance between minimising the burden on the participant, and ensuring they have the bike long enough to get used to it and demonstrate truly naturalistic behaviour. It is considered that four to six weeks per participant worked well in this regard. The overall length of a study will therefore depend on how many participants are required and whether or not multiple databikes will be deployed concurrently. (Note that, if it is possible to use a participant’s own vehicle, the time required to ‘get used to the bike’ would be avoided).

**Question 3: How could the instrumentation be modified/ integrated to improve the observation of riders’ behaviours?**

Recommendations are set out in detail earlier in this document, but perhaps the key findings in this respect were the desire for a button mounted on the bike for the rider to flag an event at the time (or just after) it happened; and also the importance of ensuring that there is video data showing the forward view. Without the context of what the rider sees and what the actions are of vehicles around the rider, the remaining data is largely useless. Establishing a reliable forward facing camera is critical and any further cameras will likely provide additional useful contextual information. With regards to the desire for a rider button, it should be pointed out here that this could potentially detract from the 'naturalism' of the trial. However, the button would be anticipated to be used infrequently and would require only a short and simple interaction. It's presence would be expected to have no greater (or perhaps less) impact on the rider's sense of being recorded than, say, the rider-facing camera that was installed on the test bikes in this trial. At this stage it is considered that the benefits of such a button would outweigh the potential costs.

**Question 4: How could other elements of the study (data storage, analysis methodology etc.) be modified/ integrated to improve the observation of riders' behaviours?**

Again, this is addressed in detail within the document. However of particular note is the importance of gaining rider feedback in travel diaries. In fact these generally worked well during the study, but some participants were found to put far more detail in the diaries than others. It is recommended that the importance of the travel diaries be stressed to the participants, along with clear instructions of the sort of detail to be included. If participants are found to be providing insufficient detail, or are failing to fill in the diary at all, introducing some form of incentive could be considered.

**Question 5: Was there a specific issue that was not taken into account which is a prerequisite for the successful implementation of a larger naturalistic riding study?**

It was not established exactly how many incidents would be required in order to perform confidently a reliable statistical analysis of the data; however given that it was not known what frequency of incident detection would be experienced this question was largely irrelevant at the start of this study. Given the relative frequency of incidents seen in this study it should be possible to make a prediction about how many might be observed in future studies. The question of how many incidents are required should therefore be asked in the initial planning stages of such studies and the scale of the study planned accordingly. What this study has shown is that the expected number of incidents will vary depending on the type of bike, rider and riding environment being studied. If it is to be larger bikes, used in a rural setting, it might be as low as one incident for perhaps every three to five hours of data. Smaller bikes in an urban setting might be expected to produce up to two or three (low severity) incidents per hour. (Although it should be noted that different studies may define different thresholds for what constitutes an incident, which will naturally influence the frequency at which that they are detected).

**Question 6: What rider patterns can be identified by the data? Could these patterns be correlated with specific rider profiles?**

As stated in the response to Objective 2 earlier, this was not expressly explored in this study. However it is proposed that the personalised trigger-threshold approach could be explored further when seeking to relate riding patterns to rider profiles. Moreover, the proposed multivariate framework may be used to identify specific riding patterns that occur at the emergence and during certain typical incidents, such as incidents involving a moving or stationary obstacle, overtakes and incidents involving traffic in the opposite direction of travel. The entire methodological approach to define riding patterns tailored to individual riders and assign specific patterns to specific incident types is transferable and may be implemented in future NRSs.

**Question 7: How can one define and distinguish between riding under "normal" conditions and riding at conflict? What are the parameters that one should record and are there specific values that could be set to define conflicts quantitatively? This would also allow setting triggers for conflicts.**

This required finding a trigger that would indicate to the analyst that the rider was not riding under "normal" conditions, but at conflicts. This trigger in Naturalistic Driving Studies is the parameter "time-to-collision" which can be directly calculated from the acquired sensor data. The specific NRS treated the problem of distinguishing between normal and irregular riding using statistical outlier detection techniques on sensor data. The analysis of Greek data in particular showed that there is promise in being able to define these objectively. The evaluation of multiple control inputs and their interaction with each other is perhaps likely to yield the best results.

**Question 8: What are the contributing factors and dynamic scenarios involved in conflicts? – This will also provide answers to the questions: "How do riders behave and cause an accident?" "How do riders behave to avoid an imminent accident?" and "How do riders behave in order to avoid getting into an accident?"**

Given the low numbers of incidents seen in this trial, it is difficult to extrapolate the results to the wider population, but in those incidents that were seen it is considered that sufficient information was able to be obtained to give a fairly clear account of what happened and why. Obtaining the contextual information of what the rider was thinking at the time proved to be extremely useful and, despite the obvious inability to determine what drivers of other vehicles were thinking at the time, was typically enough to piece together the perceived likely causal and contributory factors. Nevertheless, in the Greek experiment, an attempt to associate specific riding patterns to the occurrence of certain types of incidents has been conducted and critical riding patterns at the emergence and during an incident have been revealed.

**Question 9: What are the differences between one week of field data and one month of naturalistic riding data?**

The more data one acquires the higher the number of repetitive patterns is found. This would allow defining riding patterns that would representative of the real rider's behaviour. In addition, it might be the case that there are more conflicts, hence a large enough sample to analyse different riding conditions as well (in terms of the road environment, traffic conditions and weather conditions).

Selecting the proper data-collection methodology should be related to the problem that one wishes to tackle. The problem will define the data analysis and inclusiveness. This specific NRS has proved that high resolution data from extended periods should be collected in order to have a representative sample of incidents / near misses etc and proceed to a "safer" statistical evaluation of the riding patterns involved. Evidently, it has also been shown that the type of data used in this NRS is not adequate to quantify the risk of having an accident.

**Question 10: What are the differences among the different scenarios in the different countries?**

It was accepted in the early planning stages of the project that the typical riding behaviours in the different countries differed enough to make exploring a uniform approach to data collection impractical. This was taken into account when deciding to use, say, a 300cc scooter in Italy and a 1000cc sports bike in the UK. However, what was suggested by the results was that this may also have a profound implication for the number of incidents likely to be seen, the different types of incidents, and what this may mean for how best to capture data for them. For example, the higher speeds achievable on a sports bike means that there will be situations where a rider perceives an incident to have occurred, even though the control inputs may be small, simply due to the fact that the potential for serious injury in the result of a loss of control is higher and there may well be a perceived – whether genuine or not – smaller margin for error.

**Question 11: What are the differences among the factors that contribute to these scenarios, in different countries?**

It was not possible to determine this given that, in the UK and France, insufficient events were recorded to determine meaningfully the relative frequencies of incident types. However, given that such an analysis was possible on the Greek and Italian data it suggests that such a comparison between countries would be achievable in larger studies.

## 9.3. Hypotheses

**Hypothesis 1: The instrumentation does not alter PTW dynamics and rider driving behaviour.**

Feedback from riders suggested that there were no complaints about the additional kit altering the handling unacceptably. It is also believed that riders fell quickly into their normal routines and riding styles. However, if the next step was to include sensors that record distance and speed of adjacent vehicles (front, side and rear) this might not be the case. In addition, instrumentation such as cameras that would show in great detail the riders face could not be included due to constraints because of helmet use. Last, the instrumentation did not alter PTW dynamics and rider behaviour but it could distract or alter other drivers'/riders' behaviour since parts of the instrumentation (mounted cameras) were visible.

**Hypothesis 2: The instrumentation is appropriate and all required parameters are recorded in a proper manner (no data fail, appropriate accuracy, synchronisation of the different data, etc.).**

Many problems with sensors were encountered in the setting-up phase, but the systems were reasonably reliable once the data-collection started. With things like the reliability of wiring-connections aside, persistent issues that may require further attention in future studies include the start-up time for GPS-related instrumentation and a more accurate system for measuring wheel speeds. In addition, a button that the rider could use to flag events being part of the instrumentation may provide added value.

**Hypothesis 3: The data parameters and their accuracy are sufficient to provide a good quantitative and qualitative description of rider behaviour.**

The combination of the sensor data (and the individual rider thresholds), along with the subjective feedback from the rider travel diaries, provided a clear indication of rider behaviour in the events observed at both a quantitative and qualitative level. Information on the distance and speed of adjacent traffic are critical for the further evaluation of the causalities involved in the riding patterns observed.

**Hypothesis 4: The procedure of data storage did not influence the course of the study, and was implemented efficiently.**

On the whole the procedure for data storage and collection went without problem. However in the UK the lack of data storage space on the bike resulted in a need for daily downloads, which threatened to cause difficulties but was thankfully accommodated. In future studies a minimum storage space sufficient to store at least a week's worth of data would be recommended and so this issue would be avoided.

**Hypothesis 5: The methodology for data analysis is appropriate and yields the requested output.**

This aspect was not able to be explored as deeply as had initially been hoped, given that the UK and French data could not be interrogated statistically. However even without this statistical work the discursive interpretation of the video, sensor and rider feedback data revealed some interesting insights into the development of several types of conflict situations. In Greece and Italy the analysis was able to be more in-depth and in these cases there is a strong indication that the analysis tools used would yield valuable results if applied to a much larger dataset from a full-scale study. Nevertheless, the proposed data analyses provided a set of valuable statistical tools for automatically detecting critical riding situations from the sensor data that may be transferred to future NRSs.

**Hypothesis 6: No legal or ethical issues are raised during the study and during data processing.**

In order for a study such as this to produce viable results, it is imperative that participants display genuine naturalistic behaviours and this tenet is at the heart of any legal or ethical issues. It would be naive to think that none of the participants would display illegal riding behaviours at any time during the study (particularly so riders of high-powered sports bikes) and indeed if no evidence of speeding was seen at all then it would have been a major warning sign that riders were altering their behaviours as a direct result of their participation in the study. Thus each research institution is effectively asking participants potentially (and in fact probably) to provide incriminating evidence of themselves committing violations and so must be able to ensure that this data is kept strictly confidential. Not only is this crucial on an ethical level in terms of the institute's duty of protection for the participant, but is also necessary to ensure that the riding community remains engaged in such work and that future studies are able to recruit effectively. The practices employed by each partner during this study are believed to have upheld this core principle.

A slightly different issue arose when one of the participants was asked to cease involvement prematurely due to persistent behaviour considered to be unnecessarily risky. This posed a difficult decision between gaining potentially valuable and insightful data of such riding behaviour, and concerns over liability against the research organisation should an accident occur and they be seen to have knowingly allowed such behaviour to continue. Ultimately, organisers of future studies would be advised that such situations are likely to happen again, and each organisation must assure themselves that they have put in place enough measures to be able to confidently show that participation in the study had not caused the test rider to change their behaviour, and so any illegal behaviour witnessed was entirely at the discretion of the participant and therefore solely the participant's responsibility. It is recommended that organisers of future studies may wish to get explicit clarification of this matter from a legal advisor. The use of a participant's own machine for use in the trial would potentially help in making the case that their behaviour had not been altered due to participating in the trial. The extensive time required to instrument the bikes used in this trial may be considered to be prohibitive of such an approach. In addition, the work often required cosmetic damage to certain parts of the bike, which would undoubtedly deter many potential participants. However, as equipment becomes smaller and instrumentation setups are refined and able to be more standardised, the possibility of using participants' own machines will become more practicable. Indeed, at the time of writing, IFFSTAR have made refinements to the instrumentation setup such that a fully transferable rig, with only minor cosmetic damage required to the host bike, seems attainable.

# 10. References

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# Appendix 1 – CIDAUT analysis of Italian data

## *Rider Behaviour Analysis*

In this section, analysis of three Italian riders will be shown (rider 02, rider 04 and rider 06). These analyses will detail how the rider behaviour has behaved (from a risky point of view) and if this behaviour has led to a conflict (with or without an accident associated).

Before giving details about the way of riding of these three riders, it must be explained the following concepts that are going to be used:

.- Participant number: This is the number of the rider who has been analysed (2, 4 or 6).

.- Date and Time: This will the information of the moment in which that rider behaviour has been chosen.

.- Risky Rider Behaviour: This will the kind of behaviour that this rider has in the moment selected and it is supposed it will be a risky behaviour (coming from the rider or other driver).

.- Conflict: Each risky behaviour detailed previously will be able to finish (or not) as a conflict: This conflict, in turn, can be an accident or not. The main difference between “risky rider behaviour” and “conflict” is the fact that for each rider its “behaviour” will be described, but not for all the “risky behaviour” a conflict is going to be associated.

.- Trigger: This will be the cause of selecting this moment to be analysed. There are the following options as “triggers”: High front brake pressure (abrupt change), high rear brake pressure (abrupt change), high steering angle (abrupt change), high throttle angle (abrupt change) or simply through the analysis of images recorded during each riding. It must be said that many times these “trigger” variables have taken to “false” situations to be analysed (for example, not always an abrupt change of steering angle means a risky behaviour, therefore, it is necessary to analyse images from “video recorder” to determine if this moment selected is suitable to be included in this chapter.

For each one of the behaviours selected to be analysed, the following moments will be described: overview of event; pre-event situation; start of event; climax of event and resolution of event.

**Event 1**

Event identification

| | |
|---|---|
| Participant number | 2 |
| Date & Time | 11/05/2011 – 14:42:11 |
| Risky Rider behaviour | Longitudinal control: Brake abruptly with conflict.<br>Use of lane: overtake from wrong site.<br>Curve: Extreme route in lane. |
| Conflict | Left turn |
| Trigger | Image (video record) |

Overview of event

The rider is riding through an urban street, approaching to an intersection ("+ intersection"). In front of him, there are two passenger cars. He decides to overtake both of them (using the opposite lane). Once he has overtaken the first vehicle, the rider decides to turn left while he is overtaking the second vehicle (using also the opposite lane). During this turn, the second passenger car decides also to turn left, this is the moment of the conflict because the second passenger car and the motorcycle are close to be involved in a side-to-side crash.

Pre-event situation

The rider approaches an urban "+" intersection. The traffic flow is fluid and only two passenger car appear in front of them and in the same direction. The visibility is perfect.

Start of event

The rider is just behind the second vehicle and he decides to overtake both of them, although the "+" intersection is near.

Climax of event

The rider is involved in a double overtaking (passenger car 1 and passenger car 2). The overtaking is carried out successfully although the rider uses the opposite lane. The most dangerous situation is when the rider decides to turn left as well as the second vehicle. Due to the second vehicle does not see the motorcycle (due to a wrong overtaking from the rider), the side-to-side crash almost happen.

Resolution of event

Finally, the rider turns left parallel to the second passenger car and continues unharmed.

**Event 2**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 01/07/2011 – 11:07:09 |
| Risky Rider behaviour | Longitudinal control: Short distance in line.<br>Use of lane: weaving.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider is going along an urban street, approaching to an intersection. In front of him, there is a van. He overtakes the van invading the opposite lane while the van stops near the intersection. He overtakes the van practically at the intersection, with possible oncoming traffic that he cannot detect.

Pre-event situation

The rider goes along a two-way traffic street. The traffic flow is fluid and just a van is in front of him. There is good visibility.

Start of event

The rider is just behind the van and he decides to overtake, although the intersection is very close.

Climax of event

He overtakes when he very close to the van, changing lane a few meters away from the intersection. Even the overtake was successful, the rider took a risk because the intersection was near and oncoming traffic could appear while using the opposite lane. He does not respect safety distance, neither longitudinal nor lateral.

Resolution of event

The rider overtakes and stops at the traffic lights.

**Event 3**

Event identification

| | |
| --- | --- |
| Participant number | 4 |
| Date & Time | 05/07/2011 – 11:07:48 |
| Risky Rider behaviour | Longitudinal control: Short distance in line.<br>Use of lane: weaving.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider approaches to a Y intersection where there is heavy traffic. He decides to overtake 4 vehicles and in the last second he comes back to the correct lane, crossing a continuous line.

Pre-event situation

Rider circulates in a two-way street with fluid traffic flow.

Start of event

He approaches to a Y intersection regulated by lights where several vehicles are stopped.

Climax of event

The rider start overtaking vehicles and when he sees that there is no more space to continue overtaking he comes back to the right lane, crossing a continuous line, and performing an aggressive manoeuvre.

Resolution of event

He comes back to the right lane and goes along the route.

**Event 4**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 05/07/2011 – 11:09:33 |
| Risky Rider behaviour | No risky behaviour |
| Conflict | Vulnerable road user |
| Trigger | Image (video record) |

Overview of event

When the rider turns right, there is a pedestrian walking on the pavement. He has to modify his trajectory and ride far left.

Pre-event situation

The rider goes along an urban area with fluid traffic flow.

Start of event

The motorcyclist turns right, leaving a two-way street and going into a one way street.

Climax of event

After turning right, the rider faces the street but a pedestrian is walking along the road, which makes the rider goes to the left.

Resolution of event

The motorcyclist rides far left and keeps going with his route.

**Event 5**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 05/07/2011 – 18:05:19 |
| Risky Rider behaviour | Other risk behaviour |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider closes a button of his shirt while he is riding.

Pre-event situation

The rider goes along a motorway.

Start of event

He decides to close the top button of his shirt.

Climax of event

He rides over than 40 seconds with just one hand, whilst he is closing the button with the other hand.


Resolution of event

He finishes closing the button and keeps going with his route.

**Event 6**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 05/07/2011 – 18:19:04 |
| Risky Rider behaviour | Longitudinal control: Short distance in line. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider overtakes two vehicles at the same time than another passenger car, so he cannot see if there are vehicles coming from the opposite direction.

Pre-event situation

The rider circulates trough a two-way rural road behind three cars.


Start of event

When it is permitted to overtake, the passenger car just in front of the rider starts overtaking the other two cars.

Climax of event

The rider decides overtake the two vehicles just after the passenger car, which makes difficult to him to see oncoming vehicles.


Resolution of event

The car and the rider finishes the overtaking manoeuvre.


**Event 7**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 05/07/2011 – 18:30:25 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The motorcyclist reaches an intersection regulated by a stop sign and he does not obey the sign, he performs a yield sign instead stop.

Pre-event situation

The rider circulates along a urban area, no cars around.

Start of event

He approaches to an intersection regulated by a stop sign.

Climax of event

He looks right and keeps going with his route, ignoring the sign.


Resolution of event

He continues his route.

**Event 8**

Event identification

| | |
| --- | --- |
| Participant number | 4 |
| Date & Time | 06/07/2011 – 10:50:26 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Longitudinal control: Short distance in line.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

The rider overtakes a car in a curve with continuous line, crossing the middle line and another car is coming from the opposite direction.

Pre-event situation

The rider circulates along an outside urban area two-way road. Is a sinuous road with two lanes. There is a car in front of the motorcyclist

Start of event

The rider gets close to the passenger car and decides to overtake.


Climax of event

He overtakes between two curves crossing the continuous middle line. When he is performing the manoeuvre he sees a car coming from the opposite direction.


Resolution of event

He comes back to the left lane abruptly.


**Event 9**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 10:50:46 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Longitudinal control: Short distance in line.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

Just alter the previous event the rider goes along a left side bend and he uses an extra lane to turn left the vehicles from the opposite direction to take the curve.

Pre-event situation

The rider approaches goes along the same rural road.


Start of event

He approaches to a left hand curve

Climax of event

When he faces the left side bend he decides to cross the middle lane and use an extra lane to pass the curve. He invades the extra lane that the opposite direction vehicles have to turn left

Resolution of event

The rider has to reduce speed because there is a light van in front of him. However, he tries to overtake him even with a double solid line but he cannot do it because there is a right hand bend.

**Event 10**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 10:51:08 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Longitudinal control: Short distance in line.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

A few seconds after the previous event, the rider overtakes the light van crossing the solid line. He starts the manoeuvre in a left side bend.

Pre-event situation

The motorcyclist is right behind a light van after the previous curve.


Start of event

The rider is trying to overtake the van since he caught it.

Climax of event

In the last part of a left side bend he starts overtaking the van, crossing a solid line.


<u>Resolution of event</u>

After he overtakes the van he continues with his way.

**Event 11**

<u>Event identification</u>

| | |
| --- | --- |
| Participant number | 4 |
| Date & Time | 06/07/2011 – 11:23:35 |
| Risky Rider behaviour | Use of lane: ride far left. |
| Conflict | Lane change |
| Trigger | Image (video record) |

<u>Overview of event</u>

Along a motorway, the rider is overtaking a passenger car and the passenger car goes in to the rider's lane to let other cars incorporate from an access. The motorcyclist has to slow down and let the car pass

<u>Pre-event situation</u>

The rider is circulating through a motorway with fluid traffic.


Start of event

He decides to overtake a passenger car just in a merging access to the motorway.


Climax of event

The passenger car changes lane to the left to let the other vehicles incorporate to the motorway. This action forces the rider to slow down and let the passenger car pass


Resolution of event

The car comes back to the right lane and the rider overtakes him.

**Event 12**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 11:47:35 |
| Risky Rider behaviour | Curve: Extreme route in lane.<br>Curve: Cross solid line.<br>Use of lane: weaving.<br>Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider takes an exit of a motorway which finishes in a roundabout. There is heavy traffic and a lot of vehicles are stopped, so the rider decides to overtake all the vehicles using the right shoulder.


Pre-event situation

The rider takes a motorway exit.

Start of event

When he approaches to the roundabout there is heavy traffic. Lots of vehicles are stopped waiting to get to the roundabout.

Climax of event

The rider decides to overtake using the right shoulder until he gets to the roundabout.


Resolution of event

When the rider reaches the roundabout he continues with his route.

**Event 13**

Event identification

| | |
| --- | --- |
| Participant number | 4 |
| Date & Time | 06/07/2011 – 11:55:19 |
| Risky Rider behaviour | Use of lane: ride far right. |
| Conflict | Lane change |
| Trigger | Image (video record) |

Overview of event

The rider is approaching to a light and a passenger car changes lane just in front of the motorcyclist.

Pre-event situation

Motorcyclist is circulating through a two lanes and one way street. Traffic is fluid.

Start of event

The rider approaches to a red light so he reduces speed progressively.

Climax of event

A passenger car changes lane forcing the rider to turn and ride far right.

Resolution of event

The motorcyclist rides far right and put himself in the front line.

**Event 14**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 11:55:53 |
| Risky Rider behaviour | Use of lane: weaving. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider approaches to an intersection regulated by lights. The traffic is dense so he decides to overtake between the two lanes and after he crosses to the right margin of the road and keeps overtaking until he reaches the front line.

Pre-event situation

The rider is circulating through a two lanes and one way street. Dense traffic.

Start of event

When the rider sees all the vehicles stopped at the lights, he decides to overtake.

Climax of event

The motorcyclist overtakes all vehicles, firstly between the two lanes and then between the right margin of the road and the cars.

Resolution of event

He rides until the front position at the lights.

**Event 15**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 11:57:20 |
| Risky Rider behaviour | Longitudinal control: Short distance in line.<br>Use of lane: weaving.<br>Use of lane: ride far left.<br>Use of lane: overtake from wrong site. |
| Conflict | Lane change |
| Trigger | Image (video record) |

Overview of event

The rider overtakes two passenger cars using the shoulder and the parking spaces.

Pre-event situation

The motorcyclist goes along a two lanes and one way street. There is dense traffic with slow speed due to that they are approaching to an intersection.

Start of event

The rider changes lane to the left

Climax of event

He starts overtaking vehicles using the left parking spaces, and when he finds a car parked in front of him, he comes back to the left lane without respecting the lateral distance with the other vehicles.

Resolution of event

He slows down an passes, putting himself in front of all the vehicles.

**Event 16**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 12:26:06 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: overtake from wrong site. |
| Conflict | Lane change |
| Trigger | Image (video record) |

Overview of event

As there is dense traffic, the rider overtakes lots of vehicles using the left shoulder and the middle of the road crossing continuous lines in several times.

Pre-event situation

Dense traffic in both streets. One of the streets is a two-ways street with two lanes and the other one is a one way with two lanes.

Start of event

The rider approaches an intersection and with a very congested traffic.

Climax of event

He decides to use the opposite lane to overtake crossing a continuous line. He turns left and there is heavy traffic in the new street. The rider decides to overtake lots of vehicles using the left side and after the middle, between the two lanes, where he crosses the continuous central line several times.

Resolution of event

He reaches an intersection and then a one lane street.

**Event 17**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 12:32:44 |
| Risky Rider behaviour | Use of lane: not to obey "stop". |
| Conflict | Lane change |
| Trigger | Image (video record) |

Overview of event

The rider gets to an intersection regulated by a stop sign but he does not obey the sing even those two cars are circulating trough the other road.

Pre-event situation

The motorcyclist goes along an urban area with fluid traffic and he turns left to incorporate to a different street.

Start of event

When he gets near to the intersection he looks at the traffic ongoing.


Climax of event

He decides to do not stop and keeps riding even that two cars were circulating on that road

Resolution of event

He rides far right and gets in to lane progressively.

**Event 18**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 16:32:44 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Longitudinal control: Short distance in line.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

The rider overtakes a passenger car which circulates slow crossing a continuous line.


Pre-event situation

The rider goes along a two-way rural road.

Start of event

When the motorcyclist gets close to a vehicle he decides to overtake. The vehicle in front goes quite slowly.

Climax of event

The rider overtakes the vehicle crossing the central continuous line, even there is another vehicle coming from the opposite direction.


Resolution of event

He performs the manoeuvre and keeps going with his route

**Event 19**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 17:00:23 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The motorcyclist overtakes a passenger car and a tractor crossing a solid line in s slight curve.

Pre-event situation

The rider goes along a two-way rural road.

Start of event

He reaches a tractor followed by passenger car which are circulating slowly.


Climax of event

He decides to overtake the two vehicles crossing a continuous line.


Resolution of event

He performs the manoeuvre and continues his way.

**Event 20**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 17:05:31 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

<u>Overview of event</u>

The rider overtakes several cars using the right side gap between the vehicles and the sidewalk.

<u>Pre-event situation</u>

The rider circulates along a two-way urban road with some traffic.

<u>Start of event</u>

He reaches a queue of vehicles stopped at the lights.


<u>Climax of event</u>

He decides to overtake them using the right side of the road.


<u>Resolution of event</u>

The motorcyclist puts himself in front of everyone at the lights and keeps going with his route.

**Event 21**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 17:13:31 |
| Risky Rider behaviour | Use of lane: stop on the road. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider does not obey a stop sign at an intersection.

Pre-event situation

The rider circulates along an urban street on his own.


Start of event

He approaches an intersection regulated by a stop sign.

Climax of event

He does not obey the sign, and he does not even look to the right.


Resolution of event

He turns left, without looking and continues his way

**Event 22**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 18:09:52 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: overtake from wrong site. |
| Conflict | Lane change |
| Trigger | Image (video record) |

Overview of event

As there is heavy traffic the rider overtakes lots of vehicles using the left shoulder and the middle of the road crossing continuous lines in several times.

Pre-event situation

Dense traffic stopped in lights. One way street with two lanes.

Start of event

The rider affronts an intersection with dense traffic.

Climax of event

He decides to overtake all vehicles which are stopped at the lights using the between lanes gap.

Resolution of event

He put himself in front of all vehicles and continuing the route.

**Event 23**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 22:58:58 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider approaches a stop intersection and he does not stop, but this time there is no traffic ongoing.

<u>Pre-event situation</u>

The motorcyclist rides along a two lanes street. There is not more vehicles circulating along the street.

<u>Start of event</u>

The rider approaches to an intersection.


<u>Climax of event</u>

He does not stop at the intersection.


<u>Resolution of event</u>

He continues his route after jumping the stop sign.

**Event 24**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 06/07/2011 – 22:59:23 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

Once again, the rider does not obey a stop sign at the intersection.

Pre-event situation

The motorcyclists are riding along an urban street with no other vehicles around.

Start of event

The rider approaches to an intersection regulated by a stop sign.


Climax of event

He reduces speed but he does not stop. The rider crosses the intersection with care but he does not stop.

Resolution of event

After he crosses the intersection, the rider parks the motorbike.

**Event 25**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 07/07/2011 – 08:18:26 |
| Risky Rider behaviour | Longitudinal control: Short distance in line.<br>Use of lane: weaving.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

The rider approaches to an intersection and overtakes several vehicles invading the opposite lane, even when some cars are coming. The motorcyclist crosses the continuous lane.

Pre-event situation

The motorcyclist rides along an urban area with heavy traffic.

Start of event

When he approaches to an intersection regulated by lights he decides to overtake the cars that are going slow due the heavy traffic.

Climax of event

The rider overtakes several cars using the opposite lane end crossing the continuous line. He keeps overtaking cars even when there is traffic oncoming.

Resolution of event

He put himself in front of all vehicles and continues his way.

**Event 26**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 07/07/2011 – 08:19:33 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

When the rider sees a chance to overtake he uses the gap between the cars parked on the right and the cars circulating and he overtakes, without keeping security lateral distance. The cars are running, not stopped.

Pre-event situation

The motorcyclist goes along a two way street with two lanes. There is heavy traffic.

Start of event

He is waiting to overtake the vehicles in front and checks both sides. When he sees a gap he starts the manoeuvre.

Climax of event

The rider overtakes several running cars using the right side. He does not respect the lateral distance.

Resolution of event

He crosses the lane to put himself in the left side because he takes the third exit in the roundabout.

**Event 27**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 07/07/2011 – 08:19:55 |
| Risky Rider behaviour | Use of lane: ride far left. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

When the rider turns in to the street, there is a van stopped in the right lane. The rider has to modify his trajectory and turns left to avoid the van.

Pre-event situation

The motorcyclist turns right in a roundabout.

Start of event

After the turning he discovers a van stopped in the right lane.

Climax of event

The rider changes lane to the left lane and overtakes the van.

Resolution of event

He passes the van and continues the way.

**Event 28**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 14:46:43 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider approaches an intersection regulated by lights and overtakes two vehicles on the right.

Pre-event situation

The motorcyclist is riding along an urban area.

Start of event

When he approaches to an intersection regulated by lights, two vehicles are stopped in the right lane because they are going to turn right.

Climax of event

The rider overtakes the two vehicles using the gap between the vehicles and the sidewalk.

Resolution of event

He puts himself in front of all vehicles and continues his way.

**Event 29**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 18:39:09 |
| Risky Rider behaviour | Use of lane: ride far left.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

The rider approaches to an intersection where lots of vehicles are stopped. He decides to overtake them on the left, crossing the middle line.

Pre-event situation

Rider approaches to an intersection regulated by lights

Start of event

As there are lots of cars stopped due to the red light, the rider decides overtake them.

Climax of event

The rider overtakes several vehicles crossing the continuous central line to move forward. And when the traffic from the opposite lane moves forward to him he comes back in to lane.



Resolution of event

He comes back in to lane when he sees vehicles coming from the opposite direction.

**Event 30**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 18:40:09 |
| Risky Rider behaviour | Use of lane: ride far left. |
| Conflict | Head on<br>Rear end |
| Trigger | Image (video record) |

Overview of event

The rider tries to overtake crossing a double continuous central line despite there are cars coming from the opposite direction.

Pre-event situation

The rider turns right following a passenger car.

Start of event

After the turn, the rider gets close to the previous car.

Climax of event

He crosses the two continuous lines to overtake.

Resolution of event

He has to come back in to lane because there are cars coming from the opposite direction.

**Event 31**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 19:24:01 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: not to obey “stop”.<br>Forbidden U turn |
| Conflict | Lane change<br>Head on |
| Trigger | Image (video record) |

Overview of event

The rider wants to turn left at an intersection, even that it is forbidden. Due to the heavy traffic ha cannot turn left so he follows his way and when no car is coming from the opposite direction he performs a U-turn. And after the u-turn he does not obey a stop sign.

Pre-event situation

Heavy traffic, he is riding along a street and wants to turn left.

Start of event

He cannot turn, even that he tries weaving between some cars, due to the heavy traffic.

Climax of event

When the rider perceives that there are no cars coming he performs a u-turn and he also jumps a stop sign.

Resolution of event

Once he is heading where he wants to go since the beginning, he continues his way.

**Event 32**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 19:24:25 |
| Risky Rider behaviour | Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Other (see explanation below) |
| Trigger | Image (video record) |

Overview of event

The rider decides to overtake several vehicles using the right side. He almost crash in to a roadwork sign.

Pre-event situation

The rider circulates along a two-ways street with dense traffic

Start of event

The motorcyclist sees that the cars in front of him are stopped

Climax of event

He decides to overtake them. Despite he performs the manoeuvre slowly; he almost crashes to a sign.


Resolution of event

The rider finishes overtaking the vehicles and continues his way.

**Event 33**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 23:32:10 |
| Risky Rider behaviour | Use of lane: ride far left. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The motorcyclist rides to far left and he passes a manhole cover.

Pre-event situation

Riding trough a roundabout

Start of event

Riding trough a roundabout

Climax of event

He rides so far left that he even rides on a manhole cover.


Resolution of event

He passes the cover and continues his way.

**Event 34**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 13/07/2011 – 23:34:37 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

This event is the exact same as the event 11, even the same intersection. The rider approaches a stop intersection and he does not stop.

Pre-event situation

The motorcyclist rides along a two lanes street. There is not vehicles circulating but there are some vehicles parked in both sides of the road.

Start of event

The rider approaches to the intersection.

Climax of event

He does not stop at the intersection.


Resolution of event

He keeps going with his way.

**Event 35**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 14/07/2011 – 08:30:06 |
| Risky Rider behaviour | Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Right turn |
| Trigger | Image (video record) |

Overview of event

The rider is turning right and there is a car in front of him which is also turning right. When the car stops at the intersection regulated by a stop sign, the rider overtakes him using the right side and he does not do the stop properly.

Pre-event situation

The rider is approaching an intersection.

Start of event

When he sees that the car in front of him stops at the intersection he decides to overtake.

Climax of event

He overtakes the car and jumps the stop sign

Resolution of event

The motorcyclist continues his way along the new road.

**Event 36**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 14/07/2011 – 08:33:07 |
| Risky Rider behaviour | Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Lane change |
| Trigger | Image (video record) |

Overview of event

The rider is going through a road with heavy traffic, so he decides to overtake all vehicles using the right shoulder even when there are other roads merging from the right.

Pre-event situation

Interurban road with heavy traffic.

Start of event

The rider checks it is possible to overtake using the right side and starts the manoeuvre.

Climax of event

He overtakes lots of vehicles using the right shoulder and he keeps going even when there are cars coming from another road which merges this one.

Resolution of event

When the traffic is fluid he comes back to the lane.

**Event 37**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 14/07/2011 – 10:03:54 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: ride far left.<br>Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

Is the same location than the event 3, but this time the rider decides to overtake the vehicles which are waiting at the lights but he has to wait because a van is going in the opposite direction. Once the van passes, he overtakes crossing the continuous central line and after weaves to overtake the rest of the vehicles using the right side, between the cars and the sidewalk.

Pre-event situation

The motorcyclist goes along a two-way street

Start of event

When he approaches to the intersection he perceives some vehicles stopped at the lights

Climax of event

He decides overtake them using firstly the opposite direction lane (crossing a continuous line) and after the right side.

Resolution of event

He puts himself in the front and he continues his way.

**Event 38**

<u>Event identification</u>

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 15/07/2011 – 08:01:45 |
| Risky Rider behaviour | Not risky behaviour |
| Conflict | Lane change |
| Trigger | High front brake pressure (abrupt change)<br>High rear brake pressure (abrupt change)<br>Image (video record) |

<u>Overview of event</u>

During the negotiating of a roundabout with two lanes the rider has to brake and let a truck pass because the goes in to his trajectory.

<u>Pre-event situation</u>

The rider approaches to a roundabout intersection.

<u>Start of event</u>

He puts himself in to the left lane because his going to take the second exit.

Climax of event

The truck invades the rider's lane and he has to brake to avoid a collision.

Resolution of event

He continues his way behind the truck.

**Event 39**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 15/07/2011 – 08:12:27 |
| Risky Rider behaviour | Use of lane: weaving.<br>Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Rear end |
| Trigger | Image (video record) |

Overview of event

The rider overtakes lots of vehicles on the motorway and in the exit of it using the right shoulder.

Pre-event situation

The motorcyclist rides along a motorway with dense traffic

Start of event

As the vehicles circulate slower than him he starts overtaking

Climax of event

He overtakes some vehicles using the right shoulder, the he comes back into lane, as the previous vehicle is slow he starts overtaking again and so on.

Resolution of event

He rides like this along the motorway, the exit access, and the following street, and the events ends when the rider turns in to a street with fluid traffic.

**Event 40**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 17/09/2011 – 08:14:15 |
| Risky Rider behaviour | Curve: Extreme route in lane.<br>Use of lane: not to obey “way indications”. |
| Conflict | Left turn. |
| Trigger | Image (video record) |

Overview of event

The rider approaches to an intersection with the aim of turning left. Although there is a lane for turning left and a lane for turning right, the rider decides to choose the right one although he is going to turn left (the reason is not to make queue behind other vehicles in the left lane). The problem (conflict) appears when the motorcycle and a passenger car are turning left at the same time in the same lane.

Pre-event situation

The rider approaches to an intersection with two lanes in the same direction (one for turning left and on for turning right). The traffic is heavy in the left lane.

Start of event

The event starts when the rider decides turning left and he is riding in the right lane.

Climax of event

The climax of the event is when he turns left from the right lane and turns at the same time than other vehicle which was correctly in the left lane.

Resolution of event

Finally, both vehicles finish turning left and the rider overtakes the vehicle (along the right side of the vehicle).

**Event 41**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 17/09/2011 – 08:15:06 |
| Risky Rider behaviour | Longitudinal control: Brake abruptly with conflict.<br>Use of lane: overtake from wrong site. |
| Conflict | Left turn |
| Trigger | High front brake pressure (abrupt change)<br>High rear brake pressure (abrupt change)<br>Image (video record) |

Overview of event

The rider arrives at a roundabout. In this place, there is already a heavy vehicle (lorry) which is turning around the roundabout. The rider decides to turn also along the roundabout, but the rider realized that the heavy vehicle is getting close to the centre of the roundabout and, therefore, avoiding the transit of vehicles behind it. The rider has to brake to avoid the rear-end or side-to-side collision.

Pre-event situation

The rider arrives at an urban roundabout under fluid traffic conditions.

Start of event

Before the rider goes inside the roundabout, another large heavy vehicle (lorry) is driving inside the roundabout.

Climax of event

When the rider is riding into the roundabout, the rider realized the lorry is getting closer from the outside of the roundabout to the centre, so the rider has to brake abruptly.

Resolution of event

The rider has to wait the lorry finish turning into the roundabout. Rider achieves the objective of riding successfully into the roundabout.

**Event 42**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 12:42:11 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider arrives to a “+” urban intersection regulated by a “STOP” sign. The rider is going to cross the “STOP” road marking without stopping.

Pre-event situation

The rider arrives to a “+” urban intersection regulated by a “STOP” sign. There is a passenger car in front of him (in the same direction) just obeying the same “STOP” sign.

Start of event

Just when the rider arrives to the road marking (STOP marking), the passenger car has just crossed this marking.

Climax of event

Although the rider has to stop, he does not obey this regulation and cross the intersection without stopping.


Resolution of event

The rider crosses the intersection without any conflict.

**Event 43**

Event identification

| | |
| --- | --- |
| Participant number | 6 |
| Date & Time | 19/09/2011 – 12:44:26 |
| Risky Rider behaviour | Use of lane: ride far left and cross solid line. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

In a heavy traffic urban road, the rider overtakes several vehicles (motorcycles and passenger cars) at the same time. The problem is this rider does the overtaking in a wrong way because he crosses the solid line.

<u>Pre-event situation</u>

Rider is in an urban street with dense traffic.

<u>Start of event</u>

The rider decides to undertake due to, probably, be in a hurry.

<u>Climax of event</u>

The overtaking action is carried out when there is a solid line. The rider crosses it.


<u>Resolution of event</u>

The overtaking action finishes just before a traffic light. The rider returns to his lane.

**Event 44**

<u>Event identification</u>

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 12:51:51 |
| Risky Rider behaviour | Longitudinal control: Ride fast with conflict.<br>Use of lane: overtake from wrong site. |
| Conflict | Side |
| Trigger | High throttle angle (abrupt change)<br>Image (video record) |

<u>Overview of event</u>

Riding is into a very heavy traffic street (one way street with one lane). The rider overtakes several vehicles wrongly, because he uses the small space between the vehicles travelling in the one lane street and the vehicles parked in the left side of the street.

<u>Pre-event situation</u>

The rider arrives to a crowded street. Taking into account the size of the motorcycle, he decides to overtake positions although legally, it is not possible because there is not enough space (only one lane).

Start of event

The rider starts overtaking. The first vehicle to be undertaken is a van, whose driver advices the rider about the danger of this action.


Climax of event

After having undertaken several vehicles in a wrong way, the rider is going to cross a road marking (islet) with the aim of gaining better positions in the lane.


Resolution of event

Finally, the rider arrives at the point when he can turn left legally.

**Event 45**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 12:52:14 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | High throttle angle (abrupt change)<br>Image (video record) |

Overview of event

In a traffic urban road, the rider overtakes one vehicle (passenger car). The problem is this rider does the overtaking in a wrong way because he crosses the solid line.

Pre-event situation

Rider is in an urban street, with fluid traffic.

Start of event

The rider is just behind the passenger car, and the rider seems to be in a hurry.

Climax of event

The rider decides to undertake the passenger car, although it is forbidden due to the existing solid line.

Resolution of event

Although there is not a conflict, the overtaking has been done crossing the solid line, and the rider is again into his lane.

**Event 46**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 12:53:17 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | High throttle angle (abrupt change)<br>Image (video record) |

Overview of event

In a traffic urban road, the rider overtakes one vehicle (passenger car). The problem is this rider does the overtaking in a wrong way because he crosses the solid line.

Pre-event situation

Rider is in an urban street, with fluid traffic.

Start of event

The rider is just behind the passenger car, and the rider seems to be in a hurry. Nevertheless, he can see several vehicles are in the opposite way.

Climax of event

The rider decides to undertake the passenger car, although it is forbidden due to the existing solid line.

Resolution of event

Although there is not a conflict, the overtaking has been done crossing the solid line, and the rider is again into his lane.

**Event 47**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 12:53:49 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Longitudinal control: Brake abruptly with conflict.<br>Use of lane: ride far left.<br>Use of lane: overtake from wrong site.<br>Use of lane: not to obey “give the way”. |
| Conflict | Front-side |
| Trigger | High front brake pressure (abrupt change)<br>High rear brake pressure (abrupt change)<br>Image (video record) |

Overview of event

Riding arrives to a roundabout (with exit and access islets). Although there is a heavy vehicle in front of him, he tries to gain positions using the left shoulder. Once he arrives to the “give the way” line together the roundabout, he goes on riding and he is close to collide with other vehicle which is into the roundabout.

Pre-event situation

The rider arrives to a roundabout (with exit and access islets).

Start of event

Although there is a heavy vehicle in front of him, he tries to gain positions using the left shoulder and crossing the sold line in a curve area.


Climax of event

The rider arrives at the “give the way” road marking and he does not obey it. He goes on travelling and he has to brake abruptly before crashing against other vehicle.

<u>Resolution of event</u>

Finally, he exits from the roundabout and goes on with his travel plans.

**Event 48**

<u>Event identification</u>

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:24:50 |
| Risky Rider behaviour | Use of lane: weaving. |
| Conflict | No conflict |
| Trigger | High steering angle (abrupt change)<br>Image (video record) |

<u>Overview of event</u>

Riding is into a very heavy traffic street (one way street with two lanes). The rider overtakes several vehicles wrongly, because he uses the small space between the vehicles travelling in the one lane street and the vehicles parked in the left side of the street; or the space between the two lanes.

<u>Pre-event situation</u>

The rider arrives to a crowded street.

<u>Start of event</u>

Taking into account the size of the motorcycle, he decides to overtake positions using the space between vehicles in the left lane and vehicles parked.

<u>Climax of event</u>

The climax of the event is when the rider starts weaving among vehicles, with the respective risk associated.

Resolution of event

Finally, the vehicles arrives at a point in which he is not able to advance further, so he has to wait until the rest of vehicles in front of him start moving.

**Event 49**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:25:03 |
| Risky Rider behaviour | Longitudinal control: Ride fast with conflict.<br>Use of lane: overtake from wrong site. |
| Conflict | Side-side<br>Vulnerable road user |
| Trigger | Image (video record) |

Overview of event

Riding is into a very heavy traffic street (one way street with two lanes). The rider overtakes is travelling together several motorcycles. The rider decides to overtake between two motorcycles very close to them.

Pre-event situation

The rider is travelling in a very heavy traffic street, plenty of motorcycles.

Start of event

The rider moves closer to other two motorcycles in front of him.

Climax of event

The rider decides overtaking them along the space both of them have.

Resolution of event

The rider goes on travelling in this crowded street.

**Event 50**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:26:53 |
| Risky Rider behaviour | Longitudinal control: Accelerate fast.<br>Longitudinal control: Brake abruptly with conflict.<br>Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Right turn<br>Side-side |
| Trigger | Image (video record) |

Overview of event

Riding arrives to a roundabout (with exit and access islets). Although there is a passenger car in front of him, he tries to gain positions using the right shoulder just in the own roundabout with the aim of existing from the roundabout as soon as possible.

Pre-event situation

The rider arrives to a roundabout (with exit and access islets).

Start of event

Although there is a passenger car in front of him, he tries to gain positions using the right shoulder.


Climax of event

The rider arrives at the "give the way" and do not take into account the manoeuvre from the other passenger car. The rider goes along the right shoulder and goes towards the first exit (very close to the passenger car which is going correctly along the roundabout).

Resolution of event

After reaching the exit, the rider goes on with his travel plans.

**Event 51**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:29:11 |
| Risky Rider behaviour | Use of lane: not to obey "traffic calming device". |
| Conflict | Single vehicle |
| Trigger | Image (video record) |

Overview of event

Riding is travelling in an urban area. This area (straight sector) has a "traffic calming device" with the aim of reducing travelling speed. The rider finds this device in his route.

Pre-event situation

Normal riding in an urban area. It is possible this area is crowded of schools, universities,…because there are traffic calming devices.

Start of event

The rider sees the a traffic calming device, and brakes.

Climax of event

Instead of crossing the traffic calming device in a normal way, the rider detects an area where there is a space when there is not "traffic calming device". The rider decides to go through this space without the traffic calming device (therefore a high steering angle change exists).

Resolution of event

The rider, after crossing the traffic calming device, goes on with a slower travelling speed.

**Event 52**

Event identification

| | |
| --- | --- |
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:54:58 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

Riding arrives to an access road (to a highway). Although there is a van in front of him, he tries to gain positions using the left shoulder. Once he arrives to the integration of this “access lane” and the “highway”, the rider crosses illegally the islet (road marked) to access quickly to the highway.

Pre-event situation

Rider and van are travelling in an access road towards a highway.

Start of event

Both vehicles arrives very close to the highway.

Climax of event

The rider tries to overtake the van trespassing the road marking (islet) and accessing as soon as possible to the highway.

Resolution of event

The rider accesses to the highway after circulating across the islet and after overtaking illegally the van.

**Event 53**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:58:01 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

In a traffic urban road, the rider overtakes one vehicle (passenger car). The problem is this rider does the overtaking in a wrong way because he crosses the solid line.

Pre-event situation

Rider is in an urban street, with fluid traffic.

Start of event

The rider is just behind the passenger car, and the rider seems to be in a hurry. He can see there are not any vehicles in the opposite way (although the manoeuvre is illegal because there is a solid line).

Climax of event

The rider decides to undertake the passenger car, although it is forbidden due to the existing solid line.

Resolution of event

Although there is not a conflict, the overtaking has been done crossing the solid line, and the rider is again into his lane.

**Event 54**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 13:58:24 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider arrives to a “T” urban intersection regulated by a “STOP” sign. The rider is going to cross the “STOP” road marking without stopping.

Pre-event situation

The rider arrives to a “T” urban intersection regulated by a “STOP” sign.

Start of event

When the rider arrives to the road marking (STOP marking), it seems no other vehicle are around.


Climax of event

Although the rider has to stop, he does not obey this regulation and cross the intersection without stopping.


Resolution of event

The rider crosses the intersection without any conflict.

**Event 55**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 19/09/2011 – 14:00:16 |
| Risky Rider behaviour | Use of lane: not to obey “stop”. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider arrives to a “+” urban intersection regulated by a “STOP” sign. The rider is going to cross the “STOP” road marking without stopping.

Pre-event situation

The rider arrives to a “+” urban intersection regulated by a “STOP” sign.

Start of event

When the rider arrives to the road marking (STOP marking), it seems no other vehicle are around.

Climax of event

Although the rider has to stop, he does not obey this regulation and cross the intersection without stopping (just behind the passenger car that has just crossed this intersection).

Resolution of event

The rider crosses the intersection without any conflict.

**Event 56**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 26/09/2011 – 08:51:14 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | Head on. |
| Trigger | Image (video record). |

Overview of event

Riding is into a very heavy traffic street (one lane for each way). The rider overtakes several vehicles riskily. Although with broken line existing is possible to overtake them, the problem existing is due to the high quantity of vehicles in queue and the possibility of having a head-on accident with a vehicle in the opposite lane.

Pre-event situation

The rider arrives to a crowded street.

Start of event

The rider starts overtaking. The line between the lanes is a broken line, so it is possible to overtake but there are not enough space between all the stopped vehicles (so the motorcycle is not able to access to the space between vehicles).

Climax of event

After having undertaken several vehicles in a risky way, the rider can see how a vehicle is approaching from the opposite way, so the rider comes back to its lane (into a space between two vehicles).


<u>Resolution of event</u>

The rider stops waiting for resumption of the traffic.

**Event 57**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 26/09/2011 – 08:52:45 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | Head on. |
| Trigger | Image (video record). |

Overview of event

Riding is into a very heavy traffic street (one lane for each way). The rider overtakes several vehicles riskily. Although with broken line existing is possible to overtake them, the problem existing is due to the high quantity of vehicles in queue and the possibility of having a head-on accident with a vehicle in the opposite lane.

Pre-event situation

The rider arrives to a crowded street.

Start of event

The rider starts overtaking. The line between the lanes is a broken line, so it is possible to overtake but it can be dangerous to move among moving vehicles.

<u>Climax of event</u>

After having undertaken several vehicles in a risky way, the rider can see how a vehicle (another motorcycle) is approaching from the opposite way, so the rider comes back to its lane.

<u>Resolution of event</u>

The rider goes on in its lane and reduces the travel speed due to a “traffic calming device”.

**Event 58**

<u>Event identification</u>

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 26/09/2011 – 08:53:59 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | Head on. |
| Trigger | Image (video record). |

Overview of event

Riding is into a very heavy traffic street (one lane for each way). The rider overtakes several moving vehicles in a risk way because he crosses the solid line. During this multiple overtaking, he finds several vehicles opposite to him moving towards him.

Pre-event situation

Rider is in an urban street (two directions), with dense traffic.

Start of event

The rider is just behind a passenger car, and the rider seems no to be ready to wait and circulate after this passenger car (although there is solid line).

Climax of event

The rider decides to undertake firstly the passenger car, and then, the rest of vehicles that he finds in the same line. During this multiple undertaking, the rider finds a motorcycle which is coming towards him in the opposite lane.

Resolution of event

The rider has been travelling in the opposite lane while he has been undertaking, until he finds a passenger car coming towards him in the opposite lane. This is the reason, the rider has to go inside the initial (and correct) lane, just to avoid a head-on collision. The rider waits in queue until vehicles start again travelling.

**Event 59**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 26/09/2011 – 08:59:47 |
| Risky Rider behaviour | Longitudinal control: Accelerate fast.<br>Longitudinal control: Brake abruptly with conflict.<br>Use of lane: ride far right.<br>Use of lane: overtake from wrong site. |
| Conflict | Right turn<br>Side-side |
| Trigger | Image (video record) |

Overview of event

Riding arrives to a roundabout (with exit and access islets). Although there is heavy vehicle and other passenger car in front of him, he tries to gain positions using the right shoulder just in the own roundabout with the aim of existing from the roundabout as soon as possible.

Pre-event situation

The rider arrives to a roundabout (with exit and access islets).

Start of event

Although there is a heavy vehicle and passenger car in front of him, he tries to gain positions using the right shoulder.

Climax of event

The rider arrives at the “give the way” and do not take into account the manoeuvre from the other passenger car (just on its left). The rider goes along the right shoulder and goes towards the first exit (very close to the passenger car which is going correctly along the roundabout).

Resolution of event

After reaching the exit, the rider goes on with his travel plans.

**Event 60**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 26/09/2011 – 12:13:02 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

Riding is into street (one lane for each way divided with a solid line). The rider finds an urban bus and after riding after it, he decides to overtake it crossing the solid line.

Pre-event situation

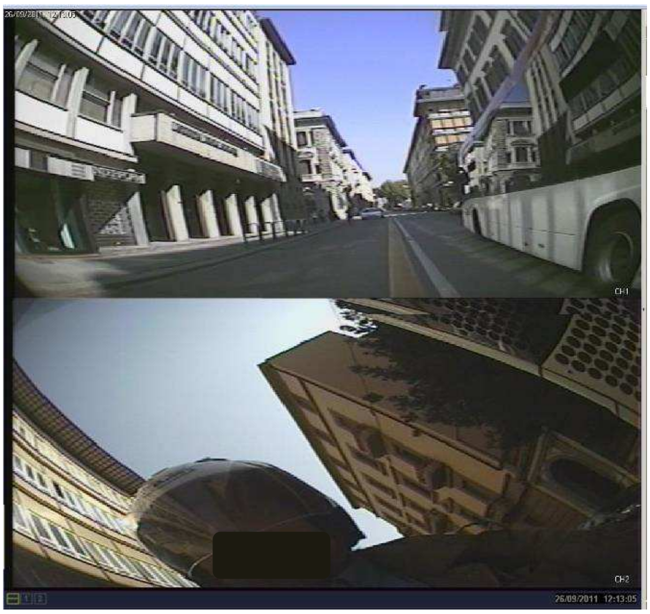
Rider is in an urban street (two directions), with fluid traffic. Lanes are divided by a solid lane.

Start of event

The rider is just behind an urban coach, and the rider does not seem to wait behind the bus.

Climax of event

The rider decides to undertake the bus, although there is a solid line dividing the two lanes.



Resolution of event

The rider goes on riding in the correct (initial) lane.

**Event 61**

Event identification

| | |
| --- | --- |
| Participant number | 6 |
| Date & Time | 26/09/2011 – 12:36:31 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider is just behind a passenger car in a double way urban street (two lanes). Both lanes are divided by a solid line. The rider is going to overtake the passenger car.

Pre-event situation

Rider is in an urban street (two directions), with fluid traffic.

Start of event

The rider is just behind a passenger car, and the rider seems no to wait and circulate after this passenger car (although there is solid line).

Climax of event

The rider decides to undertake the passenger car. Although there is not a conflict (no vehicles come in the opposite lane), this is considered as a risky action.

Resolution of event

The rider goes on riding in the correct (initial) lane.

**Event 62**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 27/09/2011 – 07:51:13 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

Riding is into street (one lane for each way divided with a solid line). The rider finds an urban bus and after riding after it, he decides to overtake it crossing the solid line.

Pre-event situation

Rider is in an urban street (two directions), with fluid traffic. Lanes are divided by a solid lane.

Start of event

The rider is just behind an urban coach, and the rider does not seem to wait behind the bus.

Climax of event

The rider decides to undertake the bus, although there is a solid line dividing the two lanes.

Resolution of event

The rider goes on riding in the correct (initial) lane.

**Event 63**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 27/09/2011 – 14:11:38 |
| Risky Rider behaviour | Curve: Cross solid line.<br>Longitudinal control: Short distance in line.<br>Longitudinal control: Accelerate fast.<br>Use of lane: overtake from wrong site. |
| Conflict | Head on |
| Trigger | Image (video record) |

Overview of event

Riding is into a very heavy traffic street (one lane for each way). The rider overtakes several moving vehicles in a risk way because he crosses the solid line. At the end of this multiple overtaking, he finds a vehicle opposite to him moving towards him in a curve sector.

Pre-event situation

Rider is in an urban street (two directions), with dense traffic.

Start of event

The rider is just behind a passenger car, and the rider seems no to wait circulating after this passenger car (although there is solid line).


Climax of event

The rider decides to undertake firstly the passenger car, and then, the rest of vehicles that he finds in the same line. At the end of this multiple undertaking, the rider finds a passenger car which is coming towards him in the opposite lane.

Resolution of event

The rider has been travelling in the opposite lane while he has been undertaking several vehicles, until he finds a passenger car coming towards him in the opposite lane. This is the reason, the rider has to go inside the initial (and correct) lane, just to avoid a head-on collision. The rider waits in queue until vehicles start again travelling.

**Event 64**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 05/10/2011 – 14:54:40 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | Head on. |
| Trigger | Image (video record). |

Overview of event

Rider arrives to a traffic light and finds the respective queue. The rider decides to overtake all the stopped vehicles and reach first positions (just close to the line of traffic light). The problem (conflict) is that the rider overtakes these vehicles using the opposite lane (lanes are divided by a solid lane) and at the end of this overtaking, the rider finds a motorcycle coming towards him.

Pre-event situation

Rider is in an urban street (two directions), with fluid traffic. Lanes are divided by a solid lane. The rider arrives at the queue just before a traffic light.

Start of event

The rider decides to overtake all the stopped vehicles and reach first positions (just close to the line of traffic light).

Climax of event

The problem (conflict) is that the rider overtakes these vehicles using the opposite lane (lanes are divided by a solid lane) and at the end of this overtaking, the rider finds a motorcycle coming towards him.

Resolution of event

The rider waits in the traffic light line until the traffic flow starts again.

**Event 65**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 05/10/2011 – 14:56:28 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider is travelling in an urban road (two lanes, one for each direction). The rider finds a passenger car in front of him travelling in the same direction. The rider decides to overtake it crossing, not only the solid line, even an islet (road marking).

Pre-event situation

Rider is in an urban street (two directions), with fluid traffic. Lanes are divided by a solid lane. The rider is travelling behind a passenger car.

Start of event

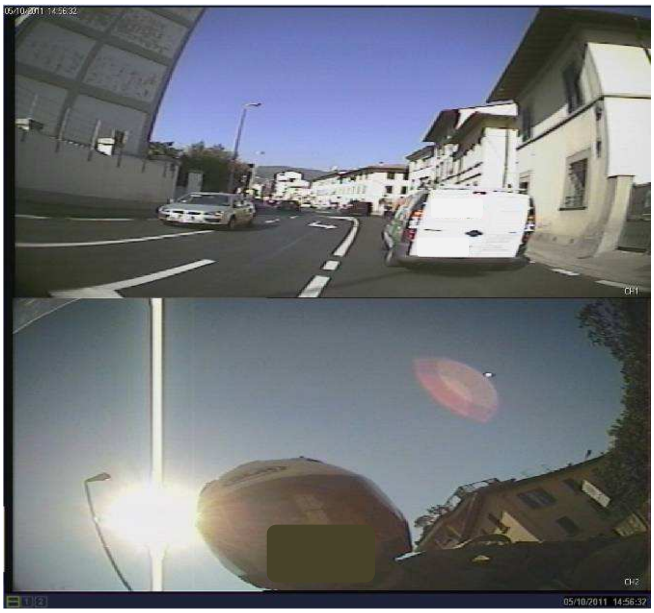
The rider decides to overtake the passenger car.

Climax of event

The overtaking is going to be carried out crossing, not only the solid line, even an islet (road marking).

Resolution of event

The rider goes on into the lane, but he finds another vehicle in front of him (which will probably to undertake later).



**Event 66**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 10/10/2011 – 14:03:10 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

The rider is travelling in an urban road (one lane for each direction). Although the traffic is fluid, the rider decides to overtake the vehicles which are in front of them circulating in the same direction (these overtaking are carried out crossing the broken line). After these overtaking, the rider goes on straight, crossing even an islet (road marking).

Pre-event situation

The rider is travelling in an urban road (one lane for each direction).

Start of event

The rider finds vehicles (in the same direction) which are travelling.

Climax of event

The rider decides to overtake these vehicles (in a road sector with broken line). During this overtaking, the rider is travelling in the opposite lane. After overtaking these vehicles, the rider crosses illegally an islet (road marking).

Resolution of event

The rider finishes this risky manoeuvre and goes on riding.

**Event 67**

Event identification

| | |
|---|---|
| Participant number | 6 |
| Date & Time | 10/10/2011 – 17:54:59 |
| Risky Rider behaviour | Use of lane: overtake from wrong site. |
| Conflict | No conflict |
| Trigger | Image (video record) |

Overview of event

In a one-way interurban road (highway), the rider is into a traffic jam (probably due to the transition from a highway to a conventional road). The road has two lanes (for each direction) and a wide shoulder. The rider decides to overtake vehicles using the shoulder (illegal manoeuvre).

Pre-event situation

Rider is travelling in a highway (or similar: two wide lanes and wide shoulder and median). The traffic is very dense, such a pit that there is traffic jam.

Start of event

The rider decides to overtake (taking advance of the size of the motorcyclist).

Climax of event

The rider decides to use the shoulder to overtake the highest number of vehicles making the queue under the traffic jam.

Resolution of event

When the highway finishes (the traffic jam was due to the transition from the highway to conventional road), the rider comes back to its lane leaving the use of the shoulder.

### *Failure Mode and Effects Analysis.*

A FMEA analysis can be described as a systemized group of activities intended to: recognize and evaluate the potential failure of a product/process and its effects, identify actions which could eliminate or reduce the chance of the potential failure occurring, and document the process. It is complementary to the process of defining what a design or process must do to satisfy the customer. In the case of road safety, a FMEA analysis will help to understand the motivations of the onset of the dangerous situations the riders have had during their action.

The results of the FMEA analysis over three riders (Italian riders 02, 04 and 06) will be shown as follows, detailing a series of variables: “Failure Mode”; “Effects of Failure”, “Causes of Failure” and “Recommendations Actions and Good Practices”. The aim of showing these variables is to summarize the “failure mode and the effects of these failures” as well as to define possible countermeasures that will help to avoid the accident or minimize the consequences.

The interpretation of the variables that are going to take part in this FMEA analysis is as follows:

.- Number of failure: This is a sequential number to be used with the aim of identifying each failure. The order of analysing each failure is based on the number of times each failure mode appears, so the first failure mode analysed is supposed to be the most frequent one.

.- Failure Mode: This variable will mention the mode each failure has been. The possible values are:

- Longitudinal control: Brake abruptly // Short distance in line // Ride fast // Accelerate fast.
- Use of lane: Overtake from wrong site // Weaving // Not to obey “stop” // Ride far left // Ride far right // Stop on the road // Not to obey “give the way” // Not to obey “traffic calming device” // Forbidden U turn.
- Curve: Extreme route in lane // Cross solid line.
- No risky behaviour (there can de situations in which there has been a conflict although the rider has not have any risky behaviour).

.- Effects of Failure: This field will detail the effects of each failure. The possible values are:

- Conflict: Left turn // Right turn // Head on // Lane change // Rear end // Side-side // Front-side.
- Conflict: Single vehicle (just in case, the conflict only involves the own motorcycle).
- Conflict: Vulnerable road user (just in case, the conflict involves – apart of the own motorcycle – other users as vulnerable ones – pedestrians and cyclists).
- No conflict (Not all the risky behaviours are going to end in a conflict, therefore this value must be in the options of this variable).

.- Causes of Failure: The causes of this failure will be explained here. Most of them will be related to human behaviour because the objective of the analyses carried out over the riders was to study rider behaviour.

.- Number of failures: Out of 67 moments in which these three Italian riders are riding in a risky way or there is a conflict, through this variable it will be possible to quantify how many times each failure appeared during the riding action.

.- Recommendations Actions and Good Practices: Focusing on avoiding “causes of failure”, in this variable effective countermeasures (recommendations and good practices) will be detailed. The source for detailing these recommendations are the European Projects ROSA (www.rosaproject.eu/) and eSUM (www.esum.eu/), which were carried out during 2009 and 2010 and were focussed on giving effective good practices related to Road Safety for Motorcyclists (in this chapter, only effective good practices will be detailed, although in ROSA project and eSUM project, many potential effective good practice can be consulted). In this way, synergies coming from European Projects are taken into account.

.- Number of failure: 1.

.- Failure Mode:

- Use of lane: Overtake from wrong site.

.- Effects of Failure:

- Conflict: Left turn (1 time) // Right turn (2 times) // Head on (10 times) // Lane change (4 times) // Rear end (1 time) // Side-side (4 times) // Front-side (1 time).
- Conflict: Single vehicle (1 time).
- Conflict: Vulnerable road user (1 time).
- No conflict (19 times).

.- Causes of Failure: During the analysis over the three riders, this has been the most common failure done by the riders. Although most of times, there have not been any conflict, it is worth to know why this action is carried out by the riders. Based on images from video recording, the causes of failure were mainly the lack of waiting behind other road users along the lane.

.- Number of failures: In 42 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of infrastructure (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=2&mimetype=application/pdf):
  - "Good Practice 1.3.2.1.A.1: Moving mopeds from cycle lanes onto the carriageway".
  - "Good Practice 1.3.2.1.A.2: Motorcycles in Bus lanes v2".
  - "Good Practice 1.3.2.1.A.3: Motorcycle Only Lane, Route R2 Malaysia".
- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf and http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=7&mimetype=application/pdf):
  - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
  - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
  - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
  - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
  - "Good Practice 3.3.2.1.A.2: Safety Cameras in London".
  - "Good Practice 3.3.2.1.A.3: Effectiveness of red light cameras on the right-angle crash involvement of motorcycles".
  - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
  - "Good Practice 3.3.3.1.A.2: Red Light Jumper Cameras".
  - "Good Practice 6.2.1.A.3: Shiny Side Up Partnership".
  - "Good Practice 6.3.1.A.1: Kill Spills BMF/IAM (Campaign, 2003)".
- From the point of view of the other road users (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
  - Good Practice 3.6.1.A.1: Car drivers' attitudes in relation to motorcyclists.

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.- Number of failure: 2.

.- Failure Mode:

- Use of lane: Weaving.

.- Effects of Failure:

- Conflict: Head on (1 time) // Lane change (1 time) // Rear end (1 time).
- No conflict (11 times).

.- Causes of Failure: This failure uses to happen in traffic jams, when the rest of vehicles are stopped and the rider do not want to wait behind the rest of vehicles and decide to weave along them with the aim of moving forward.

.- Number of failures: In 14 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of infrastructure (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=2&mimetype=application/pdf):
    - "Good Practice 1.3.2.1.A.1: Moving mopeds from cycle lanes onto the carriageway".
    - "Good Practice 1.3.2.1.A.2: Motorcycles in Bus lanes v2".
    - "Good Practice 1.3.2.1.A.3: Motorcycle Only Lane, Route R2 Malaysia".
- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf and http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=7&mimetype=application/pdf):
    - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - "Good Practice 3.3.2.1.A.2: Safety Cameras in London".
    - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
    - "Good Practice 6.2.1.A.3: Shiny Side Up Partnership".
    - "Good Practice 6.3.1.A.1: Kill Spills BMF/IAM (Campaign, 2003)".
- From the point of view of the other road users (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - Good Practice 3.6.1.A.1: Car drivers' attitudes in relation to motorcyclists.

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.- Number of failure: 3.

.- Failure Mode:

- Use of lane: Ride far right.

.- Effects of Failure:

- Conflict: Right turn (1 time) // Lane change (2 times) // Rear end (1 time) // Side-side (2 times).
- Conflict: Single vehicle (1 time).
- No conflict (3 times).

.- Causes of Failure: This failure uses to happen in traffic jams, when the rest of vehicles are stopped and the rider do not want to wait behind the rest of vehicles and decide to move forward them using the right shoulder of the road.

.- Number of failures: In 10 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf and http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=7&mimetype=application/pdf):
  - “Good Practice 3.2.1.A.1: Perception of risk in motorcyclists”.
  - “Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists”.
  - “Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders”.
  - “Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers”.
  - “Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course”.
  - “Good Practice 6.3.1.A.1: Kill Spills BMF/IAM (Campaign, 2003)”.

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.- Number of failure: 4.

.- Failure Mode:

- Longitudinal control: Short distance in line.

.- Effects of Failure:

- No conflict (9 times).

.- Causes of Failure: This behaviour is very common for riders specially in urban areas with dense traffic. Instead of keeping a constant speed, the rider tries to overtake the highest number of vehicles he can and this means the rider has to be firstly very close to the other vehicle.

.- Number of failures: In 9 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf and http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=7&mimetype=application/pdf):
  - “Good Practice 3.2.1.A.1: Perception of risk in motorcyclists”.
  - “Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists”.
  - “Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders”.
  - “Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers”.
  - “Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course”.
  - “Good Practice 6.3.1.A.1: Kill Spills BMF/IAM (Campaign, 2003)”.
  - “Good Practice 6.1.1.A.3: The Motorcycle Training Programme”.

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.- Number of failure: 5.

.- Failure Mode:

- Use of lane: Not to obey “stop”.

.- Effects of Failure:

- Conflict: Head on (1 time) // Lane change (1 time).
- No conflict (7 times).

.- Causes of Failure: Taking advantage of the high power of motorcycles and the easiness for doing any manoeuvre, when the rider approaches to an intersection (STOP line), the rider does not obey the STOP in many situations (especially when he/she "thinks" there are not any vehicle coming to him/her).

.- Number of failures: In 9 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
  - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
  - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
  - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
  - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
  - "Good Practice 3.3.2.1.A.2: Safety Cameras in London".
  - "Good Practice 3.3.2.1.A.3: Effectiveness of red light cameras on the right-angle crash involvement of motorcycles".
  - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
  - "Good Practice 3.3.3.1.A.2: Red Light Jumper Cameras".
  - "Good Practice 6.2.1.A.3: Shiny Side Up Partnership".
  - "Good Practice 6.3.1.A.1: Kill Spills BMF/IAM (Campaign, 2003)".

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.- Number of failure: 6.

.- Failure Mode:

- Use of lane: Ride far left.

.- Effects of Failure:

- Conflict: Head on (3 times) // Lane change (2 times) // Front-side (1 time).
- No conflict (3 times).

.- Causes of Failure: This failure uses to happen in traffic jams, when the rest of vehicles are stopped and the rider do not want to wait behind the rest of vehicles and decide to move forward them using the left shoulder of the road or using the short space between the moving vehicles and the parked ones.

.- Number of failures: In 9 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of infrastructure (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=2&mimetype=application/pdf):
  - "Good Practice 1.3.2.1.A.1: Moving mopeds from cycle lanes onto the carriageway".
  - "Good Practice 1.3.2.1.A.2: Motorcycles in Bus lanes v2".
  - "Good Practice 1.3.2.1.A.3: Motorcycle Only Lane, Route R2 Malaysia".
- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
  - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
  - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".

  - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
  - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
  - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
- From the point of view of the other road users (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
  - Good Practice 3.6.1.A.1: Car drivers' attitudes in relation to motorcyclists.

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.- Number of failure: 7.

.- Failure Mode:

- Curve: Cross solid line.

.- Effects of Failure:

- Conflict: Head on (3 times).
- No conflict (5 times).

.- Causes of Failure: Thinking the rider he/she is able to have a wider visual field, when the rider takes a bend, he/she rides very close to the opposite lane (probably to shorten the distance), and in some cases the rider even crosses the solid line.

.- Number of failures: In 8 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of infrastructure (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=2&mimetype=application/pdf):
  - "Good Practice 1.3.2.1.A.1: Moving mopeds from cycle lanes onto the carriageway".
  - "Good Practice 1.3.2.1.A.2: Motorcycles in Bus lanes v2".
  - "Good Practice 1.3.2.1.A.3: Motorcycle Only Lane, Route R2 Malaysia".
- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
  - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
  - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
  - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
  - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
  - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
- From the point of view of the other road users (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
  - Good Practice 3.6.1.A.1: Car drivers' attitudes in relation to motorcyclists.

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.- Number of failure: 8.

.- Failure Mode:

- Longitudinal control: Brake abruptly.

.- Effects of Failure:

- Conflict: Right turn (1 time) // Side-side (1 time).

- No conflict: (3 times).

.- Causes of Failure: This behaviour is very common for riders specially in urban areas with dense traffic. Instead of keeping a constant speed, the rider tries to overtake the highest number of vehicles he can and this means the rider has to be firstly very close to the other vehicle, and if the traffic suddenly stops, the rider has to brake abruptly.

.- Number of failures: In 5 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".

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.- Number of failure: 9.

.- Failure Mode:

- Curve: Extreme route in lane.

.- Effects of Failure:

- Conflict: Left turn (2 times).
- No conflict (1 time).

.- Causes of Failure: Similar to the failure mode "" Curve: Cross soli lane", in this situation the rider takes a bend very close to the opposite lane for shorting the distance.

.- Number of failures: In 3 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".

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.- Number of failure: 10.

.- Failure Mode:

- Longitudinal control: Accelerate fast.

.- Effects of Failure:

- Conflict: Side-side (2 times).
- No conflict (1 time).

.- Causes of Failure: This behaviour is very common for riders specially in urban areas with dense traffic. Instead of keeping a constant speed, the rider tries to overtake the highest number of vehicles he can and this means the rider has to accelerate very fast in some moments and to be under a high speed condition.

.- Number of failures: In 3 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - o "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - o "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - o "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - o "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - o "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".

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.- Number of failure: 11.

.- Failure Mode:

- Use of lane: Not to obey "traffic calming devices".

.- Effects of Failure:

- Conflict: Left turn (2 times).
- No conflict (1 time).

.- Causes of Failure: This behaviour is very common for riders specially in urban areas in which it is necessary to moderate the traffic speed. These devices are very uncomfortable for riders, but they are also necessary to moderate speed for PTW. With the aim of feeling this device along the motorcycle, the rider decides to avoid these devices (using shoulders, for instance).

.- Number of failures: In 3 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - o "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - o "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - o "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - o "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - o "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".

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.- Number of failure: 12.

.- Failure Mode:

- Use of lane: Not to obey "give the way".

.- Effects of Failure:

- Conflict: Left turn (1 time) // Front-side (1 time).

.- Causes of Failure: Taking advantage of the high power of motorcycles and the easiness for doing any manoeuvre, when the rider approaches to an intersection (GIVE the way), the rider does not obey the sign and even when there is another vehicle coming, the rider decides to go on instead of giving the way.

.- Number of failures: In 2 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - "Good Practice 3.3.2.1.A.2: Safety Cameras in London".
    - "Good Practice 3.3.2.1.A.3: Effectiveness of red light cameras on the right-angle crash involvement of motorcycles".
    - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
    - "Good Practice 3.3.3.1.A.2: Red Light Jumper Cameras".
    - "Good Practice 6.2.1.A.3: Shiny Side Up Partnership".

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.- Number of failure: 13.

.- Failure Mode:

- Longitudinal control: Ride fast .

.- Effects of Failure:

- Conflict: Side-side (2 times).

.- Causes of Failure: Thinking the rider he/she is able to have a wider visual field, and the motorcycle has high power (horse power), the rider action is risky, especially in urban areas, when he/she rides too fast close to the rest of vehicles.

.- Number of failures: In 2 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - "Good Practice 3.2.1.A.1: Perception of risk in motorcyclists".
    - "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
    - "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
    - "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
    - "Good Practice 3.3.2.1.A.2: Safety Cameras in London".
    - "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
    - "Good Practice 3.3.3.1.A.2: Red Light Jumper Cameras".
    - "Good Practice 6.2.1.A.3: Shiny Side Up Partnership".
    - "Good Practice 6.3.1.A.1: Kill Spills BMF/IAM (Campaign, 2003)".

.- Number of failure: 14.

.- Failure Mode:

- Use of lane: Stop on the road.

.- Effects of Failure:

- No conflict (1 time).

.- Causes of Failure: Although motorcycles are smaller than the rest of powered vehicles, this not means the riders can stop on the road (shoulders,….) to modify-change-put correctly whatever. They think do not disturb traffic conditions, and even when it is possible they cannot consider the possible danger associated to this fact (due to the lack of conspicuity).

.- Number of failures: In 1 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - o “Good Practice 3.2.1.A.1: Perception of risk in motorcyclists”.
    - o “Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists”.
    - o “Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders”.
    - o “Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers”.
    - o “Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course”.
- From the point of view of Protective Equipment (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=5&mimetype=application/pdf):
    - o “Good Practice 4.3.3.1.A.1: Use of reflective and brightly colour clothing to be better seen on the road”.
    - o “Good Practice 4.3.3.1.A.2: Motorcycle rider conspicuity”.
    - o “Good Practice 4.3.3.1.A.3: Attention and search conspicuity of motorcycles as a function of their visual context”.

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.- Number of failure: 15.

.- Failure Mode:

- Use of lane: Forbidden U turn.

.- Effects of Failure:

- Conflict: Lane change (1 time).

.- Causes of Failure: Taking into account the small size the motorcycles have, the high power the motorcycles also have and the easiness of these vehicles to carry out any manoeuvres; the riders decide to carry out some forgiven manoeuvres instead of moving along the lane until they can do the manoeuvre in a correct way.

.- Number of failures: In 1 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: The following good practices will help to avoid this failure carried out by the rider or the other road users or the manufacturers or the administrations.

- From the point of view of Human Factor (available on: http://www.rosaproject.eu/contenidoAction?ACTION=FIND&id_contenido=4&mimetype=application/pdf):
    - o “Good Practice 3.2.1.A.1: Perception of risk in motorcyclists”.

- "Good Practice 3.2.2.A.1: Best training methods for teaching hazard perception and responding by motorcyclists".
- "Good Practice 3.2.2.A.2: Enhancing hazard avoidance in teen-novice riders".
- "Good Practice 3.2.2.A.3: Using a riding trainer as a tool to improve hazard perception and awareness in teenagers".
- "Good Practice 3.3.2.1.A.2: Safety Cameras in London".
- "Good Practice 3.3.2.1.A.3: Effectiveness of red light cameras on the right-angle crash involvement of motorcycles".
- "Good Practice 3.3.3.1.A.1: Rider Risk Reduction Course".
- "Good Practice 3.3.3.1.A.2: Red Light Jumper Cameras".

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.- Number of failure: 16.

.- Failure Mode:

- No risky behaviour.

.- Effects of Failure:

- Conflict: Lane change (1 time).
- Vulnerable road user (1 time).
- No conflict (1 time).

.- Causes of Failure: Actually, this failure is not due to the rider, either it is due to the dazzling sun shine during a brow of a hill, due to the presence of a elder pedestrian into the road (in a forgiven area) or due to the wrong manoeuvre of a truck driver.

.- Number of failures: In 2 out of 67 situations detected in which the rider was riding in a risky way, this failure mode was present.

.- Recommendations Actions and Good Practices: In this case, no recommendations are given to riders. The good practice should be focussed on the awareness and education of the rest of users (as elder pedestrians).

# Appendix 2 – Analysis of full UK dataset

**Event 1**

Event identification

| | |
|---|---|
| Participant number | 1 |
| Date & Time | 23/03/2011 – 07:42 |
| Event severity | Near-crash |
| Trigger | High front brake pressure |

Overview of event

The rider accelerated away from the traffic lights onto a roundabout, preparing to take first exit. However, the car in front braked and the rider only just braked in time to prevent going into the back of it. The aerial photograph below shows the location at which the event occurred. The rider approached the roundabout via the slip road from the NW, exiting via the first exit to the NE.

Pre-event situation

The rider approaches a set of traffic lights controlling the flow of cars onto a roundabout. The traffic lights are currently at red, causing a queue of vehicles, and the rider filters through the stationary vehicles, ultimately pulling up behind the lead vehicle. However, there is not sufficient room for the rider to pull in completely behind the lead vehicle and so he must take station to the left hand side of the lane. The rider is in the middle lane of three entering the roundabout and there are two available for the exit the rider intends to take. The left lane must turn left but the middle (rider's) lane can either turn left or continue ahead. The rider wishes to turn left.

Start of event

The traffic lights change to green, allowing traffic to enter the roundabout. The rider follows closely behind the lead vehicle, possibly so as to ensure his place ahead of the following vehicle, although it seems more likely that it is in an attempt to get ahead of the lorry in the left-hand lane. Either way the rider has committed himself to a position too close to the vehicle ahead.

Climax of event

The lead vehicle is continuing around the roundabout and the rider is either expecting the car to continue moving ahead smoothly or is simply concentrating on the lorry to the left rather than looking ahead. Either way, when a van cuts in front of the lead vehicle and causes the driver to brake slightly, the rider is apparently caught by surprise. In the video, the front of the bike is seen to dip jerkily as the rider takes evasive action to prevent going into the back of the lead vehicle, seemingly by braking heavily.

Resolution of event

The rider cuts to the left of the lead vehicle and continues unharmed, taking the exit as planned.

Discussion

The primary cause of the event was the unexpected braking of the lead vehicle, exacerbated by the fact that the rider was following too closely. Why the braking of the lead vehicle caught the rider so by surprise is not clear, but it seems probable that it was because he was attempting to get in front of the lorry in the left-hand lane and was concentrating on this rather than what was happening ahead. In the build-up to the incident it is noteworthy that the rider, having filtered through the stationary traffic, was unable to gain a dominant position at the lights, instead being forced off to the left. It may be because of this that the rider felt the need to pull away from the lights quickly and thus ended up too close to the lead vehicle. As such the positioning of the rider at the lights may have been a contributing factor.

The incident was detected through the sensor analysis due to a heavy application of the front brakes. The threshold detection value for Participant 1 was 64.7 psi and in this case the actual front brake pressure was 71.6 psi, the second highest value seen in all of Participant 1's data. However, somewhat confusingly the data-trace shows that the rider began applying the front brake almost immediately upon pulling away and that in fact the peak braking occurred before the car in front braked. This would imply that the rider did anticipate the car's actions but does not explain why he still came so close to hitting the car, nor the jerky bike movements seen in the video following the car braking. It is possible that there is a slight discrepancy in the time coding between the sensor data and the video data but this could not be determined confidently.

**Event 2**

Event identification

| | |
|---|---|
| Participant number | 2 |
| Date & Time | 01/03/2011 – 09:13 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider accelerated onto a motorway at speed. Having come off the slip lane the rider pulled across to the outside lane to overtake traffic. As the rider did so a car driver in the middle lane started to pull across to the outside lane in front of the rider, seemingly unaware of the rider's presence. The rider rode through a narrowing gap between the car and the central reserve whilst travelling at 110 mph. The aerial photograph below shows the location at which the event occurred. The rider joined the motorway via the slip road from the E. The event occurred shortly before the over-bridge with the rider heading SW.

Pre-event situation

The rider is pulling onto the main carriageway from the slip road. At this point the rider is travelling at roughly 120 mph.

Start of event

The rider has pulled across to the middle lane and is continuing to move across to the outside lane to overtake the cars in front. At this point the rider is travelling at roughly 115 mph.

Climax of event

The rider is now attempting to overtake the car in front using the outside lane. However the car is itself now pulling into the outside lane, seemingly unaware of the presence of the rider. It is not clear whether the rider could brake and fall-in behind the lead car or if he has no choice but to overtake, however the rider decides to overtake. At this point the rider is still travelling at roughly 115 mph.

Resolution of event

The rider cuts through the narrowing gap between the car and the central reserve, still travelling at over 110 mph, and emerges into a clear lane, in control of the vehicle. It is difficult to tell from the video but there is a suggestion that at the last moment the car driver identifies the rider and starts to pull back slightly towards the middle lane. The whole sequence from entering the motorway to passing the lead vehicle takes less than 5 seconds.

Discussion

The primary cause of the conflict was that the rider attempted to overtake at the same time as the vehicle being passed was pulling into the outside lane. It appears as though the driver was simply unaware of the riders presence, which rather than being an observational fault of the driver is almost certainly the result of the both the speed at which the rider was travelling and the rapid transition from the slip road to the outside lane, clearly placing the rider at fault. It is also noteworthy that the vehicle in question was a sports car with probably limited rear visibility, making it even more important for the rider to properly make his presence known. Given how quickly the entire sequence unfolds it is perhaps not surprising that the rider makes few control inputs to the bike, however it is interesting to note that the rider performs the overtake at a fairly constant speed (i.e. does not brake nor try to accelerate through the gap). This suggests the rider did not panic and instead maintained focus, which may have helped prevent an otherwise much more serious outcome. It is also interesting to note that, despite the serious situation unfolding, the sensors were not able to detect anything of note and the detection of the event was through rider feedback alone. In fact, the rider's control inputs throughout the sequence was entirely within the normal range for that rider, with no harsh acceleration, braking or steering inputs.

**Event 3**

Event identification

| | |
|---|---|
| Participant number | 2 |
| Date & Time | 11/03/2011 – 18:46 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

This was a somewhat similar event to Event 2, but less severe. The rider was in this instance performing an undertake manoeuvre (using the inside lane) on the motorway when a car in the middle lane began to pull in to the inside lane, again seemingly unaware of the rider's presence. As with Event 2 the rider again chose to ride through a narrowing gap, although in this case the gap was larger and there was a hard shoulder available as an escape route. The aerial photograph below shows the location at which the event occurred. The rider was travelling NE.

<u>Pre-event situation</u>

The rider is travelling in the middle lane of the motorway, with relatively free-flowing traffic but some impedance to the rider's movements. At this point the rider is travelling at roughly 85 mph.

<u>Start of event</u>

There is a car in the middle lane blocking the rider's progression. Seeing a bigger gap on the left than the right, the rider chooses to undertake using the inside lane. The rider is still travelling at approximately 85 mph. It now becomes apparent that in front of the car (that the rider was initially attempting to undertake) is a 4x4 vehicle; it is indicating to pull into the inside lane in front of the rider and has already started to pull across.

Climax of event

The driver of the 4x4 has seemingly not seen the rider and continues to pull across. The rider is now faced with the decision to either abort the undertake or to continue through the narrowing gap available. The rider chooses to continue on the inside, accelerating quickly to ensure he makes it through. By now the rider is doing roughly 95 mph.

Resolution of event

The rider passes through the gap unharmed and continues ahead on the, now clear, inside lane. As he clears the 4x4 the rider is travelling at about 105 mph.

Discussion

As with Event 2, the primary cause of the incident is another vehicle moving into the rider's lane as he is attempting to pass. As before, one reason the driver of the lead vehicle seemingly does not see the rider is likely to be because he is travelling faster than other traffic on the road. In this case it is also influenced by the fact that the rider is performing a potentially risky undertaking manoeuvre (which the 4x4 driver is unlikely to have anticipated) and the rider will likely have been obscured until the last moment by the car following the 4x4. Once he had pulled into the inside lane to perform the undertake, he was also directly in front of another following vehicle and may have been lost in its headlights. As with the previous event, there were no sensor triggers identifying the event, with rider feedback being the only means to identify the incident. Even though the rider accelerated fairly briskly to get through the gap, it was well within the rider's normal range. In fact the threshold to trigger an event in the acceleration sensor for rider 2 was around 6.2 $m/s^2$, but in this sequence it never exceeds 3.35 $m/s^2$.

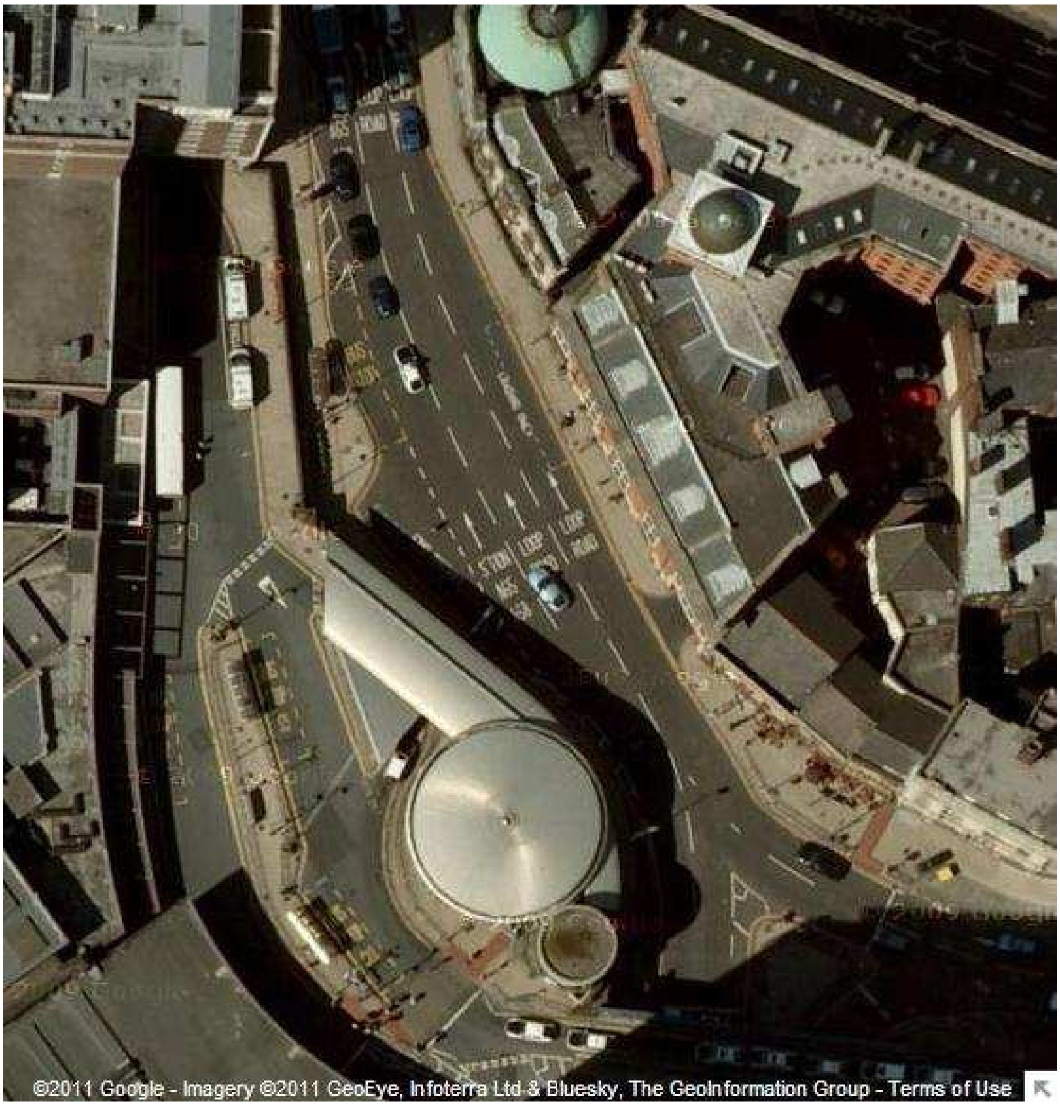
**Event 4**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 28/03/2011 – 07:49 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider was caught in traffic and went to overtake, but failed to check his blind-spot. He pulled out in front of another PTW that was also overtaking and had to quickly move back left to avoid a collision. The aerial photograph below shows the location at which the event occurred. The rider entered from the S, heading N. (note that the road layout has changed slightly since this picture was taken, with the road now marked with 2 lanes rather than the 3 shown.



Pre-event situation

The rider is following a car in front that comes to a standstill at the back of line of traffic waiting for a set of traffic lights ahead to change.

Start of event

Rather than deciding to overtake as soon as he comes up behind the lead vehicle, the rider seems to ‘dither’ and ends up getting very close. The rider decides to pull out to overtake the line of cars, but his proximity to the car in front means he ends up swinging the bike further out to the right than perhaps would otherwise have been necessary. The rider also reported in his feedback that he failed to check his blind-spot before doing so.

Climax of event

The rider notices another PTW approaching from behind, also intending to overtake the queue of cars. The rider pulls back left sharply to avoid riding into the other PTW.

Resolution of event

The rider manages to leave enough room and the other PTW rider squeezes past. Both PTWs then continue ahead to the front of the queue.

Discussion

The cause of this event can be attributed to a rider error in failing to check the blind-spot before moving off, exacerbated by the fact that the rider did not act decisively upon approaching the lead vehicle which resulted in him making a wider manoeuvre than required and may have made it more difficult for the following motorcycle rider to anticipate what he would do. Any resulting crash would have been fairly low-speed in this case, but contact was seemingly only narrowly avoided. As with the previous two events, there were no sensor readings that indicated a potential event in the data. Rider feedback was instead required.

**Event 5**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 30/03/2011 – 12:43 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider approached a queue of traffic waiting at traffic lights and attempted to filter through to the front of the queue. However at the last moment the lights changed and the traffic began to move off, forcing the rider to brake and cut back in behind the lead vehicle to avoid potentially being crushed between two vehicles. The aerial photograph below shows the location at which the event occurred. The rider approached from the NW, with the event occurring at the advanced stopping area for cyclists before the junction.

Pre-event situation

The rider approaches the back of a queue of vehicles waiting at a set of lights and decides to filter through down the right hand side, using the lane set aside for vehicles turning right at the junction.

Start of event

The rider approaches the head of the queue and identifies a gap between the lead vehicle continuing ahead and the lone vehicle turning right. The rider aims for the gap, intending to get to the front of the queue to wait in the marked green zone, which is the advanced stopping position for cyclists.

Climax of event

At the last moment the lights change for traffic continuing ahead and the lead vehicle to the left sets off, effectively cutting off the available gap. The rider is forced to apply the brakes and to try to cut in behind the lead vehicle, thus simultaneously having to avoid the stationary vehicle to the right, the moving lead vehicle to the left, and potentially the vehicle second in the queue to the left.

Resolution of event

The rider performs the manoeuvre and continues on behind the lead vehicle.

Discussion

In the end the situation was resolved without any major difficulty; however the rider came fairly close to being in a far more awkward situation. It is not possible to say, had the lights changed a moment later and the rider committed to entering the gap, whether or not the driver of the lead vehicle would have spotted the rider and given way or continued as was the case here. Had it been the latter there could conceivably been a collision, potentially with the rider being crushed between two vehicles. The event seen here therefore highlights a potential type of accident if a rider misjudges the timings at a set of traffic lights when filtering. Importantly, the rider did not provide himself with a back-up option. The lights changing to green were a clearly predictable event and there should have been a safe course of action lined up for this occurrence before the rider committed to the manoeuvre.

**Event 6**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 02/04/2011 – 11:18 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider rounded some street furniture in the middle of the road to find an oncoming vehicle, overtaking another car and encroaching onto the rider's side of the carriageway. The rider swerved slightly to avoid the car. The aerial photograph below shows the location at which the event occurred. The rider entered the scene from the S, travelling N when the event occurred.

<u>Pre-event situation</u>

The rider is travelling through an urban area at about 28mph, within the speed limit. He approaches a slight bend in the road, seemingly slightly obscured by some bollards in the middle of the road (although it should be noted that the image above represents a point of view lower than the rider's actual eye view).

<u>Start of event</u>

As the rider rounds the corner he spots an oncoming vehicle performing an overtaking manoeuvre and encroaching into his lane. The car that is being overtaken is turning into a side-road and it is not clear whether the following driver makes a pre-meditated decision to overtake or if he/she is taken by surprise and moves out as more of an avoidance manoeuvre.

Climax of event

The rider quickly straightens the bike up in order to keep left in the lane and give the oncoming car more room. He does not feel the need to brake, instead maintaining a steady speed of around 27 mph.

Resolution of event

The oncoming car moves back across onto the other side of the road and in the end there is plenty of room for the rider to pass.

Discussion

The cause of the situation seems to be that the oncoming vehicle started an overtake manoeuvre without identifying the fact that there was an oncoming bike. It is not clear how much the street furniture played a part, but it seems likely that it would have acted in some way to make the rider less conspicuous to the overtaking driver. Two possible scenarios would be that either the driver pulled out spontaneously to avoid the vehicle turning left and so was not necessarily thinking about what might be coming the other way; or that the driver pulled out impatiently, with the street furniture sufficient to obscure the rider from the driver's view and the driver potentially feeling, mistakenly, that he/she was able to see the road ahead sufficiently. It can only be speculation, but it is possible the driver was, either consciously or subconsciously, scanning for larger vehicles and not open to the possibility that the bollard could be hiding an oncoming bike.

**Event 7**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 06/04/2011 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider misjudged a left-hand bend on a country road. Rider reported that he had to shut-off the throttle part-way round and make two apexes, taking a wider line than intended. The aerial photograph below shows the location at which the event occurred. The rider approached the corner from the W.

Pre-event situation

The rider approaches a left-hand bend on an open country road and begins to turn in. At this point the rider is travelling at approximately 35 mph and this speed remains relatively constant throughout the remainder of the sequence, dipping by only a couple of mph.

Start of event

The rider picks his line and leans in, making his intended apex at this point before starting to ease off on the lean. It is believed that the rider has leaned in too soon and by committing himself to the apex at this point, without yet being able to see the end of the bend, he has placed himself in a vulnerable position.

Climax of event

As the bend continues the rider realises that the corner is sharper than first anticipated. Having already made his apex he is now in a position whereby he cannot easily resolve the situation. He begins to run wide and is forced to make a second apex, leaning the bike over steeply, reaching the peak lean at the point shown above. He continues to run slightly wide, coming close to the centre-line.

Resolution of event

The rider resolves the situation and brings the bike back onto roughly the intended line in time for the next corner.

Discussion

The cause of this incident was that the rider misjudged the corner, failing to adequately anticipate the angle. This was exacerbated by the fact that the rider turned in too early and thus was not in a position to alter easily his line once he realised his misjudgement. The fact that he misjudged the angle of the corner at all is interesting because the landscape is open and flat, with no obvious features blocking the rider's view on the inside of the bend. However, because the road is so flat the grass verge is sufficient to un-sight the rider and he reported this as being the reason for his mistake. Although there is a noticeable rut in the road around the bend, the rider did not report this as being relevant to the situation. This example shows how even on open roads, it is possible for a rider to become unsighted by seemingly innocuous vegetation. Ultimately though, it shows the importance of good cornering technique.

**Event 8**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 06/04/2011 – 20:12 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider approaches a junction and moves to overtake the cars ahead using a cross-hatched area in the centre of the carriageway. As the rider moves out he identifies another motorcyclist performing an overtake in the opposite direction, also using the cross-hatched area. The rider is forced to pull back across to make way for the oncoming bike. The aerial photograph below shows the location at which the event occurred. The rider approached from the N, heading S.

Pre-event situation

The rider approaches a junction with which he is very familiar.

Start of event

The rider sees the red traffic lights ahead and anticipates that there will be a queue forming. He begins to manoeuvre right to overtake the cars ahead using the cross-hatched area, a manoeuvre he performed on other occasions during the study.

Climax of event

As he is crossing the dashed line he spots an oncoming motorcyclist, also overtaking using the cross-hatched area, and moves back left to leave room.

Resolution of event

The rider is safely in his lane as the oncoming rider moves back onto his side of the road and passes by at high speed.

Discussion

The cause of this incident was that two motorcyclists attempted to perform a similar overtaking manoeuvre in opposite directions, at the same time, using the same piece of road. There is no clear rider upon whom to place fault as they were both performing the same manoeuvre, however the oncoming rider was travelling at considerably higher speed – likely to have been significantly above the limit for that road – and emerged from behind an HGV – so had a poor view of the road ahead. The actions of the test rider ensured that the situation did not come close to conflict, but it can be seen how the seeds for a high-speed head-on collision had been sown. Also of interest is how easily the oncoming motorcyclist appears to be lost among the mass of headlights of the oncoming vehicles (image 3 in the sequence). This may be largely a result of the video quality, given how quickly the rider identified the motorcyclist in reality, but it is an interesting example of how a single rider's headlamp can be lost in a group.

**Event 9**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 08/04/2011 – 16:27 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider is waiting at a traffic-light-controlled junction. The lights change and the rider moves off, however a car entering from a side road to the left has jumped the lights and cuts in front of the rider, who is forced to brake heavily to avoid a collision. The aerial photograph below shows the location at which the event occurred. The rider approached from the N, heading S; the driver jumping the lights approached from the E, heading N.

Pre-event situation

The rider approaches the same junction referenced in Event 8. As usual he filters down the right-hand side of the queue of cars to a stop at the front of the queue, waiting in the cross-hatched area. The traffic signals cycle through various phases, with the last phase allowing traffic to enter from the side road to the left and turn right, as shown in the image above.

Start of event

The queue of traffic turning right has cleared and the lights change ahead of the rider. Knowing the junction well the rider sets off immediately, probably aiming to get ahead of the car alongside him to his left.

Climax of event

A car entering from the left has jumped the lights and suddenly turns out from the side road, directly into the path of the rider (the car is in fact visible prior to making the turn but is partially obscured by the railings. It is also fair to assume the rider would likely not be concentrating on traffic entering from the side road once the traffic lights had changed to green). He is forced to apply the brakes heavily to avoid a head-on collision.

Resolution of event

Fortunately the rider reaches no more than about 6 mph before applying the brakes and is able to bring the bike to a stop safely. There is sufficient room for the turning car to pass by without a collision.

Discussion

The cause of this event was the car entering from the left against the lights. This particular situation involved risk to the other car drivers in the queue as well as the rider, however the risk to the rider was elevated for a number of reasons: firstly, the rider is naturally more exposed than a car driver; secondly, the rider was further over to the right, due to filtering past the queue of vehicles, and so was closer to the path of the turning car; and thirdly, the greater available acceleration to the rider than that of the car driver to his left would allow him to set off from the lights quicker and so get closer to the path of the turning car.

The sensor analysis failed to identify the event from the braking for two reasons: Firstly, the front brake pressure only reached 23.6 psi (the threshold detection level for Rider 3 was 56.0 psi); and secondly, even if the brake value had been above the threshold level, it would not have registered due to the low speed at which the event occurred. In the early stages of the analysis it was discovered that all the braking events flagged up were from when the rider was stationary (e.g. waiting at traffic lights). In order to remove these false-positives, brake pressure data was filtered to remove values recorded at speeds less than 10 mph. Thus this event would have been filtered regardless of the brake pressure value recorded. It is also worth mentioning that the maximum value of 23.6 psi is also slightly dubious as this value remains fixed for approximately 2 seconds through the period when the video indicates braking reached its maximum, raising the possibility that the sensor may have frozen at the critical moment.

**Event 10**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 14/04/2011 – 07:54 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider was filtering between two lanes of traffic on approach to a set of traffic lights. A pedestrian stepped out into the path of the rider from between two vehicles, away from the designated crossing. The aerial photograph below shows the location at which the event occurred. The rider approached from the S. (Note that the road markings have changed since this picture was taken, with there now being 2 lanes marked rather than the 3 shown).

Pre-event situation

The rider approaches a queue of traffic and moves left to filter through between the two lanes of traffic.

Start of event

The rider continues to filter through, slowly decelerating using his rear brake to control his speed. A pedestrian then emerges from between two vehicles on the right-hand side (her head can be seen just below and to the right of the red traffic signal ahead). She is crossing away from the designated crossing area and steps out without looking left.

<u>Climax of event</u>

The woman looks left and is seen to momentarily check her movement, but ultimately continuing across regardless. The rider exerts some extra pressure on the rear brake to slow himself.

<u>Resolution of event</u>

The pedestrian makes it across safely and the rider continues forward to the stop line.

<u>Discussion</u>

The cause of this event was the pedestrian stepping out in front of the rider without looking. It is likely that she did not consider that a motorcycle (or indeed pedal-cyclist) might be filtering between the lanes and so felt that her path was free from hazards, with the vehicles around her already halted. It is suspected that a collision would not actually have occurred even if the rider had not braked any harder, but the clear potential for a collision resulted in this being categorised as an event.

**Event 11**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 17/04/2011 – 09:56 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

The rider was attempting to overtake two vehicles on a country road, but found he had misjudged the speed of an oncoming vehicle and had to move back in between the two vehicles. The aerial photograph below shows the location at which the event occurred. The rider was travelling N.

Pre-event situation

The rider approaches two vehicles travelling fairly closely together on a country road.

Start of event

The rider is travelling quicker than the two lead vehicles and decides to overtake immediately, pulling out into the opposing lane.

Climax of event

The rider intends to pass both vehicles in a single manoeuvre, but as he approaches the lead vehicle he realises that the oncoming car is closing the gap more quickly than he anticipated and he is instead forced to apply the brakes and move back left behind the lead vehicle.

Resolution of event

The oncoming vehicle passes safely and the rider is able to complete the overtake manoeuvre, continuing past the lead vehicle.

Discussion

The rider reported that he misjudged the speed of the oncoming vehicle rather than not see it. The slight dip in the road is likely to have hidden the oncoming car from him when he first started the overtake and so it seems that he then identified it but decided to continue past both vehicles. The gap between the two lead vehicles was sufficiently large that the rider was able to pull in behind the front one without too much difficulty, but had he pushed ahead with the overtake a head-on collision would have been a distinct possibility.

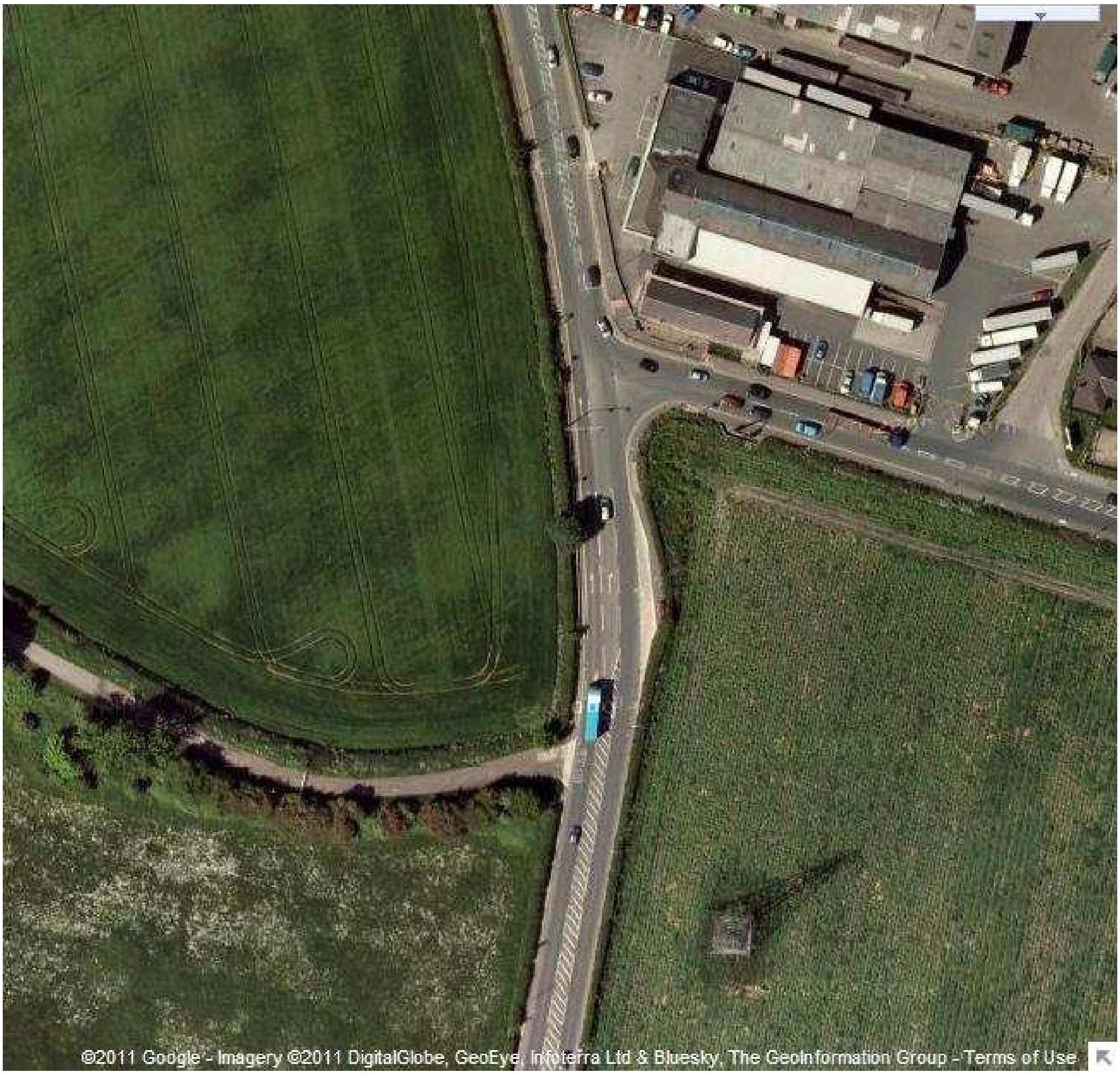
**Event 12**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 18/04/2011 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider pulled out to overtake a line of vehicles at a junction. As he crossed over the junction the rider was still pulling back across when an oncoming car driver saw the rider. Although the rider felt there was little possibility of a conflict the driver of the oncoming car braked and steered away from the rider. The aerial photograph below shows the location at which the event occurred. The rider approached from the N, heading S; the other car was heading N.



Pre-event situation

The rider approaches the same junction as described in Events 8 and 9 and, as before, he has filtered down the right-hand side. As he approaches the front of the queue the lights change to green and he continues ahead, intending to complete the overtake of the line of cars, as well as the motorcycle that was also stopped at the lights.

Start of event

Due to his intention to overtake the motorcyclist as well as the cars the rider chooses to take a wide line through the junction. There is no immediate problem with this as this side of the road is clear, but an oncoming car can be seen just rounding the bend ahead.

Climax of event

The rider begins to pull back across onto the correct side of the road, but is still in the lane reserved for oncoming traffic wishing to turn right at the junction. It can be seen that the oncoming car is intending to turn right and has moved across into the turning lane, thus bringing the two into potential conflict. At this point the oncoming car can be seen to apply the brakes and move left in its lane to avoid the rider. (Note however that, although the car appears to be in the turning lane at this point, it has in fact moved across prematurely and is in a cross-hatched area.)

Resolution of event

The rider makes it back into his lane and the oncoming car passes by safely.

Discussion

As mentioned previously, the rider noted that he believed the oncoming driver had over-reacted. Nonetheless he recognized that he had forced a defensive manoeuvre and so a situation had occurred. The rider was familiar with this junction and probably performed this manoeuvre many times previously. However it seems that the presence of the second motorcyclist caused the rider to take a wider line than usual. The oncoming driver may have perceived the rider as being not one but two lanes across onto the wrong side of the road and therefore felt less able to anticipate what the rider would do next, thus feeling it necessary to take evasive action. It is also possible that the car driver realised he/she was in a cross-hatched area and so, being further across than they should have been, felt the need to correct this. Nonetheless, the final image of the sequence shows that, had the driver maintained speed and position in the turning lane, the two vehicles would have passed by closer than might be considered comfortable.

**Event 13**

Event identification

| | |
|---|---|
| Participant number | 3 |
| Date & Time | 20/04/2011 – 16:59 |
| Event severity | Incident |
| Trigger | High front suspension compression and high deceleration |

Overview of event

The rider intended to overtake a line of stationary cars queuing at a signalised intersection, but aborted the manoeuvre at the last moment due to a van pulling out from a side road on the right. The rider braked sharply to fall in behind the line of stationary cars. The aerial photograph below shows the location at which the event occurred. The rider was approaching from the N; the van was approaching from the W, turning left to head N.

Pre-event situation

The rider approaches a line of cars queuing at a set of traffic lights. There is a stream of oncoming cars and several vehicles queuing down an adjoining side road. A van in visible waiting to join the main carriageway from a side road.

Start of event

As the rider approaches the back of the queue the last car in the stream of oncoming vehicles is passing. Seemingly the rider perceives this as creating a gap for him and he moves across to overtake the queue of vehicles.

Climax of event

As the final oncoming car passes and the rider is starting to overtake he realises that a van has started to pull onto the main road from the adjoining side road and that he is about to pull out into its path. The rider brakes heavily and starts to pull back across to the left, aborting the overtake.

Resolution of event

The rider comes to a stop behind the vehicle in front. The lights then almost immediately change ahead and so the rider waits here until traffic moves off, keeping station behind the vehicle in front.

Discussion

Although at the final moment before the overtake the van appeared to be at least partially obscured by the final passing car, it was clearly visible for most of the preceding approach. It is not clear whether the rider failed to spot the van (instead focussing on the queue of cars ahead and the stream of oncoming cars), or whether the rider had spotted the van but simply believed that it would not move off as quickly as it did. It is at least plausible that the rider saw the van but failed to appreciate its importance due to the need to concentrate on other traffic already on the main carriageway. The incident could possibly fall into either the 'looked but failed to see' or the 'saw but failed to respond appropriately' categories.

In this event the sensor analysis proved capable of identifying the incident. The suspension compression and deceleration values recorded were 24.6 mm and 3.69 $m/s^2$ respectively, with the threshold values being 22.9 mm and 3.66 $m/s^2$.

**Event 14**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 23/04/2011 – 07:58 |
| Event severity | Near crash |
| Trigger | Rider report |

Overview of event

The rider was making a right-hand turn through a bend when the back wheel momentarily lost traction and kicked out. The tyre almost immediately regained traction and kicked the bike up into a brief wobble. The aerial photograph below shows the location at which the event occurred. The rider was heading N.

Pre-event situation

The rider approaches a right-hand bend. At the start of the bend there is a transition in road surface, with the bend itself having had a newer surface applied fairly recently. The rider stated that he was aware of the new surface and that it might be slippery, and that he approached the corner slowly because of this. The rider was travelling at approximately 34 mph, was lightly applying the front brake and no rear brake at the point the above picture was taken.

Start of event

As the rider is roughly halfway around the bend the back wheel momentarily loses traction; enough time for the wheel to slide out slightly to the left and with a noticeable increase in the lean angle of the bike.

Climax of event

Almost immediately the rear tyre regains traction and the bike begins to right itself. The wobble caused is only minimal but there is a noticeable reduction in the lean angle.

Resolution of event

The rider quickly regains control and is able to continue through the bend along roughly the intended line. The rider exits the bend in full control of the bike.

Discussion

The pictures above show that the physical effect on the bike was minimal, with only a slight variation in the lean angle of the bike throughout the incident. This belies the fact that the rider came very close to experiencing a single-vehicle crash, either through losing the rear wheel entirely or through being 'high-sided' when the rear wheel regained traction. This is in spite of the fact that the rider stated that he was aware of the potential for slipping on the new road surface and specifically entered the bend slower than he normally would have. Interestingly there was no indication in the wheel-speed data of a mismatch between front and rear (which would be inactive of either a wheel-spin or a lock-up). This supports the rider's statement that he was neither accelerating nor braking when the event occurred; either one of which could potentially initiate a loss of wheel traction.

**Event 15**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 23/04/2011 – 08:14 |
| Event severity | Near-crash |
| Trigger | Rider report |

Overview of event

A van overtook the rider but cut back in far too quickly, nearly clipping the rider. The aerial photograph below shows the location at which the event occurred. The rider was heading E.

Pre-event situation

The rider has just passed through a country village. The rider is seen here passing the transition from the 30 mph zone to a 40 mph zone. As he passes the signs the rider is travelling at approximately 42 mph.

Start of event

Soon after passing the signs the rider realises that a van is coming up closely on his right-hand side and begins to move over to the left of the lane.

Climax of event

The van is then seen to cut in sharply in front of the rider, narrowly missing clipping the bike.

Resolution of event

The van makes it past without contact

Discussion

At the point where the overtake occurred the rider was travelling at roughly 45 mph – above the speed limit – yet the van driver still decided to overtake. Not far ahead the limit changes to national speed limit (60 mph) and it seems likely that the van driver knew this. It is not known for sure what caused the van driver to pass with such little clearance, although the video shows another car passing in the opposite direction approximately 3.5 seconds later that may have caused the van driver to panic slightly, although the road at this point is straight and open and so the driver would almost certainly have been able to see the car approaching before he started to overtake. There is also the possibility, although speculation, that the driver purposely ‘cut the rider up’ as an act of aggressive driving.

**Event 16**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 27/04/2011 – 07:49 |
| Event severity | Incident |
| Trigger | Rider report |

Overview of event

The rider was overtaking several cars and pulled in behind the lead car, to find it brake unexpectedly for a cyclist, taking the rider by surprise and causing him to brake. The aerial photograph below shows the location at which the event occurred. The rider was heading W.

<u>Pre-event situation</u>

The rider is overtaking the second of two vehicles travelling closely together.

<u>Start of event</u>

The rider starts to pull in behind the third (lead) vehicle when it starts to brake. The rider believes the road ahead to be clear and is unsure why the car is braking, as evidenced from the rider report.

Climax of event

The rider realises the car is braking for something significant and that he too must brake in order to avoid running into the back of the car.

Resolution of event

The car pulls out to pass a cyclist and it becomes clear the reason for the car's slowing.

Discussion

It is clear that the car driver slowed for the cyclist, however it is interesting to note that this section of road is straight and fairly flat and yet the car driver decided not to overtake as soon as he/she reached the cyclist. This decision to brake rather than overtake is what confused the rider, as he could see no reason for the driver to brake and therefore did not expect the car to continue slowing at the rate it did. It can only be speculated, but it is believed that the car driver saw the PTW rider approaching and, having seen him just overtake several vehicles, anticipated that the rider may well overtake his/her own car as well. The driver thus slowed to avoid pulling out in front of the motorcycle rider. This might therefore be an example of how conflicting expectations of other road users' behaviours can lead to a difficult situation that might otherwise not have arisen.

**Event 17**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 01/05/2011 – 13:15 |
| Event severity | Incident |
| Trigger | High front brake levels, suspension compression and deceleration rate |

Overview of event

As the rider approached a roundabout the car in front slowed unexpectedly quickly due to an ambulance coming the other way. The rider was forced to brake heavily to avoid running into the back of the car. The aerial photograph below shows the location at which the event occurred. The rider was approaching the roundabout from the S.

Pre-event situation

The rider is approaching a roundabout. The lead vehicle is braking gently and the rider is coasting to lose speed gently.

Start of event

The lead vehicle begins to brake much more heavily and the rider starts to make up ground.

Climax of event

The rider realises what is happening and applies the brakes heavily. By now it is clear what has caused the sudden braking of the lead vehicle; an ambulance coming the other way is trying to overtake and vehicles are trying to make room for it to pass.

Resolution of event

The ambulance makes it past and the rider and lead vehicle accelerate towards the roundabout.

Discussion

This is similar to the previous Event in that the rider was caught out by a lead vehicle braking harder than the rider was expecting. In this case there is no suggestion that it was influenced by the car driver misinterpreting the rider's intentions, simply that the rider would not have been anticipating the presence of the ambulance. That said, it cannot be determined from the video exactly when the rider would have first detected the ambulance. Image 2 in the sequence shows the ambulance largely hidden behind the lead vehicle, but the rider's actual eye position would have been higher than this and so he may have been able to see over the top of the car. It is possible the rider had seen the ambulance but not yet fully appreciated its significance.

This was another incident flagged up by the sensor analysis. In this case the brake pressure, suspension compression and deceleration rate were 106.4 psi, 37.2 mm and 3.89 $m/s^2$ respectively, with the corresponding threshold values for Rider 4 being 80.3 psi, 33.1 mm and 3.81 $m/s^2$.

**Event 18**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 05/05/2011 – 16:22 |
| Event severity | Incident |
| Trigger | High front brake levels and suspension compression; and rider report |

Overview of event

The rider was caught out by the braking of a vehicle in front and was forced to apply the brakes heavily to avoid going into the back of it. The aerial photograph below shows the location at which the event occurred. The rider was heading E.

Pre-event situation

The rider approaches a roundabout. Cars in front can be seen to be braking for it.

Start of event


The rider starts to brake gently.

Climax of event

The rider realises that the car in front is slowly more quickly than he had originally anticipated and is forced to brake heavily.

Resolution of event

The rider is able to slow the bike and maintains a safe distance to the car in front.

Discussion

From the footage it is clear that the rider does not come particularly close, physically, to the vehicle in front. However, this is in fact the only event from the 20 identified that was flagged up by both the sensor analysis and by rider report; which is why although seemingly fairly innocuous, it was included as an incident in the analysis. In this case the brake pressure, suspension compression and deceleration rate were 96.9 psi and 34.1 mm respectively, with the corresponding threshold values for Rider 4 being 80.3 psi and 33.1 mm.

**Event 19**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 11/05/2011 – 22:04 |
| Event severity | incident |
| Trigger | High front brake levels, suspension compression and deceleration rate |

Overview of event

The rider either failed to identify or misjudged the arrival of another vehicle as he was attempting to join a roundabout. The rider was forced to brake hard to avoid coming into conflict with the other vehicle. The aerial photograph below shows the location at which the event occurred. The rider was approaching the roundabout from the NW, intending to continue SE. It is not certain from which direction the other car approached but it seems likely it joined the roundabout from the W, continuing E.

Pre-event situation

The rider is approaching a roundabout on a clear road and begins to brake.

Start of event

The rider realises late that there is a vehicle, either entering or already on the roundabout, that has priority and that he must give way to it. There is just perceptible jerk at this point as the rider applies extra force to the front brake

Climax of event

The rider reaches the point of maximal braking, with the front suspension heavily compressed.

Resolution of event

The rider eases off the brakes, having slowed sufficiently for the other vehicle to pass in front, taking the exit. The rider continues around the roundabout.

Discussion

The bike's braking profile from when the brakes are first applied until maximal braking is actually fairly smooth. However, in the video the eye is able to perceive a slight jerk as the front dips down, at the point where it is believed the rider identified the risk posed by the other vehicle. It is not known whether the incident occurred due to the rider failing to spot the vehicle, failing to recognise the need to give way, or if he misjudged the relative speeds of the two vehicles. Once again this incident was flagged up by the sensor analysis. The brake pressure, suspension compression and deceleration rate were 99.6 psi, 35.4 mm and 3.87 m/s$^2$ respectively, with the corresponding threshold values for Rider 4 being 80.3 psi, 33.1 mm and 3.81 m/s$^2$.

**Event 20**

Event identification

| | |
|---|---|
| Participant number | 4 |
| Date & Time | 15/05/2011 – 09:20 |
| Event severity | Near crash |
| Trigger | Rider report |

Overview of event

The rider pulled out to overtake a van without properly checking that the way was clear and nearly crashed into an oncoming car, just managing to pull back in at the last moment. The aerial photograph below shows the location at which the event occurred. The rider was travelling NE.

Pre-event situation

The rider is on a social ride with another biker. The other bike has passed a van in front and the rider is looking to do the same. He has positioned himself close to the centreline in order to identify a gap in oncoming traffic.

Start of event

It is not clear why the rider does not maintain his position near the centreline. However, having believed he has identified a suitable gap the rider has moved across to the left of the lane. As the 4x4 passes the rider leans right to begin his planned overtake, despite being unsighted at the time.

Climax of event

As the rider pulls out he realises that there is in fact another vehicle coming. The rider quickly leans the bike over to the left, but this is not sufficient to bring the bike back over the centreline.

Resolution of event

The rider is still riding to the right of the centreline when the oncoming vehicle passes, narrowly missing him (fortunately the car driver has moved across in an attempt to leave as much room as possible). The rider then continues past the van.

Discussion

The above sequence is probably the closest to a serious crash that any of the riders came during the study. The cause of the event was that the rider pulled out into an inappropriate gap, but this was exacerbated by the fact that the rider swung across right as quickly as he did. It is not clear why the rider moved over so far left in the lane prior to the overtake, but it meant that he not only crossed the centreline too swiftly, but also that he was unsighted to oncoming traffic for several seconds prior to starting the overtake. The fact that he was riding with a companion may have been an influencing factor, making the need to pass the van quickly seem more pronounced. Being on a social ride may also have made the rider feel more like he wanted to promote the feeling of having fun on the bike, which may also help to explain the wide, sweeping manoeuvre.