2BESAFE

2-WHEELER BEHAVIOUR AND SAFETY

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Executive summary

Naturalistic driving studies that have to date involved the deployment of four-wheeled vehicles instrumented with equipment to automatically record vehicle and driver behaviour, provide a unique insight into driving behaviour and performance, in normal, near-critical and critical situations. This methodology will be employed to comprehend riding behaviour within the 2BESAFE project.

Naturalistic riding studies – as indicated by their name – are based upon research on the natural environment looking at participant (rider) behaviour and performance in the real world. Hence, the aim of naturalistic riding studies is to unobtrusively collect data on riding behaviour and performance in naturalistic settings and conditions. However, as the participant is aware of being monitored and as there is instrumentation that could be visible by the participant, practically, unobtrusively means interfering as little as possible with participant decisions and performance.

Several naturalistic driving studies have been implemented in Europe, the US and Australia to understand driver behaviour. However, the situation is quite different with naturalistic riding studies. There is only one such study that is known to be underway, with no results being public. This report illustrates the development of a detailed methodology for conducting a series of parallel naturalistic riding studies in Europe – namely, in France, Greece, Italy and the UK, involving several instrumented PTWs. The know-how of naturalistic driving study methodologies will be used as a basis upon which the methodology of the naturalistic riding study will be elaborated taking into account the distinct differences between PTWs and passenger cars as well as several constraints implied by this type of study and project. Hence, because of several different features between a passenger car and a PTW the design of a naturalistic riding study will have similarities with that of a driving study, but will also have significant differences.

The core difference between these types of studies is that existing knowledge about passenger car movement characteristics and driver behaviour has been extensively studied. On the contrary there is little knowledge on PTW movement characteristics and driver behaviour. This makes the job of rider behaviour observation a more difficult one; and at the same time, a more challenging one. There are no set values to describe riding patterns, conflicts, etc of PTW riders. This will be achieved through a synthesis of the existing knowledge on passenger cars, the determination of the differences between a passenger car and a PTW, and a trial-and-error procedure described in this report.

The core similarity between the naturalistic driving and riding study methodologies is that the steps that need to be taken towards its design are similar. In particular, the aim of the experiment has to be defined and the different hypotheses and questions need to be elaborated. Based on the above, the behaviours that one wants to capture should be determined through the appropriate variables and scenarios. This means defining participant characteristics, instrumentation for collecting and recording data, and other data tools. Other issues that need to be considered include the development and implementation of participant recruitment and briefing/training materials, instrumentation installation and testing, data storage and analysis, the resolution of legal and ethical issues and other issues relating to the conduct and implementation of the study.

This report presents an experimental design that is recommended when conducting a naturalistic riding study, taking as a starting point the knowledge that has been acquired through naturalistic driving studies. Following this, the differences between a PTW and a passenger car are presented leading to the identification of the significant differences between a driving and a riding study. The possible objectives of a naturalistic riding study and the ones that are relevant to the present study are discussed, along with the research questions and hypotheses that derive from them. All the necessary elements comprising a naturalistic riding study are investigated and presented starting from observed behaviours and appropriate study parameters, scenario design (including participant and riding environment characteristics) continuing through to tools used for the experiment and data issues leading to conduct of the experiment and implementation strategies. In the concluding section of the report, an implementation plan is presented which details the practical procedures that should be followed step-by-step in order to realise the study.

1. Introduction

PTW riders are considered to be vulnerable road users since their risk rates are high, especially compared to that 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 2BESAFE 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 2BESAFE 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 naturalistic driving studies that have been undertaken was conducted. This was necessary, as a starting point, for the design of the naturalistic riding study due to the absence of other naturalistic riding studies. In particular, following an extensive search, only one such study (i.e. riding rather than driving) was identified, which is still underway, and as yet no results have been made public. Hence, using knowledge of the methodology of a naturalistic driving study that is acquired through Activity 2.1 and using 2BESAFE partners' expertise and experience, the experimental design of a naturalistic riding study is in this report defined within the framework of Activity 2.2. Within Activity 2.3 the experimental design defined in this report will be implemented.

PTW's demonstrate both high accident rates and high severity rates, the latter being a consequence mainly of the absence of separation between the rider and the road environment. Hence, for the exact same accident e.g. hitting a tree with a speed of 50km/h a driver would most probably suffer less severe consequences than a PTW rider. Factors that contribute to accidents and their consequences can be classified into three distinct categories:

- Human behaviour
- Road environment
- Vehicle

The first category involves human causes that mainly involve human errors (of riders, drivers and pedestrians), which are dependent on several parameters - some quantitative and others qualitative- some identifiable, and others not. Such parameters can include rider age, gender, riding experience, motives for riding, aim of trip, use of helmet and protective clothing, conspicuity issues, state of mind at the time of the trip, familiarity with the specific route etc. It must be noted that the above also involve driver and not just rider characteristics, as in many cases PTW accidents involve other vehicles.

Road environmental factors involve several characteristics such as road and pavement design and prevailing characteristics (road surface, type of road or intersection, number of lanes, speed limit, bends, gradient, roadside barriers, visibility, lighting etc.), traffic conditions (prevailing speed, traffic composition, traffic density and flow etc.) or other more general environment characteristics (weather, time of day, etc.).

Last, under the vehicle characteristics category, elements such as type of PTW, PTW characteristics (engine size, PTW size, type of brakes etc.), maintenance condition (brakes, tyres, lights etc.) and additional instrumentation/items (ABS, baggage, navigation systems) are involved.

Accidentology is not a new scientific domain, and the number of PTW accident studies is quite large. Accident analysis either at a macro or at an in-depth level has indicated the degree at which several of the aforementioned parameters contribute to road accidents and their outcomes. In addition, research of human and societal factors that may lead to increased risk for PTW riders has also progressed through the implementation of several methods (such as questionnaires, guided discussions, employment of video-based methods etc.).

The above methods can illustrate the "what's" (factors that increase rider risk) and the "whys" (mainly from a human and societal point of view). However, what has not been well established is the "how". The "how" can be described through capturing riding behaviour at a micro and continuous level. The following can describe the different issues that could be answered by the "hows":

- How do riders behave in general?
- How do riders behave to cause an accident?
- How do riders behave to avoid an imminent accident?
- How do riders behave in order to avoid getting into an accident?
- How do riders interact with other road users (riders, drivers etc)?

Understanding riding behaviour together with results coming from other methods could set a more concrete basis for the design of accident countermeasures, and is hence essential. The best way for understanding riding behaviour given improvements in modern technology is through monitoring, recording and analysing it. Such an objective can be established in an efficient manner through the performance of naturalistic riding studies.

Naturalistic riding studies – as indicated by their name – are based upon research on the natural environment looking at participant (i.e. PTW rider) behaviour and performance in the real world. Hence, the aim of naturalistic rider studies is to unobtrusively collect data on riding behaviour and performance in naturalistic settings and conditions. However, as the participant is aware of being monitored and as there is instrumentation that could be visible by the participant, unobtrusively means in a practical sense interfering as little as possible with participant decisions and performance.

Several naturalistic driving studies have been implemented in Europe, the US and Australia to understand driver behaviour, however, the situation is quite different with naturalistic riding studies. There is only one known study that is underway, with no results being public yet (Doerzaph, 2008). Hence, because of several different features between a passenger car and a PTW, the design of a naturalistic riding study might have similarities with that of a naturalistic driving study, but there will be many significant differences.

This report defines the experimental design for conducting a naturalistic riding study, taking as a starting point the knowledge that has been acquired through naturalistic driving studies. Following this, the differences between a PTW and a passenger car are presented leading to the identification of the significant differences between a driving and a riding study. The possible objectives of a naturalistic riding study and the ones that are relevant to the present study are discussed, along with the research questions and hypotheses that derive from them. All the necessary elements comprising a naturalistic riding study are investigated and presented starting from observed behaviours and appropriate study parameters, scenario design (including participant and riding environment characteristics) continuing through to tools used for the experiment and data issues leading to conduct of the experiment and implementation strategies. In the concluding section of the report, an implementation plan is presented which details the practical procedures that should be followed step-by-step in order to realise the study.

2. About naturalistic driving and riding studies

2.1. Review of major naturalistic driving studies

The first step towards the elaboration of the experimental design and implementation plan of the naturalistic riding study involved acquiring the necessary knowledge on naturalistic driving studies. Hence in Activity 2.1 several naturalistic driving studies were reviewed in search of information useful for the design stage of the naturalistic riding study. Relevant studies involving Field Operational Tests (FOTs) were also reviewed as these, like NDSs, involve the observation of driver performance and behaviour using instrumented vehicles, but in a more constrained way experimentally. The following studies were reviewed:

- The 100-Car Naturalistic Driving Study;
- A study on driver distraction in commercial operations based on NDS data;
- A comprehensive examination of naturalistic lane-changes;
- Naturalistic driving observation to investigate distraction exposure and IVIS pattern of use;
- Distractions in Everyday Driving; and
- Naturalistic Studies of Driver Assistance System Use

These were complemented by review of the Test Site Sweden FOT and the Field opErational teSt supporT Action (FESTA) project.

The review derived common information about vehicles, research questions and behaviours observed, as well as sensors and signals, and experimental methodologies. The topic of sensors and signals will be discussed in chapter 5, while experimental methodologies are discussed in the next section.

Vehicles: all these studies used 4-wheeled vehicles (cars or trucks), and thus not all the information can be transposed to the 2BESAFE naturalistic riding study because of different PTW kinematics and space constraints for sensors.

Research questions and behaviours: four studies, including the 100-car study, investigate as the primary or secondary objective driver distraction in terms of distraction typology and related frequency (the distraction types are reported in 2BESAFE deliverable D4). Two additional studies concentrated respectively on the monitoring of (Advanced) Driver Assistance Systems and In-Vehicle Information Systems (IVIS). However only the 100-car Naturalistic Driving Study focuses, as its primary objective, on conflicts with other road users, ranging from crashes to near-crashes and incidents (definitions of terms are contained in D4 or in the project reports).

2.2. Experimental methodology

The reviewed studies provided information also on the following topics:

- Size of the study (vehicles employed and duration),
- Vehicle ownership and installation of instrumentation,
- Participant characteristics,
- Data storage, and
- Data analysis.

Size of the study: the number of vehicles used for the naturalistic studies is not always specified. However 100 vehicles were used in “The 100-car naturalistic driving study” and 55 trucks in the “Driver distraction in commercial operations”.

Vehicle ownership and installation of instrumentation: in all studies the vehicles were owned by the drivers or their companies, and in no case by the research institutes. The drivers’ vehicle ownership requires a specific attention to the installation of the instrumentation with an accurate planning and a strict methodological approach since:

- Drivers use their vehicles daily and a long installation time is not acceptable to them;
- The installation cannot require structural modification of the vehicles as also a de-installation must be performed to restore the status quo.

In addition, to simplify the installation procedures, the vehicle choice must be limited to a few makes and models.

Participant characteristics: little information was found about this in the previous studies. The most important statement is from “The 100-car naturalistic driving study” where the recruitment strategy was to look for drivers with a risk exposure above the average. The practical implementation was to select drivers with high yearly mileage and young drivers. Extreme drivers (very safe or very unsafe) were eliminated from the selection process.

Data storage: all research that addressed this topic, pointed out the necessity to use a *fail safe* procedure for data storage (and download). A minimum requirement of two copies for the raw data must exist until data processing. Afterwards a single copy of raw data is acceptable in parallel to a database of processed data (e.g. database of events or of behaviours).

Data analysis: typical data analysis includes the review of raw data to identify relevant events or/and behaviours (data reduction) and subsequent analysis for calculation of various indexes. In case video data is complemented by other signals, automatic triggers for a pre-screening of the events is possible, although a manual review is always necessary. A typical record of a relevant event/behaviour includes both signals prior and posterior to the main matter. The time repartition is usually 1/3 and 2/3 respectively for the pre- and post-event.

Reduced data are always stored in an appropriate database structure to facilitate subsequent analysis. The similarities of the 2BESAFE naturalistic riding study and of “The 100-car naturalistic driving study” can be exploited to use the database of the latter study as a starting point both for the definition of the database structure and for the coding of events (e.g. manoeuvres, contributing factors, and behaviours). The review has indicated that elaboration of indexes needs also the availability of data for normal driving conditions, which requires the creation of a baseline database comprised of non-events/behaviours extracted from the same set of raw data.

2.3. Differences between powered two-wheelers (PTWs) and passenger vehicles

PTWs have distinctively different characteristics from passenger vehicles. Hence, the development of the experimental design for a naturalistic riding study can be built upon that of a naturalistic driving study taking into account several significant differences between the two vehicle platforms. Within this sub-section the differences between a PTW and a passenger car - both the inherent characteristics but also their consequent effect on riders and riding behaviour - are dealt with. The easiest identifiable differences involve inherent characteristics. These include:

- Movement on two rather than four wheels
- Absence of separation with the driving environment
- Smaller length
- Significantly smaller width
- Significantly less weight and higher weight/rider weight ration
- Higher seat position
- Smaller free space in the vehicle
- Higher deceleration and acceleration values
- More degrees of freedom of movement (the bike can roll from side to side)

As a result of some of the aforementioned elements, the rider body and the PTW comprises one system concerning vehicle movement, as body position also affects vehicle dynamics. Hence, taking into account all of the aforementioned differences one can state that PTW dynamics differ significantly from those of passenger cars leading to:

- Higher severity risk in the event of a collision
- Different vehicle control behaviour
- Different driving motives

PTW's demonstrate higher severity risk than passenger cars due in part to the reduced stability of the PTW (leading to easier loss of control of the PTW) and due to the absence of separation between the rider and the driving environment. For the same situation, for example the opening of a door of a parked vehicle just in front of a moving vehicle, the accident consequences would differ significantly between the vehicle being a PTW and a passenger car. In the first case, the PTW could go out of their way and also fall on the road and the rider could be also thrown on the pavement. In the second case, there would only be minor property damage issues.

Different driving behaviour involves several types of behaviour that PTW's can and do exhibit. These include abrupt braking and accelerating, keeping small headways both longitudinal and lateral ones with other vehicles, weaving within a lane, lane splitting, rolling the bike when manoeuvring, etc. This type of movement makes the trajectory of a PTW more difficult to be captured and described.

2.4. Similarities and differences between naturalistic driving and riding study methodologies

The core difference between these types of studies is that today the existing knowledge of passenger car movement characteristics and driver behaviour is well advanced. On the contrary there is relatively little knowledge on PTW movement characteristics and rider behaviour. This makes the job of rider behaviour observation more difficult and at the same time more challenging, as the performance measurements cannot be tailored to specific behaviours. There are no set values to describe riding patterns, conflicts, etc. This will be achieved through a synthesis of the existing knowledge on passenger cars, the determination of the differences between a passenger car and a PTW and a trial-and-error procedure.

The core similarity between the naturalistic driving and riding study methodologies is that the steps that need to be taken towards the design are similar. In particular, the aim of the experiment has to be defined and the different hypotheses and questions need to be elaborated. Based on the above, the behaviours that one wants to capture should be determined through the appropriate variables and scenarios. This means defining participant characteristics, recording instrumentation, and other data tools. Remaining issues relate to participant recruitment and briefing/training, instrumentation installation and testing, data storage and analysis, legal and ethical issues and other issues related to the conduct and implementation of the study.

In general, in naturalistic driving studies extreme values of the scenario variables are avoided (i.e. high risk driver groups) so as not to put the driver at great risk. As noted in the previous section, PTW riders are at greater risk of crashing and seriously injuring themselves than drivers of other vehicles. This results in having to be even more cautious when designing the scenarios (determining rider characteristics and rider recruitment strategies, location characteristics and PTW characteristics), in order to avoid risky situations that could lead to PTW accidents during the study. Such variables can include for example type of road, road surface, weather conditions, participant age, participant experience, riding with passengers etc.

Another similarity involves the monitored variables and the capabilities of the instrumentation. For example, in both cases the space and speed trajectory need to be recorded - and in both cases, there is a minimal frequency at which the recording should be made. In addition, a video camera providing an image of the surrounding road environment is always a supporting tool. However, PTW dynamics are more complex than those of other vehicles, and additional parameters are required for their description. This leads to the necessity of introducing new variables to describe PTW movement. Such an example is the angle between the road surface and the vehicle. The PTW/rider body/road surface can demonstrate various angles rather than just a fixed one which is the case for other vehicles. Other examples include yaw angle, roll angle, rear and front wheel spin angles, pitch angle, and the actuation of front/rear brakes. Consequently, instrumentation that caters for these additional needs has to be used. Due to the complex movement characteristics of PTW's (in PTW riding behaviour) the investigated parameters should be well monitored. Hence, recording accuracy is of greater importance than for naturalistic driving experiments - at least involving specific variables such as vehicle coordinates, longitudinal and lateral headways, speed, etc. This may also mean that errors in recording parameters are more difficult to be traced and filtered.

Both the existing and the additional needs in respect of the selected instrumentation should be catered for within the framework of further constraints involving the instrumentation, which follow:

- Instrumentation should be weather proof unless if it can be fitted in a “top box”,
- Instrumentation should not be too big so that it can be accommodated in the limited space available on the motorbike,
- Instrumentation should be light so as not to increase the PTW weight significantly,
- Instrumentation has to be carefully placed so as not to alter the centre of mass of the PTW,
- Instrumentation has to be of small size so that it does not alter the “appearance” of the PTW,
- Instrumentation should be such that in case of a fall it produces the least additional consequences for the rider,
- Instrumentation should be such (weight, dimensions and placement) that obstruction of the ridervwhile riding should be kept to a minimum.

In addition, capturing rider face and eye movement unobtrusively is rather challenging especially in the case where the rider is wearing a helmet.

Participant training and briefing are expected to be similar as in both cases the wording “naturalistic” is of great importance. No particular training is required as drivers are instructed to drive normally. One difference between the present study and most of the previous naturalistic driving ones is that in the latter case participants used their own vehicle for the study. However, in the present study participants will be given a PTW owned by the institute conducting the study. This requires a selection process that should take into account the type of PTW ridden by the participant which should be as similar to the instrumented one as possible. Data storage and data analysis issues are more similar for riding and driving studies. One difference might be the way in which data are collected, i.e. the manner and frequency.

Similar legal and ethical issues are raised in the study design of both naturalistic driving and riding studies, in that instrumentation is added on the vehicle and personal data are recorded. Other issues that may arise involve vehicle certification. Apparently, the equipment that can be instrumented on a PTW is “less” (smaller, less items, less weight) than that on a passenger car, due to the limited space on the PTW. However, wherever vehicle certification is required it might be harder to prove that the instrumented PTW is safe, and hence to obtain the certification.

By and large, naturalistic driving studies can provide a good basis upon which a naturalistic riding study can be built. Still, all the selected elements of the study should be determined with great caution so as to design a successful study.

3. From research questions to key elements

3.1. Study objectives

This section identifies the objectives of the study allowing for their classification under specific scenarios starting from basic to more complex ones. In general, naturalistic driving studies aim at understanding driver behaviour and interaction with the driving environment including other road users and the road environment. They usually focus on identifying elements of driver behaviour and driving environment that are related to road accidents, in order to determine suitable measures for improving road safety. Another type of naturalistic riding study, called a Field Operational Test (FOT) aims at testing specific systems and their impact on driver behaviour. In the case of PTW, the study described here is one of the first naturalistic riding studies. Consequently, there is no basis upon which the methodology for the study can be based (other than reference to studies involving four-wheeled vehicles) to cater for the distinct characteristics of PTW. In addition, riding behaviour has not been studied in depth, resulting in several aspects of this behaviour being unknown.

The lack of knowledge on the two aforementioned key issues results in the need to define a more fundamental objective for this study. This involves the validation of the experimental methodology which includes choice of several experimental elements (behaviours observed, monitored parameters, etc) instrumentation, data collection and data analysis tools and procedure. Hence, on this basis the first objective of the experiment is to:

" 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." (Objective 1)

This objective is not a purely scientific one and can be also classified as organisational. In addition to the aforementioned elements the organisational objectives could be the following:

- test the designed methodology on PTWs and draft guidelines which can give guidance on elements for the design and implementation of a naturalistic riding study,
- verify the full observability of all rider behaviours (i.e. from our data acquisition are we seeing something that we cannot fully observe since we miss some sensors?) or the improvement of the instrumentation since some sensors could give us more information although not new behaviours (e.g. we have no distance from the leading or surrounding vehicles; is this missing information?),
- deliver a data structure that can be used for a larger study and is validated by the 2BESAFE experience (or created and then complemented by enhancements derived from the 2BESAFE experience).

The remaining objectives that will be discussed in this section can be classified as purely scientific.

The second objective is to:

"distinguish between, and hence be capable of describing, different riding patterns, from the recorded data." (Objective 2)

This involves understanding the differences in data values and their combinations and de-coding the different data parameters that have been collected into different types of riding behaviour.

A third objective is to:

"understand riding behaviour in two distinct situations – under "normal" conditions and where there is conflict behaviour." (Objective 3)

Hence, the observation of riding behaviour and PTW dynamics through the recorded parameters collected during the study should yield some indications of how to quantitatively identify when a conflict or near-accident takes place. This would allow the development of triggers for the next and final objective of such a study which is:

"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)." (Objective 4)

Hence, for the fourth objective of the study the following elements are involved:

- Start the observation of riders' behaviours during near-miss situations and perform a classification and quantification,
- Determine the relevant: pre-event manoeuvres, avoidance manoeuvres, driver factors (where appropriate the same subcategories as in the 100-car naturalistic driving study can be used: wilful behaviour, driver impairments, driver proficiency error, inattention to forward road i.e. secondary tasks, and driving related inattention) and post avoidance manoeuvres.

If results are such that this objective could be achieved, 2BESAFE could give a good contribution in the redefinition of the section on driver factors, as PTW riders demonstrate distinct differences in their riding behaviour in relation to the driving behaviour of car drivers (in addition, specific driver behaviours are inapplicable to riders and vice versa). Other elements of the traffic environment that may affect road safety, and could be identified through a naturalistic riding study (as was the case with the 100-Car driving study) are:

- precipitating factors,
- contributing factors (which include the already mentioned driver factors plus infrastructure, environmental and vehicle factors),
- associated vehicles/roadway states (with subcategories of driving environment, and infrastructure).

In the case where data are not adequate then, instead of only near-accident conflicts – which will be referred to as conflicts in the text – incidents (conflict[s] requiring an evasive manoeuvre, but of lesser magnitude than a near-crash) could also be investigated as an alternative (again this was the case with the 100-Car driving study).

Generally speaking, the organisational part of the objectives is much focused on providing a basis for future studies - for example allowing for the possibility of a large follow up European study. Although this is not clearly stated in the 2BESAFE Annex, it still comprises a significant output.

3.2. Hypothesis testing

According to the different objectives that were set in Section 3.1, different hypotheses are proposed. Starting from the organisational objectives, the following hypotheses should be tested.

- The instrumentation does not alter PTW dynamics and rider driving behaviour.
- 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.).
- The data parameters and their accuracy are sufficient to provide a good quantitative and qualitative description of rider behaviour.
- The procedure of data storage did not influence the course of the study, and was implemented efficiently.
- The methodology for data analysis is appropriate and yields the requested output.

- No legal or ethical issues are raised during the study and during data processing.

Questions that should be answered are the following:

- What are the lessons learned from the naturalistic riding study in respect to the above elements?
- What is the most appropriate implementation time schedule for a large NRS?
- How could the instrumentation be modified/integrated to improve the observation of riders' behaviours?
- How could other elements of the study (data storage, analysis methodology etc.) be modified/integrated to improve the observation of riders' behaviours?
- 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?

Scientific hypotheses cannot be defined as one is not certain about the results of the study. However, several questions should be considered to achieve the aforementioned scientific objectives.

- What rider patterns can be identified by the data? Could these patterns be correlated with specific rider profiles? – This question mainly corresponds to several of the "how" questions mentioned in section1.
- How can one define and distinguish between riding under "normal" conditions or riding at conflicts? 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.
- 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?"
- What are the differences between one week of field data and one month of naturalistic riding data?
- What are the differences:
- among the different scenarios in the different countries?
- among the factors that contribute to these scenarios, in different countries?

3.3. Behaviour observation

In terms of behaviour observation there are four different aspects that should be investigated. The first involves "simple" observation in order to validate the instrumentation, data collection and analysis whereas the other aspects involve more complex observation. Hence, for the first aspect (validation of instrument), no specific type of behaviour needs to be observed.

For the second aspect, different riding patterns should be established. These could involve different types of riding. A simple classification could be cautious versus risky riding behaviour. Other types of riding patterns could also emerge from the data.

The third aspect involves distinguishing between two different situations – namely, riding under "normal" conditions and conflict behaviour. In this case, completely different behaviour that only applies for a short period of time should be sought. The elements of the "different" behaviour should be investigated to conclude whether this is conflict behaviour or not.

Last, once a conflict has been defined in the data, the behaviour occurring prior to and following the conflict should be investigated to see whether aggregated results can be extracted, for several such cases.

3.4. Parameter identification

There are several vehicle and rider parameters that describe elements of rider behaviour, some of which are the following (for most parameters min/max/average and variation are of interest):

- Speed
- Acceleration
- Deceleration
- Steering angle
- Longitudinal time/space headway
- Lateral (time)/space headway
- Relative speed with vehicles in the close proximity
- Reaction time
- Position in lane
- Lane changing behaviour
- Rider position on the PTW
- Use of turn indicators
- Use of lights
- Eye glance behaviour (where is the driver looking? for how long? i.e. road scene, mirrors etc)
- Psycho-physiological measures of rider's state
- Use of protective devices (indirect)

The possibility of being able to describe rider behaviour in an accurate manner increases with the increase in the number of recorded parameters. However, this implies more complicated data analysis which needs more time to be implemented and is not guaranteed to provide results in the end. Hence, an optimal solution is to record the most significant parameters that are expected to be adequate for rider behaviour description in the manner mentioned previously. However, as there are no predecessors of naturalistic riding studies, the knowledge of which are the most appropriate parameters does not exist.

Other constraints (other than time) in choosing to record all the aforementioned parameters are equipment cost, installation and de-installation procedures, rider obstruction (of view or relating to riding tasks), issues with PTW certification, complexity in data synchronisation and analysis. These constraints together with the parameters that are expected to be of significance will set the guidelines for selecting the study parameters and the respective instrumentation. It must also be noted that the frequency with which these parameters are recorded and their accuracy also play an important role in understanding riding behaviour.

Parameters that are anticipated to be significant for PTW rider behaviour are speed, acceleration and deceleration, longitudinal and lateral headways (especially for urban scenarios), position in the lane, rider position on the PTW (especially at bends), and steering angle.

3.5. Scenario design

Scenario design is a crucial step towards designing a study, even in the case of a naturalistic riding study where the rider is instructed to ride normally. In this study, each partner performing the study will define different characteristics of the specific elements of the scenario design.

In the case of naturalistic riding studies the different elements that comprise the scenario design can be somewhat defined by the choice of the participant. Participant characteristics that might be of interest in a naturalistic riding study and that might serve as criteria in participant selection are the following:

- Rider age – young riders and elderly riders are at higher risk of crashing than "middle-age" riders,
- Rider experience – novice riders demonstrate higher risk and different behaviours from experienced riders, different types of errors have also been identified,

- Rider gender – male riders usually ride “bigger” bikes and exhibit riskier riding behaviour than women,
- Type of PTW – because the PTW used in the study will not be owned by the participant, it is preferable to use a PTW similar to the one the participant typically uses; type of PTW may also yield the actual motives (e.g. riding for recreation) for riding,
- Use of both car and PTW for trips – this has not been investigated but it could be the case that a rider who also drives a car has different behaviour from the rider who only uses a PTW,
- PTW mileage – high PTW mileage (at least higher than average) is considered to provide more accurate results in a study,
- Accident history – is an indicator of rider behaviour in terms of individual crash risk,
- Typical types of trips with the PTW – defines several elements such as type of network where trips take place, trip flexibility. e.g. if PTW is used for trips for work it might be the case that the rider needs to reach the destination at a specific time, he/she cannot postpone a trip in the case of adverse conditions, the rider is familiar with the road network etc.,
- Area of residence, work, trips – defines the type of network in which the trips take place, together with typical types of trips,
- Motives for riding – indicates riding behaviour, e.g. wants to ride fast, whether rides for commuting reasons etc
- Sensation seeking behaviour.

Hence, participants with specific characteristics can be recruited depending on the aims of the naturalistic study, e.g. where riding behaviour of specific groups should be investigated (i.e. risky riders, commuters, pleasure riders, riding in rural areas etc). As this study is a simple one, no specific behaviours are sought; general characteristics and type of network where trips take place will be selected. The general characteristics could include rider age, gender, experience, exposure, accident history and type of PTW ridden.

The definition of the riding environment comprises a significant element of the study experimental methodology. As this is a naturalistic study, which means that participants are instructed to use the PTW as they would for their usual trips, there are no restrictions on the riding environment and hence this element of the study cannot be pre-determined. However, it could be somewhat determined at a more general level indirectly through the choice of participants. For example, if one is interested in investigating urban trips, then selecting a participant who uses his/her PTW for commuting and both his/her home and work are in an urban area (even better if in the same city), this will result in the recording of urban trips. However, a microscopic determination, e.g. use of specific types of intersections, cannot be achieved. In addition, traffic conditions can also be somewhat selected if needed, once more by selecting a participant who performs trips at specific networks and ay specific times of day. However, there can be variations in respect to the riding environment characteristics compared to those originally set. In broad terms, what is of interest is the type of road network: urban, interurban, rural, etc.

The determination of the tools used to collect the data will be mainly defined by the selected parameters (and vice versa). Hence, according to the above-mention constraints and to the specific parameters of interest, the type of instrumentation will be defined. In addition, self-reported (i.e., subjective) data tools will also be designed to support and complement the (objective) data that will be recorded automatically. The self-reported data tools will be standardised. These involve a questionnaire where rider characteristics will be recorded. In addition, a sensation seeking or risk taking questionnaire can also be used. Last, a questionnaire serving in the form of a travel diary serving as a data log can also be used.

4. Riding behaviour and experimental scenario design

Carrying out a naturalistic riding study means letting riders use an instrumented vehicle exactly in the same way they would use their own motorbike, for the same purpose, without any constraints. This implies a *transparent* experimental design: nothing is really controlled or imposed. However, **this does not mean that there is no experimental design at all**. There are still a lot of parameters which the experiment designer can choose, or on which he/she may have an influence. These parameters are the following:

- vehicles
- riding environment and driving patterns
- riders

To control those parameters as much as possible, in a relevant way, the following actions have taken place:

Use of accidentology data to identify typical accident scenarios in each country – to decide which types of scenarios are of interest for the research

- From the aforementioned accident scenarios, the situations which preceded them (i.e. the situations we're searching for in the study) are derived, as well as the characteristics of typical riders, vehicles, and environment characteristics which correspond to those scenarios.

PTWs which are representative of general PTW usage while also being commonly involved in accidents are selected to be used in the study. These types of PTW will be instrumented in order to be able to monitor and record rider behaviour

Recruited riders who:

use a similar kind of motorbike,

ride in environments and have driving patterns corresponding to those found in the selected accident scenarios,

have relevant characteristics (age, gender, experience, personality traits, such as attitude toward risk), corresponding to the situations.

This workflow is synthesized in the following figure:

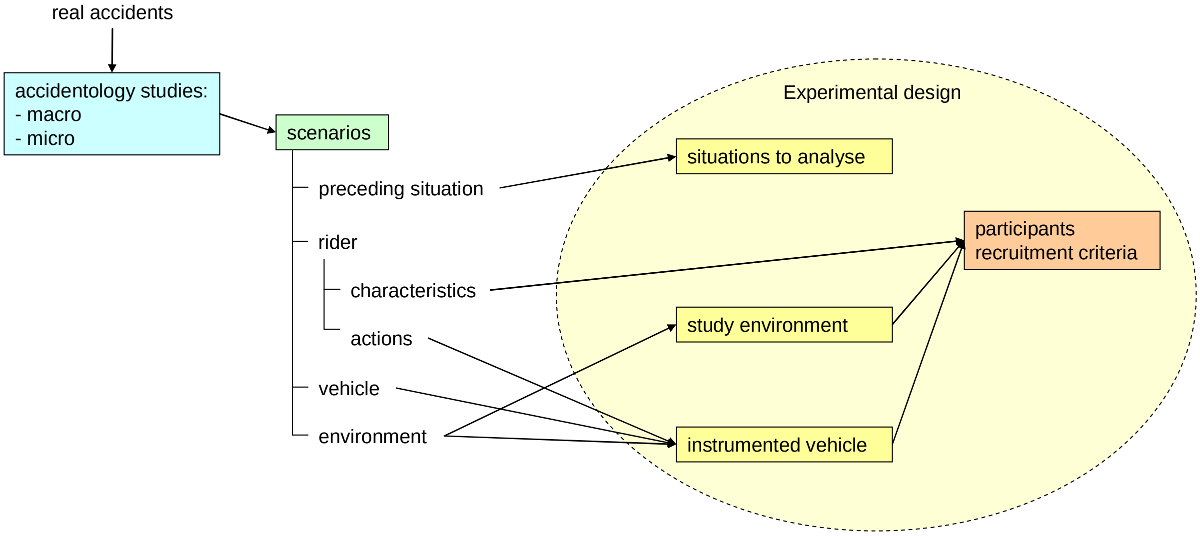


Figure 4.1. Experimental design specification workflow.

Where data allows, it is a process which will be implemented on a country-by-country basis. This process is detailed in the following subsection of the chapter (Section 4.2.2.).

4.1. Definition of riding behaviours

The aim of this chapter is to identify the most frequent road accidents and risky situations from a macro and micro point of view, in order to define dangerous riding behaviours of PTW users. At each study site, the experimental design will then be defined in a way allowing the observation and analysis of situations which precede, and may lead to or cause, the most frequent accident types. This chapter is based on the results of the deliverable WP1, D1, "Rider and Driver behaviours and road safety for PTW", from the 2BESAFE project (Phan et al., 2010).

In the 2BESAFE project, only motorcycles (motorbikes and scooters, above 50cc) will be instrumented and studied (France : 800cc Honda VFR and 1000cc Honda CBF, Italy: Piaggio Beverly Tourer 300, Greece: 650cc BMW Funduro, United Kingdom: 1000cc Yamaha). Therefore, we decided that only motorcycle accidents would be considered, excluding mopeds.

4.1.1. Rider risk factors

4.1.1.1. Identification of motorcycle accidents

Accidentology results extracted from national databases and in–depth databases, for a 2-year period, from 2006 to 2007, have been used to identify the most frequent fatal motorcycle accident scenarios in Finland, France, Greece, Italy and United Kingdom. Even if other, less critical, accident types are important, mainly fatal accidents have been analysed within WP1, because this was the only way to get data which could be compared among the different countries. This decision to focus on fatal crashes is retained, as the data is the same as that used in WP1.

Macro analysis level (national data)

Motorcycle accidents data

The analysis of national databases in the five countries studied in 2BESAFE project (Finland, France, Greece, Italy and the United Kingdom) shows that:

- 68% to 96% of PTW (mopeds and motorcycles) accidents are motorcycle accidents;
- 68% to 96% of PTW fatal accidents are motorcycle fatal accidents.

PTW fatal accidents	Accidents	Fatalities
Finland	74	75
France	2221	2292
Greece	912	954
Italy	2768	2891
The United Kingdom	1154	1187
Total	**7129**	**7399**

Motorcycle fatal accidents	Accidents	Fatalities
Finland	50 (68%)	51 (68%)
France	1564 (70%)	1625 (71%)
Greece	816 (89%)	853 (89%)
Italy	2117 (76%)	2212 (77%)
The United Kingdom	1109 (96%)	1141 (96%)
Total	**5656 (79%)**	**5882 (79%)**

Table 4.1. PTW fatal accidents and motorcycle fatal accidents (2006,2007)

These data confirm the focus on motorcycles, instead of mopeds.

Motorcycle accident configurations and scenarios

The accident configurations were selected according to the type(s) of other vehicles involved in the accident, the number of vehicles (including pedestrians) involved in the accident, location of the accident (outside or inside urban area) and road layout configuration (whether accidents happen at a junction).

Table 4.2 summarizes the different motorcycle accident scenarios for each study country and the type and number of vehicles involved in the accident. In total, there are 12 motorcycle accident configurations.

% → is the percentage of PTW accident configuration per number of vehicles involved in the accidents. For instance, 81.8% of fatal single motorcycle accidents in Finland are outside urban areas and not at intersections.

%T →is the percentage of motorcycle accident configuration considering the type of PTW. For instance, 36.0% of fatal motorcycle accidents in Finland are outside urban area and not at intersections.

The table shows that:

- Motorcycle accidents not at intersections and outside urban areas, involving only a passenger car and a motorcycle, is an issue in all countries.
- Motorcycle accidents at intersections and inside the urban area, involving only a passenger car and a motorcycle, is an issue in all countries.
- Motorcycle accidents not at an intersection and inside urban areas, involving only a passenger car and a motorcycle, is an issue in France, Greece, Italy and UK.
- Motorcycle accidents at intersections and outside the urban area, involving only a passenger car and a motorcycle, is an issue in Finland, Italy and UK.
- Motorcycle accidents not at an intersection and outside urban areas, involving only a truck and a motorcycle are issues in Finland, France and Italy.
- Motorcycle accidents at an intersection and inside urban areas, involving only a truck and a motorcycle are issues in Greece and Italy.
- Motorcycle accidents at intersections and outside urban areas, involving only a truck and a motorcycle are issues only in Greece.

Motorcycle Accident configuration	Finland		France		Greece		Italy		United Kingdom	
	%	%T	%	%T	%	%T	%	%T	%	%T
Single motorcycle accident – Outside urban area – No intersection	81.8%	36.0%	55.1%	19.4%	43.3%	18.1%	53.2%	15.3%	53.1%	12.3%
Single motorcycle accident – Inside urban area – No intersection	18.2%	8.0%	37.0%	13.0%	47.4%	19.9%	35.1%	10.1%	17.2%	4.0%
Single motorcycle accident – Outside urban area –Intersection									14.8%	3.4%
Single motorcycle accident – Inside urban area – Intersection									14.8%	3.4%
Total Single motorcycle accident	***100%***		***92.0%***		***90.6%***		***88.3%***		***100%***	
Motorcycle / Passenger car accident – Outside urban area – No intersection	33.3%	14.0%	37.5%	20.8%	17.7%	9.6%	16.4%	10.5%	22.2%	11.5%
Motorcycle / Passenger car accident – Inside urban area – No intersection			14.7%	8.1%	25.2%	13.6%	19.6%	12.5%	5.1%	2.6%
Motorcycle / Passenger car accident – Inside urban area – Intersection	19.0%	8.0%	12.5%	6.9%	21.5%	11.6%	26.5%	16.9%	13.7%	7.0%
Motorcycle / Truck accident – Outside urban area – No intersection	14.3%	6.0%	13.5%	7.5%			4.5%	2.9%		
Motorcycle / Passenger car accident – Outside urban area – Intersection	14.3%	6.0%					13.0%	8.3%	22.1%	11.4%
Motorcycle / Truck accident – Inside urban area – Intersection					5.4%	2.9%	4.3%	2.7%		
Motorcycle / Truck accident – Outside urban area – Intersection					2.3%	1.2%				
Total Motorcycle / Another vehicle	***81.0%***		***78.2%***		***72.1%***		***84.4%***		***63.0%***	
More than three vehicles									100.0%	25.4%
TOTAL MOTORCYCLE ACCIDENTS		**78.0%**		**75.8%**		**77.0%**		**79.2%**		**81.0%**

Table 4.2. Main fatal accident scenarios by country according to the number and type of vehicles involved in the accident, the location and the road layout (Motorcycle fatal accidents, 2006 and 2007)

Scenarios which account for more than 10 percent of the total have been marked in red for each country. They should serve as a baseline to define the situations which will be searched for in each country where a naturalistic driving study will take place (France, Greece, Italy, United Kingdom):

In France, fatal accidents mostly happen outside urban areas, whether alone or with a passenger car, and not at of intersections. It is worth noting though, that the same configurations inside urban areas (alone or with a passenger car and not at intersections) are also represented.

In Greece, even if single-motorcycle accidents outside of urban areas are important, most accidents happen in urban areas, so this is where the focus should be directed.

The same could be said about **Italy**. Compared to Greece, however, single-motorcycle accidents outside urban areas are under re-presented, whereas interactions with passenger cars seem to be the cause of more fatal accidents.

United-Kingdom figures seem atypical with a quarter of fatal accidents involving three vehicles or more, in situations which are no more precise. However, examination of other figures shows that the study should favour the observation of situations happening outside of urban areas.

This gives general clues about the kind of environment where the recruited riders should be riding.

Information about the characteristics of riders involved in those accidents and their motorcycles is available in micro analysis-level studies. Those studies would also allow us to clarify the environments where accidents happen. However, data from all countries is at present used together to contribute to the characterization of each scenario. Differences between countries would therefore be more difficult to take into account at that level of description. Though, we can still rely on the fact that some scenarios are more frequent than others in each country.

Micro analysis level (in–depth database)

For the in-depth analysis, 391 PTW (mopeds and motorcycles) accidents have been analysed in WP1 deliverable 1. The 7 main scenarios have been selected for motorcycle accidents and are defined as follows:

Scenario 1: Single motorcycle accident – Outside urban area – No intersection

Scenario 2: Single motorcycle accident – Inside urban area – No intersection,

Scenario 3: Single motorcycle accident – Inside urban area –Intersection,

Scenario 4: Motorcycle / passenger car accident – Outside urban area – No intersection,

Scenario 5: Motorcycle / passenger car accident – Inside urban area – No intersection,

Scenario 6: Motorcycle / passenger car accident – Inside urban area – Intersection,

Scenario 7: Motorcycle / passenger car accident – Outside urban area – Intersection.

Four models have been used to understand and classify the causal factors which contribute to crashes and incidents. They are described below, and we have identified for each of them in which way they could be used to build the experimental design of the naturalistic riding study:

1	Model description	The first model is the Driver-Vehicle-Environment (DVE) system description, which considers the rider (eg. the rider's professional status, family status, age, gender, etc), the other party involved in the crash, the vehicles involved (eg. vehicle type, vehicle age, vehicle defects, etc) and the environment (eg. type of road, road geometry, traffic density, etc).
	Comment	This model is of particular interest for us: it is where the most interesting conditions where we should observe naturalistic riding are identified.
2	Model description	The second model relates to each phase in the evolution of the crash – the normal driving phase, the precipitating event, the emergency phase, the crash phase and the post-collision phase (Brenac, 1997; Fleury et al., 2001).
	Comment	Results from this model won't be used as a basis for experimental design definition: the naturalistic riding study itself shall provide additional and complementary data for the understanding of normal driving to precipitating event phase. However, the way this model is defined could be used as a part of the framework used to analyse data gathered during the experiment (i.e. it can inspire a way to describe events which will be analysed).
3	Model description	The third model, the human functional failure (HFF) model (Van Elslande and Fouquet, 2007), classifies factors, characterizing the state of the system and their interactions, which explain human failures that contribute to crashes.
	Comment	This model identifies personality traits of most involved riders. Those traits could be searched for during recruitment, by the use of questionnaires. In addition, this model can be used to classify the basic rider functional failures that contribute to critical events that we find in the dataset.

4	Model description	The final model is the DREAM 3.0 model (Driving Reliability and Error Analysis Method; Warner et al., 2008). DREAM 3.0 provides a way to systematically classify and record accident causation information which has been gathered through in-depth crash investigations. The classification scheme in DREAM 3.0 consists of so-called “phenotypes” and “genotypes”. Phenotypes - Phenotypes are the “observable effects” of an accident and include human actions and system events. The 6 general phenotypes are - timing, speed, distance, direction, force, and object. The 10 specific phenotypes are: too early action; too late action; no action; too high speed; too low speed; too short distance; wrong direction; surplus force; insufficient force; and adjacent object. Genotypes - Genotypes are the factors that may have contributed to the observable effects - in other words, the contributing factors. Usually they cannot be observed, and hence have to be deduced e.g. from interviews with drivers and accident reports.
	Comment	Although Phenotypes correspond partly to what we can observe in the naturalistic riding study, Genotypes give clues about the original causes of accidents, and hence will give clue about the experimental design as well.

Table 4.3. Accident analysis models description

The results of those four models applied to the seven main scenarios are detailed in Tables 1-3, in the Annex. We will now use them to extract the information which is relevant to build the experimental plan in each country, in two steps:

We first identify basic facts about the most relevant scenarios: rider, motorbike, and environment characteristics. The naturalistic riding study should then be designed in a way where those characteristics are met.

We then list the underlying dysfunctions, and the inappropriate behaviours in which they resulted. The naturalistic riding study should then allow observing those behaviours in a much more precise than what can be inferred after an accident as happened.

The method is described below taking France as an example. Only scenarios 1, 2 and 4 are therefore used. However, the same work is carried out for each country organizing a riding study.

4.1.1.2. Riders, Motorbikes, and Environment characteristics

As explained above, Riders, Motorbikes and Environment characteristics are extracted for scenarios the most relevant to France, i.e. 1, 2 and 4.

Riders

Whatever the scenario, riders involved in accident are generally males.

In scenarios 1 and 2 (single motorcycle accident), riders have common characteristics: they are aged between 25 and 50, have 3 years of riding experience, and generally overestimate their skills.

In scenario 4, the range of age represented is different: less than 25 and more than 50 years old are overrepresented.

Motorbikes

In all 3 scenarios, either conventional street PTW or sport motorcycles are represented, the engine being typically around 600cc. Generally, motorbikes are in good state at the time of the accident.

This confirms that the choices made for the two motorbikes in the French study, a sports-tourer and a roadster, are indeed relevant, as they are representative of motorbikes generally used and specifically observed in the most frequent scenarios in that country.

Environment

Scenarios themselves roughly define the environment: most frequent scenarios in France are “outside urban areas” scenarios.

Accidents in scenarios 1 and 4 (outside urban area) generally occur throughout the day, whereas accidents in scenario 2 (single motorcycle accident in urban area) happen at night.

Although scenario 1 generally happens in curves, 2 and 4 happen on straight roads.

All accidents generally happen with good weather conditions, on a dry surface. Though, reduced friction or poor road maintenance can sometime explain single motorcycle accidents (loss of control).

The most common accident causes are dysfunctions, which resulted in improper behaviour. This is what will be now presented in detail.

4.1.1.3. Underlying dysfunctions and riders' behaviour

Some dysfunctions and improper behaviour emerge, when analysing scenarios 1, 2 and 4:

- Excessive or inadapted speed
- Intentional risk taking or insufficient risk evaluation
- Overestimation of skills
- Typical manoeuvres from other road users, misinterpreted situation, expecting another user not to perform a manoeuvre, neglecting the need to search for information are all causes of conflicts.

From this, we conclude the following:

- The instrumentation shall not only allow observing motorbike dynamics and riders' actions. It should also allow:
- evaluating the adaptation of the speed to the conditions (legal speed limit, weather, traffic density, etc.);
- visualizing the environment and determine what has been or not perceived by the rider.
- Riders' attitudes toward risk could be taken into account during the recruitment process. This can be done with questionnaires (e.g. sensation seeking scale, or a scale assessing skill estimation).

4.1.1.4. Situations that are considered risky by PTW's

Finally, we will use outputs from Deliverable 21 of 2BESAFE to complete the previous finding with riders' own point of view.

Risky events defined in Cognitive Work Analysis Report

Motorcycle riders with many years of accumulated riding experience are experts and have valuable knowledge, skills and experience that can be drawn on to support the design of countermeasures to prevent accidents and injury (Regan et al., 2009).

In Deliverable 21 of the 2BESAFE project ("Using Cognitive Work Analysis to Derive Recommendations for Improving Motorcycle and Scooter Rider Safety") a technique called Cognitive Work Analysis (CWA) was used to illicit this knowledge from motorcycle riders. In a series of interviews, 31 riders were interviewed, alone or in pairs, in 3 countries: France (Paris), Austria (Vienna) and Australia. CWA was used to develop and structure the questions asked during the interviews, and to analyse the information derived from them.

The findings from the CWA are useful for WP2.2, in that they provide self-reported information about *events* that riders find risky when riding their powered two wheelers. These events can become points of focus in the naturalistic riding study to understand how the events arise, and how motorcycle riders attempt (successfully or unsuccessfully) to manage them.

From the CWA, the following events were identified by riders as key risks (Regan et al., p 71):

- Cars stopping in front unexpectedly (e.g. around Police cameras)
- Cars entering rider's lane unexpectedly
- Vehicles tailgating behind
- Falling off their PTW
- Cars ahead slowing suddenly in bends
- Wind from large vehicles (eg trucks) passing them quickly

- Vehicles passing too close
- Vehicles cutting corners
- Vehicles suddenly turning left or right in front of them
- Vehicles not using turn signals when they should
- Vehicles not stopping at intersections when they should
- Doors opening from parked cars on narrow streets
- Drivers using mobile phones
- Drivers not looking to their sides
- Burning cigarette butts thrown out of cars
- Animals on country roads (e.g. deer)
- Insect caught inside rider's helmet

Situations perceived as risky from the PTW rider's point of view.

The findings from the Cognitive Work Analysis (CWA) performed in WP5.5 of the 2BESAFE project also provide self-reported information about *situations* that riders find risky when riding their powered two wheelers.

From the CWA, various situations were identified by riders as risky. These are summarized below under various headings (Regan et al., 2009).

Own behaviour	cornering too quickly not being predictable to other road users splitting lanes situations requiring emergency manoeuvres
Behaviour of others	others driving in an unfit state e.g. distracted, fatigued, inebriated, especially at night (as they are less predictable). unaware pedestrians (e.g. when distracted) vehicles and drivers that behave erratically: foreign drivers (from other cities, villages or countries) unfamiliar with local traffic conditions taxis van drivers pizza delivery scooters peer pressure from pillion riders to ride unsafely
Invisibility	i.e. any situation in which riders cannot be seen by other road users (especially by truck drivers)
Road surface features	tram tracks oil on road after light rain; slippery surface paints; smooth pavements; raked gravel surfaces; vertical height differences at the junction of road

	lanes; metal plates on bridges that act as dilation buffers; road signs placed too close to the road edge; oil and fuel spills; wet bark; wet leaves; pot holes; holes with oil metal pothole covers duct covers reflective “cats eyes” on the road dirt and mud on country roads infrastructure close to roadside waste and loads fallen from trucks, especially on country roads
Weather conditions	heavy rain being cold, which is distracting snow ice fog strong wind light dirty rain oily spray from vehicles ahead
Rider state	when inebriated (alcohol) when drugged when fatigued when distracted dust in eyes riding into the sun (ie sun glare)
Time of day	in darkness on days of week when most dangerous to ride

The aforementioned scenarios can support the de-coding of the data from variable numbers to scenarios and the explanation of several riding behaviours.

4.1.2. Summary: what should be observed

From all the findings in 4.1.1, we have finally elicited pivot points on which the naturalistic riding study should focus.

If participants are to be “exposed” riders, they should:

- be male
- likely be overconfident (sensation seekers)

No condition on age is necessary to be set. It has been shown as well that riders with some experience also have accidents, so it is not necessary to recruit beginners. Riders with a few years of experience should be favoured.

Instrumented motorcycles have already been chosen. Their instrumentation shall allow measuring their dynamics and riders’ actions (steering, accelerating, and braking). It should also be possible to evaluate the adaptation of the speed to the conditions and to visualize the environment and determine what has and has not been perceived by the rider; and, if it has been perceived, if it has been perceived correctly (video).

Riding conditions such as **weather** and **illumination** (day/night) should be monitored.

It must also be possible to derive geographic situation and specific road type characteristics from the data.

4.2. Experimental scenario design

As explained at the beginning of chapter 4, experimental scenario design will mainly end up being the definition of **who** we recruit, **where** they usually drive, and **what** type of motorbike (including instrumentation) we lend to them. Section 4.1 gave clues about what *should* be done ideally in order to investigate risky situations. However, practical constraints, safety, and the necessity to have a statistical sample sufficient enough to draw sound conclusions also impose limits. It is by crossing what we aim at with the several constraints, that an experiment can be designed in each country.

4.2.1. Recorded parameters

Two kind of parameters are recorded: objective data (instrumented motorbikes), and subjective data (questionnaires).

4.2.1.1. Objective data

Parameters recorded by instrumented vehicles are detailed in WP4 deliverable. The recorded parameters in all four studies are:

- PTW position
- Speed
- Acceleration/Deceleration
- Brake activation (and brake pressure in some sites)
- Steering angle
- Throttle position
- Activation of turn signal
- 2 channels of video (the first one filming the face of the rider and the other the raod in front of the scooter)

The observation of the aforementioned parameters can, following the appropriate analysis, demonstrate different riding patterns.

In addition, riding patterns could be classified and if “extreme” riding behaviour/patterns are found, i.e. patterns that do not resemble those that yield “normal” behaviour, it can be assumed that a conflict has taken place. However, the aforementioned analysis could not easily extract such information. Hence, in addition to the riding parameters, video footage will also be used. Hence, there will be front view video and rider's face video. From this, relevant parameters can be extracted: elements of the road scene such as longitudinal distance and relative speed with preceding vehicles; other elements of the preceding vehicle behaviour; obstacle appearance; and gaze direction. These parameters will allow a better understanding of the rider's behaviour by reconstructing the riding scene. Hence, although significant quantitative parameters will not be recorded directly, for example longitudinal and lateral headways, the addition of video footage might help overcome this limitation and manage to identify riding patterns and critical situations.

4.2.1.2. Subjective data

Subjective data allows us to:

- exclude riders from the study who do not meet the screening criteria
- obtain insights that cannot be obtained by objective methods
- collect data that cannot, for technical reasons, be collected by the vehicle data acquisition system
- understand why a hypothesis tested does not yield an expected result
- understand why a rider may have behaved they way they did
- be able to describe the participant sample

Subjective data will be gathered at different times (e.g., recruitment, during and after the study)throughout the study:

- At recruitment time, questionnaires will be administered to select the most exposed riders. These questionnaires, currently being designed, will also include the following categories :
- Socio-demographic characteristics
- Riding experience and driving patterns (including accident record)
- Riding habits (self-reporting of ordinary errors and violations)
- Attitude towards risk/ sensation seeking/ skill estimation
- Questionnaires administered during or after the experiment (for each rider) will provide for comments, description of behaviour, incidents etc.

More information about subjective data parameters and collection procedures is provided in Chapter 6.

4.2.2. Participant and environment characteristics

As has already been said, the selection of participant recruitment criteria is the most important aspect of the experimental design. Those criteria have been defined for each country, taking into account:

- Characteristics of exposed riders (4.1), especially in the most important scenarios for each country.
- Situations where accidents happen (again, on a country basis)
- Other constrains, such as insurance.

Experimental environment is controlled by:

- Recruiting riders who ride in geographical environments which are over-represented in real accident data, and by
- Organizing the experiment at a time of year where climatic conditions over-represented in real accident data are met.

4.2.2.1. French study

In the French study, participants will be:

- 12 participants who each ride 1 bike for one month (as there are two instrumented motorbikes, the duration of data collection will be 6 months)
- Males
- Of any age

- With around 2 to 3 years of riding experience (2 years being a minimum imposed by insurance)
- Using motorbikes similar to those which will be lent (for common sense reasons as well as to satisfy an insurance request).
- Who have never had any accident (insurance request) but who are not overly “prudent” either (medium to high-medium level of sensation seeking).
- Driving at least 15000 km/year (in order to gather a sufficient quantity of data), including a fair amount of riding outside of urban areas (scenarios 1 and 4).

Since riders avoid using their motorbikes when climate conditions are bad, few accidents happen then (Winkelbauer, et al., 2009), and few data would be recorded anyway if the experiment took place in such conditions. Therefore, the experiment will be organized at periods where climatic conditions are good (winter will be avoided).

4.2.2.2. Greek study

The participants should be males as they are over-represented in accidents, but also in the riding population. Hence, being over-represented in accidents does not necessarily indicate that they demonstrate riskier behaviours than female riders. The choice of male participants is supported by them being a typical rider (between the two genders) and also by them being involved in more accidents.

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 avoid the participants being involved in accidents. Hence, participants should have an actual riding experience of at least 5 years and should not be older than 50 years old.

Another issue is that the selected participant should ride a bike that resembles that of the study vehicle, which is a BMW 650cc bike, so that he is familiar with bike characteristics and movement dynamics and hence with handling the bike.

It is also important to select participants who use their bike frequently. Hence, this will also be a characteristic of the selected riders. As the study will take place in Volos, which is not a large city, riding exposure will not be judged by the annual kilometres, but by riding frequency and typical trip distance.

In addition, due to the high severity crash rates of riders, it is preferable not to select a rider with a “heavy” accident involvement record, as the possibility of the participant being involved in an accident during the study should be minimised. On the other hand, a rider with an “empty” accident record could imply a very cautious rider, who is rarely involved in conflicts. Hence, it is preferable that participants do not have an entirely empty accident record.

Last, in terms of riding environment, PTWs 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 environment. In addition, accident statistics also indicate that more accidents happen inside urban areas than outside urban areas. For these reasons, the selected participant should someone who uses his PTW for trips inside the urban area.

4.2.2.3. Italian study

The UNIFI research team will preferably recruit participants with the following characteristics:

- Males;
- Of any age (however preferably 20 to 50 years old);
- Any riding experience;
- Users of medium-/max-scooters;
- Who are able to report some near-missed accidents in the past;

- Driving at least 2000 km/year (this value is considered a minimum value for daily commuting use inside urban areas; higher mileage is welcome and it could indicate that also extra-urban journeys are made).

The scooter will be used to perform data acquisition over a 6 months period, employing 6 riders.

4.2.2.4. British study

In the British study, participants will be:

- 6 participants, 1 participant per month
- Males
- Of any age
- With around 2 to 3 years of riding experience
- Using motorbikes similar to that which will be lent (requires them to own a 1000cc bike that is classified as a ‘supersport’ motorcycle).
- No specific requirement to use riders that have not had an accident before or picked up points for speeding, however some discretion will be applied to avoid using riders who pose an excessively high risk to themselves or others.
- Driving at least 10,000 miles per year

The experiment will be conducted over the middle part of the year to avoid the winter months.

5. Tools to be used

5.1. Vehicle instrumentation

5.1.1. Available tools

The review of naturalistic driving studies and field operational tests, made in deliverable D4 of this project, gave useful information regarding the signals recorded and the instrumentation used. While a complete review can be found in the cited deliverable, here it is useful to recall the main findings to support the decisions for the design of the naturalistic riding study.

All reviewed studies collect information with questionnaires for the characterization of the drivers in terms of:

- demographic data;
- personality;
- driving style/patterns.

In addition a variable set of signals is recorded through sensors. In all cases video is used, and, in case of minimal instrumentation, it can be the sole instrumentation although several cameras are often installed. For other studies, which employed a more complex system of signals and sensors, the information is reported in the following Tables.

The 100-Car Naturalistic Driving Study	
Signals	Sensors
distance to lead and following vehicles; longitudinal and transversal acceleration; gyroscopic signals; GPS position; brake activation (light); turn signal; throttle; speed; mileage; 5 video signals (driver's face and driver side of the vehicle, forward view, rear view, passenger side of vehicle, and over-the-shoulder view for the driver's hands and surrounding areas); lane position; activation of the incident pushbutton; audio (active only if an incident pushbutton was pressed); glare.	a box to obtain data from the vehicle network (i.e. speed, throttle, turn signal, brake); an accelerometer box for longitudinal and lateral acceleration; two systems to provide information on distance respectively to lead and following vehicles (EATON VORAD EVT300 Doppler radar, 180 degrees of span, 9.14 m maximum distance); a system to detect conflicts with vehicles to either side of the participant vehicle; a GPS data module; cellular communication; an incident box to allow drivers to flag incidents for the research team; a video-based lane tracking system to measure lane keeping behaviour; video to validate any sensor-based findings (5 cameras).

Test Site Sweden FOT	
Signals	Sensors
GPS (position, speed and time for synchronisation); acceleration (longitudinal and lateral); steering wheel angle; pedal positions; gear lever position; yaw rate; engine speed; data from video (not specified); foot location (by sensors on pedals); activation of incident button.	not specified

Driver distraction in commercial vehicle operations	
Signals	Sensors
digital video; truck dynamic performance data (i.e., kinematic data; e.g., lateral and longitudinal acceleration, braking); truck-related measures (e.g., GPS, light level); incident pushbutton; audio.	connection to the vehicle network to read vehicle speed, distance since vehicle start-up, ignition signal, throttle position, and brake pressure; incident box comprised of a light meter (records the in-cab ambient illumination level) and an incident pushbutton (to flag the event and open for 30s an audio channel); 4 video cameras; driver drowsiness warning system; lane tracker.

A comprehensive examination of naturalistic lane-changes	
Signals	Sensors
video; speed; steering; acceleration; use of pedals; turn-signal use; information about surrounding vehicles, processing the data of three radar units (one forward and two rearward).	not specified

5.1.2. Instrumented PTWs

Based on the findings of the literature review and on the specific kinematics of PTWs, the project partners defined a common set of signals regarded as necessary for the observation of rider behaviour. In addition, each partner was free to include other sensors, capable of enriching the recorded information, while maintaining an unobtrusive instrumentation.

The list of basic common in all four studies vehicle signals includes:

- linear acceleration (three components);
- roll, yaw and pitch angles;
- longitudinal speed;
- brake activation;
- throttle position;
- steering angle;
- GPS position;
- turn signals;
- video: 2 cameras positioned to capture the frontal environment (required a minimum 90° field of view) and the rider's face.

Possible additions to the basic set of sensors could include:

- pressure of the brake circuits;
- rear and front wheel speed.

During the brainstorming phase for the definition of the relevant signals, the possibility to install a radar or lidar unit, to derive quantitative measurements of the surrounding environment (e.g. distance from the leading vehicle), was considered. The final decision did not include these signals and the related sensors because:

- the limited free space for the installation on the front of PTWs;
- the power requirements, which could create problems regarding the electric power balance of the vehicles.

The research group did not consider this information to be vital for the naturalistic riding study, although a future implementation may. However this decision will be revisited after the data processing phase, to make a final assessment about the necessity of this information and provide more precise guidance for future studies.

Data acquisition of all signals is set to be recorded at an accuracy of 100Hz except for video signals which are sampled at 10Hz and GPS position which can be sampled at 1Hz (values indicate minimal requirements). The specification for sampling frequency is derived from typical riders' reaction time measured independently by INRETS during previous research and by the PISa consortium (www.pisa-project.eu): an average value is 0.3-0.4 s and thus, for an appropriate instrumental description of the reactions, 15 signal samples are reputed necessary. The limitation for video frequency is set based on practical requirements for on board data storage.

The rationale behind the selection of signals will ensure that the following data are captured:

- riders' evasive manoeuvres (necessity for: accelerations, angles, speed, brake activation, throttle position and steering angle);
- causes of conflict with other road users (necessity for: video, turn signals);
- road type (necessity for: video, GPS position).

In addition, other information could be derived from the additional set of signals:

- braking action effectiveness (from pressure of brake circuits);
- distribution of braking action on the wheels (from pressure of brake circuits);
- wheel locking or skidding (from duplicated wheel speed measurements).

The PTWs used for the study are four motorbikes (Honda VFR 800 and Honda CBF 1000 at INRETS/CEESAR, Honda CBR 1000 at TRL, and BMW F650 FUNDURO at UoT/NTUA) and one scooter (Piaggio Beverly Tourer 300 at UNIFI) (Figure 5.1 to Figure 5.5). The instrumentation installed on the PTWs complies with the minimal requirements defined by the partners of the naturalistic riding study and in most cases it exceeds them:

INRETS/CEESAR vehicle:

- has two additional cameras mounted laterally on the top case to have a wider view of the forward environment;
- includes two tone wheels for the independent speed measurement of the front and rear wheel, and for a precise determination of the wheel position.

TRL vehicle:

- instrumented with a linear potentiometer on the front fork to monitor its loading;
- includes two pressure sensors to record the pressure of the brake circuits.

UNIFI vehicle mounts:

- two tone wheels for the independent speed measurement of the front and rear wheel, and for a precise determination of the wheel position;
- two pressure sensors in line with the brake circuits.

Details on the sensor characteristics and installation can be found in 2BESAFE deliverable D10, which is specific on the topic.

Figure 5.1. Honda VFR 800 (INRETS)

Figure 5.2. Honda CBF 1000 (INRETS)

Figure 5.3. Honda CBR 1000 (TRL)

Figure 5.4. Piaggio Beverly Tourer 300 (UNIFI)

Figure 5.5. BMW F650 Funduro (UoT)

5.2. Equipment installation and de-installation, testing and maintenance

5.2.1. Installation and de-installation

The naturalistic riding study organized within the 2BESAFE project has some specific characteristics compared to the naturalistic driving studies reviewed in deliverable D4. The most important ones, for the installation of the instrumentation, are:
the study is performed with PTWs owned by the research institutes and not by the riders;
each research institute will use a different bike and both scooters and motorcycles will be employed, in order to observe the most relevant usage patterns in each country.

As a consequence of these differences, in 2BESAFE no de-installation procedures were defined since:

- the instrumentation (make and type, not the signals or the functions) was defined at local (partner) level to match the requirements of the owned PTW;
- a single piece of that PTW is used in the research and thus no replication of the procedure is required;
- the de-installation is not required since the PTW is owned by the research institute and there is no necessity to restore it to the status prior to the beginning of the study to allow normal operation.

Based on these prerequisites the majority of partners involved in the research (INRETS, UNIFI and UoT) installed the instrumentation at their premises with the expertise of their technicians. UoT employed also an external technician expert on BMW motorcycles, while TRL contracted a specialized garage to perform the installations.

5.2.2. Technical support and maintenance strategies

Technical support and maintenance of the instrumented motorbikes is necessary throughout the data acquisition period to guarantee data quality and data consistence. The partners have agreed on a weekly inspection of the PTWs, performed on the occasion of the data download:

- a visual inspection will verify the status of mechanical components and sensors, to detect both loosening of components / sensors and any other mechanical damage derived from PTW use;
- an analysis of the data will allow to detect electronic failures of the sensors or even mechanical ones, for those sensors installed in area, not accessible for visual inspections.

In addition the riders will be asked to report any problem detected during PTW use. The research institutes will be directly responsible for repairs and replacements of parts and sensors. Each partner has already identified responsibilities for the maintenance.

In case of a failure the activities of the partner will be interrupted for the time strictly necessary for the reparation. Unfortunately the novelty of a naturalistic riding study does not allow to have historical data on typical failure rates of the sensors and thus no stocks can be created to shorten the intervention time. Stocks creations are also limited by the fragmentation of the PTW types and the instrumentation used.

5.2.3. Testing instrumentation inherent characteristics

Currently the INRETS/CEESAR bike has already been stressed-tested because it was used in previous experiments, while UoT has only performed short tests to verify the instrumentation accuracy, and the other partners (TRL, UNIFI) are currently completing the PTW setup.

As the setup is finalized all PTWs will be tested in operational conditions for several days by personnel of the research teams as part of a pilot study. The aim is manifold:

- test the robustness of the installation solutions;
- test the stability of the measurements over a significant period of time (at least one week);
- with a pilot test:
- verify all the procedures and activities planned for the naturalistic riding study;
- define appropriate triggers for automatic detection of events using the preliminary data acquisition.

Specifically, the measurement stability will be tested comparing the reading of the sensors at the extremities of the operative mechanical range on the bike.

In addition to the pilot study, TRL will test its bike on the internal track system, which allows it to reproduce operational conditions above the national speed limit of 70mph.

5.2.4. Testing interaction between additional instrumentation and inherent bike instrumentation

The interaction of the instrumentation with the PTW performances will be assessed during the pilot test. However the characteristics of the selected instrumentation (ref. section 5.1.2 of this deliverable and deliverable D10 -2BESAFE project-) allow us to make an a priori statement of neutral impact on PTW handling. Even the additional weight of the data acquisition systems is comparable to a typical payload stored in a box / bag and thus it will not interfere with PTW performance.

In addition, previous experiences of INRETS/CEESAR, gained in other experimental studies, have shown that riders reported one annoyance which involves difficulty in carrying stuff due to the top case occupied by the instrumentation devices. Also preliminary short tests performed by UoT have confirmed that there is no interaction between the instrumentation and the PTW.

5.2.5. Testing interaction between the instrumented PTW and rider behaviour

During the planning of the PTW instrumentation all research teams have merged information from:

- equipment suppliers;
- expert installers and/or PTW manufacturer;
- experience derived from previous research activities.

This knowledge constitutes a reliable basis to create an optimal instrumentation setup having minimal interference with rider behaviour. In addition:

- the dimensions of the sensors are always minimal because of the tight dimensional constraints on PTWs but also to minimize the interference with rider behaviour;
- the instrumentation is completely automated and thus it is expected that riders will soon forget that their actions are recorded. This statement is supported by evidence in previous naturalistic driving studies reviewed in deliverable D4.

Nonetheless, the interference of the instrumented PTW with rider behaviour will be verified during the pilot test. The evaluation method will rely on rider self-assessment compared to previous experience (modified/unmodified), since baseline behaviour of the pilot rider with the not-instrumented PTW is not available.

6. Data issues

6.1. Ensuring data quality through quality documents and procedures

6.1.1. Quality documents to be in place

The following documents are to be in place before the naturalistic riding study commences:

- Laboratory log template
- Riding log template

6.1.2. Laboratory logs

Laboratory logs represent a means of documenting the experimental activities of each project partner over the course of the trials, and of flagging any difficulties encountered and sharing the lessons learned within the group. In order for this to be successful, each partner must keep their logs up-to-date and accurate; sharing their experiences with the other members of the group in a timely manner.

The laboratory log is therefore a fluid document that will undergo numerous updates and corrections, from numerous contributors. It is advisable that this is treated as a formal process, and a document controller is identified for each partner, which will ensure the log is version controlled. To this end, all updates will go via the 'log controller', who will update the master copy and disseminate it amongst the group members. By ensuring that all changes first go through the log controller, each change can be numbered and strict control can be adhered to.

Should an issue be encountered, a deviation to the planned schedule or procedure be identified, or simply a scheduled update be required due to reaching a milestone, this will be documented in the laboratory log and forwarded to the log controller.

The logs should be periodically forwarded to the activity leaders (every 2 weeks) to ensure there are no issues with the trial implementation.

6.1.3. Experimental procedures

It essential that all partners undertake the trials in a consistent fashion, to ensure that the data obtained is both useful for statistical analysis within each country, and comparable between countries. Due to the differing logging/sensor equipment being used in each country, and possible differences in the demographic of participants, an exact match in procedures will not be possible.

One area for consideration is that the vehicle systems will require the GPS to be fully-functioning in order to track the vehicle. GPS units often require several minutes to acquire a sufficient number of satellites to track position, so riders will be asked to wait at least three minutes from when the engine is turned on before setting off on their journey. This will also help to cater for any time lag that may occur between engine start and all the data-logging equipment starting up. Given that motorcycle engines usually require a warm-up period, to avoid excess wear on moving parts, this requirement is not considered likely to represent a significant change from riders' normal routines.

If possible it would be of benefit to provide riders with a button mounted on the handlebars that will allow them to manually log a situation that they feel is of interest or where they felt endangered. This may not be in the interest of a fully naturalistic driving situation; a decision on this can be taken by each partner who will conduct trials.

6.2. Downloading data

6.2.1. Download method

Data will be downloaded by project staff during regular face-to-face meetings with the trial participant. Partners are free to download data at longer intervals i.e. monthly; however, this is done at their own risk and is not recommended as it could increase data loss if there is equipment failure. These will be conducted at a location to be agreed with each participant at the commencement of the trial – ideally at the participant's home address; reducing the need for the rider to make journeys outside 'normal use'. It may be advisable, in order to ensure the security of the research organisation's staff and to help ensure that there is always a witness to proceedings, that two members of staff should be present for each download.

Downloading data from the system, depending on the system, will be conducted by removing a compact memory card or connecting a laptop to the data logger by a USB/Ethernet cable. In order to prevent any unnecessary delays in the procedure, partner institutions will have at least two memory cards available; allowing the card to be changed-over during each data download visit.

6.2.2. Download intervals

Data will be downloaded at least a weekly basis, as it is felt this offers a balance between ensuring that data storage capacity is not exceeded and minimising disruption to the participant. As data downloads will also involve face-to-face meetings with the participant, it is felt that weekly downloads offer a good level of interaction with the participant to allow for questions to be answered and any technical issues to be quickly assessed and resolved.

The download frequency will ultimately depend on the use of the bike and the storage capacity of the logger, which may mean more frequent downloads are necessary. Video data produces large files and storage capacity is likely to limit video data to about 10-16 hours of continuous recording (logger dependant). Where possible there will be an automatic message generated by the data logger when storage capacity is nearing its limit; however, in most countries the data system will not facilitate such a warning. In cases where no system is available to alert researchers to storage capacity being exceeded, the download period will be determined following the pilot; this will give an indication of how much riding participants will do before the data is likely to be exceeded.

Riders will also be asked to inform the research institution if they have undertaken a particularly long ride, in which case an additional data download meeting will be scheduled. This will be undertaken in the normal location and under the same conditions as the regular download. In such a situation, participants will be contacted by phone to arrange the meeting.

6.2.3. Missing data

Missing data may indicate a malfunction with the recording equipment or a faulty sensor. This form of fault is inevitable during a study of this nature. Data should therefore undergo first-stage processing at the earliest opportunity following download in order that any malfunctioning equipment is identified as soon as possible to allow for repair work to be scheduled. Steps should be taken to record (in the Laboratory Log) what issue was experienced, how much data was lost and what the actions to resolve the technical issue were.

Datasets with missing data will, where possible, be processed as normal but with a note of what is missing. The decision on whether to use 'faulty' data in the analysis is to be made by the individual partner, with a short explanation being submitted to the WP2.3 leaders. Accurate maintenance of riding logs on the part of the participant will act as a further aid in identifying missing data. Participants will be reminded to keep an accurate diary during each data download meeting. If it is found that missing data is due to rider error, the participant will be advised on how to remedy their mistake; but given the equipment used this is unlikely.

6.3. Data reduction & filtering

6.3.1. Channels selected for recording

As described in 4.2.1.1. combinations of the following data channels are to be recorded (not all channels will be recorded by all partner institutions):

- Engine speed
- Throttle position
- 3-axis accelerometer
- 3-axis gyroscope (roll, pitch and yaw)
- Front and rear wheel speeds

- Handle bar rotation
- Damper load
- Brake lever application
- Front and rear brake pressures
- Foot-peg pressure
- Synchronised video
- GPS

6.3.2. Data archiving

It is advised that original data will be archived on a hard disk (on a laptop/desktop PC) at the partner's institution. The lead researcher in charge will make additional backup copies of the data at least once a week on a remote hard disk. This remote hard disk then will be kept in a secure area (possibly outside the laboratory – for data redundancy reasons).

Processed data is also to be uploaded to the FTP site (see section 6.5.1), which will act as an additional back-up and system to share information between the partners.

6.3.3. Data filtering

Filtering will be carried off-line and will be automatic; this will be dependent on data logging software that is used by the partner institute. The original data will be stored without any processing, allowing a record of the unchanged data to be kept.

Filtering will be applied prior to data analysis, or when data is converted to another data format. This ensures that if an interesting artefact is present in a particular signal, inappropriate filtering can be ruled out as a cause.

6.4. Self-report data collection tools

6.4.1. Self-report data of interest

In addition to the objective data to be recorded from the bike, it is considered important to have self-report data from the participants in order to add context to the data. The following is a list of the items that have been identified as being of interest for inclusion in the self-report data, along with the data-collection method to be used for each:

- Accounts of notable events during the trial, which should be recorded by the rider on the same day (riding log, debriefing interviews, follow-up questionnaire)
- Attitudes towards motorcycle ownership and use (primary and follow-up questionnaires)
- Details of general vehicle use throughout the trial (riding log, follow-up questionnaire)

6.4.2. Riding log

Participants will be asked to fill in a riding log during their participation in the trial. This is intended to capture their experiences and opinions; adding additional information on incidents, near-misses or other notable events. This data will supplement the quantitative data collected from the on-bike instrumentation.

The riding log must balance the desire for it to be a detailed information source on one hand, with the need to keep the log simple in order to encourage participants to use it regularly and consistently on the other. With this in mind the log will be designed to be used to fill in basic details of each ride at the end of each day. The log will also have provision for more substantial input from the participant regarding any specific experiences of note, which will lead debriefing interviews. In order to encourage participants to include details of any such incidents in appropriate detail, the log will have a number of spaces relating to specific elements. The participant will be advised to fill in as many of these as seems relevant to them in relation to the event.

6.4.3. Debriefing interviews

Debriefing interviews will be conducted with all riders at the end of their riding participation in order to capture general details of their experiences; however, it will also be useful to conduct face-to-face interviews following any notable events in order to build up a complete picture of what happened. This form of interview is best conducted soon after the event as the rider is likely to forget details over time. The rider log will be collected during each (weekly) data-collection meeting and a debriefing conducted at this time regarding any events recorded in the log.

Interviews will be conducted according to a standardised format with predetermined prompting questions. However, these will be open-ended questions where possible to encourage the participant to elaborate on the details they perceive to be important.

6.4.4. Questionnaires

A questionnaire will be sent to participants at the completion of their trial. It will contain questions relating to their experiences during the trial, as well as their general attitudes towards motorcycle ownership and use. The questionnaire will be designed by the activity leader, and circulated for use by the partners during the trial.

A primary questionnaire will be given to participants at the start of the trial in order to get information on their attitudes towards motorcycle ownership and their use of a bike; in addition to this there will be some personality profiling questionnaires, including an assessment of sensation-seeking tendencies.

6.5. Data storage

6.5.1. Storage location

In order to ensure that electronic data is kept securely and under the same conditions, data from all the partners will be transferred to a single server using a File Transfer Protocol (FTP) to be set up and maintained by TRL. However, in order to protect participant anonymity, partners will be required to psuedonymise/anonymise data files (using the codes below) before transferring the files to the communal server. Partners will therefore remain responsible for managing participant confidentiality and for retaining the ability to identify participants if required.

The electronic storage of data will include subjective data from participant questionnaires, log books and interviews. These will be converted to electronic format by partner institutions for transfer to the communal server. The original paper copies of these materials will be stored by the relevant partner institution in a secure cabinet, to which only the project leader has access.

All personal data will be destroyed once it no longer becomes necessary for analysis, if this can be defined; and if not, the data will be destroyed at the end of the study period at the latest. Non-personal data may be kept beyond the period of the study if it is felt that it may be of value to partner institutions in further work and if it can be agreed with the participant that it can be held. In such case the data will be made available to all partners, who will share equal intellectual property rights, regardless of the nationality of the source data.

6.5.2. Storage period

Data will be kept on the communal server for as long as is necessary. Given that the data will have been pseudonymised or anonymised by this stage, the sensitivity of the data will be minimal. It is therefore anticipated that all data will be stored until the end of the data analysis phase of the project.

Paper copies of the subjective data will be destroyed once the data analysis is completed.

A final decision on the storage of the data (change in procedure, destroying the data after analysis) will be made through a common decision by partners involved in Activity 2.3 during the life of the project. It is crucial that the project director and the work package leader are involved in this process.

6.5.3. Data labelling

The file name should be:

Name of partner – Participant number – Date of data collection

Example of the file name would be:

TRL_P1_(14-05-10).AVI

Or

TRL_P1_(14-05-10).TXT

6.5.4. Measures to protect anonymity

All data will be stored in a de-identidied format. The decryption key for each dataset will be held solely by the lead researcher for the relevant partner institution and will be stored separately from the data themselves. Measured data and personal data, acquired through questionnaires will be stored in separate databases. The pairing of the identity, with personal data and PTW acquired data, will only be done if requested by the participant or if required in order to resolve a technical query with the data. In any case, only the lead researcher for the relevant institution will have the power to make such a pairing - in any cases where this is necessary a report is to be made to the work package and activity leaders. Under normal circumstances, all the data processing is to be conducted without including the identity of the participant.

6.6. Data analysis

6.6.1. Synchronisation of data types

The different data streams recorded during trials will be automatically synchronised by the logger hardware/software, with the provision of 'time-stamping' as a minimum. Once the data records for each participant are collected, each country will take responsibility for ensuring the data file types are in a readily accessible format, allowing other partners to make use of the library of data that the project will produce. This will be achieved by ensuring that all partner institutions follow the same methodology as specified within this document.

All videos should be made available in their native format and in AVI or MPEG4 format

All data should be available in the original proprietary format and in txt format for import into other software

6.6.2. Data analysis tools / statistical packages

Partners will use SPSS (Statistical Package for the Social Sciences) V.17 for statistical analysis of the data where possible. If this is not possible a comparable statistical package is to be used; with the results of all statistical tests to be exported to Microsoft Excel for further use by the partners.

7. Conduct of Experiment

7.1. Legal/ethical issues

Legal and ethical issues associated with the project should be treated with great attention. Although the legal and ethical issues will differ between countries, the most crucial involve the following:

- Vehicle and driver insurance, vehicle certification
- Data privacy
- Ethical approval
- Legal aspects regarding video filming
- Agreements between promoter of the study and the participant

This section seeks to identify the legal and ethical issues that may apply to the parties involved in carrying out the naturalistic riding study within the 2BESAFE project framework. A review of all potential issues and corresponding suggestions for suitable mitigations is provided. It should be noted that the following is a review of likely risks involved in the proposed 2BESAFE study and is not intended to constitute a formal risk assessment.

7.1.1. Choice of study methodology

Potential issues:

- Chosen method is deemed to be unduly dangerous
- Alternative 'safer' method is identified
- Participant claims they have been exposed to unnecessary risks

2BESAFE Approach: The methodology chosen for the 2BESAFE project has been selected following consultation among partners. The core aim of the project is to understand naturalistic rider behaviour and so this requires that the study attempts to record naturalistic behaviour. This cannot be achieved without exposing the rider to real-world experiences and the longer the period over which data can be recorded, the better the chance that participants will behave in a 'natural' way. The necessary checks and procedures will be put in place (as discussed within this document) to ensure that riders are fit to ride the vehicles provided, both in terms of their health, riding proficiency and experience. The underlying principle is that, as participants will be asked to use the motorcycle provided in the way they normally would their own vehicle, they are not being asked to undertake any activities or risks outside of their normal routine and so should not be taking on additional risk to themselves or others. For these reasons the chosen methodology is considered to be necessary and reasonable.

7.1.2. Participant Recruitment

Potential issues:

- There is a bias in participant selection, whether intentional or not, discriminating against certain members of the population
- Participant not made aware of nature of study during recruitment
- Participant feels pressured into taking part
- Participant recruited who is not suitable for the study
- Participant dropping out of the study

2BESAFE Approach: The purpose of the study should be made clear when recruiting and it should be made clear that there is no obligation to take part. In general, such a study should aim to incorporate a representative cross-section of society in terms of gender, age, race and social background. This representative cross-section may however be naturally skewed towards a particular sub-set of the population who are motorcycle riders. It will also require that candidates have experience of riding the class of motorcycle to be used in the study to maximise both the validity of results and participant safety. It would be fair to reflect this in the selection of participants. However, as the study duration and resources are limited specific participant characteristics will be defined as described in section 4.2.2.

7.1.3. Participant Briefing

- Potential issues:
- Participant not aware of legal responsibilities
- Participant not aware of financial responsibilities
- Participant not made aware of personal rights
- Researchers not clear of participant rights
- Participant not aware of what to do in case of equipment failure
- Participant not properly briefed on the proper procedure in an emergency situation
- Participant not given sufficient opportunity to ask questions

2BESAFE Approach: Participant should be briefed in a friendly, relaxed environment where they are free to ask questions. The briefing should be given prior to signing any formal agreement, but should relate to the document such that the agreement is not perceived to raise any new issues. The briefing and the information transmitted will be given in the national language where the experiment is taking place. In addition, there should be a viewing of the PTW instrumentation systems so that the participant can get a better sense of what is involved.

7.1.4. Participant Agreement and 2BESAFE informed consent form

Potential issues:

- Participant not fully briefed before signing agreement
- Agreement does not demonstrate what the participants' briefing has entailed
- Agreement does not cover all the legal issues leaving responsibilities ambiguous
- Agreement is perceived as jargon and not fully understood by participant
- Agreement does not demonstrate that sufficient consent is given

2BESAFE Approach: All briefing materials should be finalised prior to the signing of the agreement. These materials should be explicitly appended to the agreement as a formal record of the briefing being given and of the content. The participant should be allowed to ask questions and to answer probing questions to verify their understanding. It should be clear within the signing of the agreement that the participant has been afforded this opportunity.

All test participants will be strictly adult volunteers and will have the ability to give informed written consent to participate. Indeed, experimenters will ask riders involved in the studies to sign an informed consent form. With this consent form, participants are informed of the purpose and the constraints of the study, they are informed that they are free to withdraw from the study anytime and that the confidentiality of their personal data is guaranteed and their personal data will be anonymous. Finally, if they really wish to protect their privacy, they will be able to stop the data recording for a short while. The ability for participants to do this will need to be considered during the design of the system setup on each individual data bike, as well as the implications for improper or overuse of this facility.

7.1.5. Licensing

Potential issues:

- The mounting of recording equipment renders the motorcycle unfit to ride

2BESAFE Approach: The addition of sensors and recording equipment to the motorcycle may cause an issue with regards to vehicle licensing and crashworthiness and must be properly checked for on-road legality with the appropriate national authority. The motorcycle should also be fully tested for ride and handling characteristics prior to being handed over to the participant as well as being checked to ensure there are no protruding parts of study equipment that could cause injury to a participant in the study or other member of the public.

7.1.6. Insurance

Potential issues:

- Participant's insurance invalidated by participation in study
- Research Institution's insurance not sufficient for study

2BESAFE Approach: As participants will be riding a motorcycle that is not their own there is a significant possibility that, for many, their existing insurance will not cover them for the use of that motorcycle. There may be differences between countries in finding the most appropriate solution. One option is for participants to contact their insurance provider to arrange for their policy to be changed to also include the use of the experimental motorcycle, and specifically to ensure that the insurance covers their use of the motorcycle as part of the 2BESAFE project. The participant should be asked to demonstrate that they are suitably insured for the study prior to commencement. An alternative is for the Research Institution to ensure that the rider and motorcycle are covered under the Institution's own insurance for the duration of the study.

7.1.7. Compensation

Potential issues:

- Participant not happy with responsibility for any financial imposition
- Research Institution conducting the experiment is liable for unexpected expenses

2BESAFE Approach: The specifics of who is liable for any costs (such as insurance, fuel, etc.) should be stated in the signed agreement and should be clear and unambiguous. It will be necessary to highlight to the participant which costs they would be liable for to ensure they are fully aware of their financial responsibilities.

7.1.8. Conducting the Study

Potential issues:

- Participant not kept informed about procedure
- Participant not given sufficient opportunity to ask questions
- Design of study causes or contributes to an accident
- Malfunctioning equipment causes or contributes to an accident
- Equipment injures a rider or member of the public
- Participant commits a traffic offence or some other form of dangerous riding while riding the study vehicle

2BESAFE Approach: Participants should be able to call a member of the research team for advice; if not 24/7, then during extended office hours. Need for urgent calls should be prevented by ensuring that the equipment installed during the trial cannot interrupt the normal riding task and can be switched off if necessary by the participant. Equipment should be securely fastened so that it cannot come loose except in the event of a major impact. Even in the event of such an incident, the equipment should be located and mounted in such a way that it will not contribute to rider injuries. If an offence or other form of dangerous riding is committed, the right of the participant's anonymity should be upheld - although the research team may feel it necessary to intervene within the confines of the study if poor riding is routinely observed. A clause permitting such an intervention should be included in the rider agreement as well as an express commitment from the rider not to knowingly indulge in illegal or otherwise dangerous acts whilst taking part in the study.

7.1.9. Retrieving the Data

Potential issues:

- Participant not consulted regarding data download session timing
- Motorcycle is damaged during data collection
- Participant not given opportunity to veto use of set of data

2BESAFE Approach: Data should only be retrieved in a pre-agreed manner and at pre-agreed times. Any data collection that may involve interfering with sensitive or safety critical parts of the bike should be conducted with the participant present. Participants should be given the opportunity to prevent a set of data being collected if they so wish. If this is not possible due to the nature of data collection there should be a specified delay from when data is collected to when analysis of the data commences to allow participants time to veto use of the data if they so wish.

7.1.10. Data protection

Potential issues:

- Data not properly stored
- Data not properly de-identified
- Images / data taken of third parties without their consent
- Researchers not clear of participant rights
- Researchers not clear of acceptable use of data
- Data requested by third party (e.g. police) following an incident on the road

2BESAFE Approach: Data, and any analysis material, should be stored in a secure location which can be accessed only by those members of the research team for whom access is necessary for the conduct of the study. The data should be de-identified at the earliest opportunity and the decryption key kept in a secure location, for use by only the one responsible for the whole project. Data related to third parties should not be an issue as only the designated rider may use the bike; but any such third party data that may arise should be deleted - provided this is possible and will not detract from the analysis. If deletion is not practical every effort should be made to contact the third party for consent prior to analysis being conducted of the data. Participants and researchers should be properly briefed in advance of the rights afforded to them by relevant legislation and of the procedures to be followed should reason arise for a third party to wish to view the data (for example the police, following an accident involving the participant during the study period). It is accepted that legislation will differ between countries and so partner Research Institutions will need to ensure that the rights and responsibilities of participants, researchers and the Research Institution are accounted for in line with the legislation in their own country.

7.2. Legal Documents

7.2.1. Legal requirements

The naturalistic riding studies must be implemented in full respect of the legal and ethical national requirements and code of practice. Whenever authorisations have to be obtained from national bodies, those authorisations should be considered as documents relevant to the study.

Partners will lead the research taking care to guarantee that no undue risk for the participants, whether technically, nor related to the breach of privacy, is possible.

Relevant laws and Directives to be considered (as a minimum) during 2BESAFE project are the following:

- Directive 95/46/EC concerning the protection of individuals with regard to the processing of personal data and on the free movement of such data
- Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector
- Directive 2001/20/EC or Clinical Trials Directive of Implementation of good clinical practice in the conduct of clinical trials on medicinal products for human use

In addition, to the above each country should follow their own legislation if not covered by that of the EC directives. To ensure that all legal obligations are followed during the course of the project, it is advised that institutions involved int he data collection consult a legal expert and not rely on their interpretation of the law. This is a complex area an should receive adequate resources to gain the best advice possible.

7.2.2. Legal permits

The legal documents required for riding a PTW include a rider’s driving license, the receipt of the national road tax and vehicle registration certificate. Additional, legal permits might be required for several reasons such as :

- Using the vehicle for research
- Instrumenting the vehicle with additional equipment
- Using other riders than those insured for the use of the bike
- Collecting and using personal data

As laws and protocols differ between countries, the actions undertaken by each country are somewhat different.

For France, CNIL, the French National Commission for Data protection, which is an independent French administrative authority, has a mission to ensure that data privacy law is applied to the collection, storage, and use of personal data. CEESAR will notify the implementation of the 2BESAFE database and its characteristics to the CNIL. It will also ensure that all rights of participants are respected, according to the law. In addition to that, CEESAR will submit the project to the Regional Ethics Committee for an approval before to start the experimentation.

For Greece, the instrumented PTW has been insured for use by participants. The insurance agreement also caters for the instrumentation of the PTW. No further legal permits are required for the instrumented bike to travel, according to the Greek legislation.

For Italy, UNIFI will sample the riders within the set of its employees. This choice does not limit the selections process since the riders will be not be more than 6 and UNIFI employees are 4000, but this simplifies strongly the procedures since a test plate can be used directly and thus no special permission is necessary from authorities. Italian law on the driving license apply in any case for the riders involved.

For the UK, TRL will contact the DVLA (UK Driver and Vehicle Licensing Agency) prior to commencing the study to obtain permission to use the vehicle on the UK highways (ensuring that the national road tax paid and insurance is obtained). TRL will also ensure that all riders are sufficiently trained to ride the vehicle and have a valid driving license at the time of trial.

7.2.3. Participant legal forms

The relevant legal forms involve (a) the forms provided by the participant and (b) the forms signed by the participant. In the first case, participants should present a valid riding license. Driver/rider licensing protocols differ between countries. For example, in the UK, all drivers must be in possession of a photo-card and paper counterpart to their license, the latter of which must be kept up to date with respect to driving penalties and restrictions. TRL are therefore able to check the validity of driving licenses without difficulty.

Regarding the second type of legal forms, all participants will be required to sign a consent form and a participant agreement, which will contain details on all aspects of the study. A description of the forms signed by the participant follows:

- Consent form to collect and store participant personal data. In the form it will also explain the purpose of the data collection and the participants' rights according to the law on data privacy,
- Participant agreement, which includes information on
- the project,
- the length of the data acquisition/vehicle loan,
- the experimental protocol,
- participants' rights, obligations and responsibilities (which include also the terms of use; e.g. the expenses paid by the research institute and those that must be paid by the rider).
- Authorization to use the collected data for scientific publications and presentations.

In addition, the participants should be informed about their duties during the study. These include completing the questionnaires and reports, being available for the download sessions and contacting the test leader whenever a problem or accident occurs. Riders should be asked to ride safely and to keep the traffic rules, and be reminded of their own responsibility for their riding and its consequences.

Lastly, the duration of the study and the responsibilities of the test leader have to be specified and the data of the support hotline provided.

7.3. Logistic implementation issues

Logistic implementation issues involve any type of transportation of the instrumented study vehicle. This need could result from transporting the PTW to its «base» (partner's premises usually) or to the participant (or the other way round). Another possibility that requires PTW transportation is the use of the bike by other partners.

In most cases, the participant will ride the bike from the partners' premises and return it to the same spot. Still, transportation if needed will be taken care of by the corresponding personnel of each partner. For the UK study, if the rider is based within 30 miles of the TRL site, TRL personnel will take the bike the participant's house. In addition, TRL have access to vehicles capable of transporting the motorcycle if required.

Each instrumented PTW will be used by the partner providing it. Hence, transportation of the PTW from one partners' premises to the other is not anticipated. In the case of France, there are three partners who may use the bikes and they are based in Paris, hence no specific transportation issues arise. The bikes are insured to be used by all three partners. For the case of the study undertaken by UNIFI and CIDAUT, if the bike and instrumentation would be transported to Spain, an agreement has to be drawn between partners. In this agreement issues regarding the way the PTW will be transported, handling the cost and seeking the appropriate insurance to cover the vehicle and the instrumentation must be addressed.

7.4. Experimental design

7.4.1. Duration

Setting the duration of the experiment provides a temporal start and end of the experiment. In research studies the duration of the experiment is a key variable. Experiment duration determines the amount of collected data and hence the extent to which it can be analysed. In addition, several other behavioural issues vary with experimental duration. These involve rider adaptation (to the study vehicle, with being monitored etc) and variation in prevailing conditions such as traffic conditions, weather conditions, etc. Riding behaviour both in terms of exposure and riding manner differs with weather conditions, at different degrees in different countries.

The exact total duration is not yet defined. However, an initial estimate is about six months' worth of data recording. Daily duration should not be confined since the rider should not be instructed or limited on how often and for how long he/she uses the bike. Nevertheless it is desirable to be over a threshold so as to collect a satisfactory amount of data. This threshold varies amongst the different study countries and mainly depends on the type of trips and networks the rider uses (e.g. at least 1.5 hours for urban/inter-urban trips).

7.4.2. Sample size

The sample size at each study site will be: France 12 participants , Greece two participants, Italy not more than six, and the UK six.

7.4.3. Environment

As this is a naturalistic riding study, the riding environment should not be a controlled variable. However, one way of controlling the environment indirectly without interfering with the "natural" conditions of the study is by selecting participants that mainly ride in the predefined environments of interest. Hence, for example the Greek study participants will be riders who perform trips on any road category excluding motorways within the urban and interurban road network. In general, the participant will be free to ride on whichever routes that he/she would normally choose to.

7.4.4. Riding guidelines

This is a naturalistic riding study, and hence the participant should feel free to use the bike as he/she normally would and it should be left to the rider's judgement on how to behave on the bike. However, it will be prudent to provide participants with some guidance on how the vehicle 'should' beused.

The user agreement should specify that the PTW must be used solely by the named participant of the trial. No pillion passengers are to be carried, as there might be insurance issues, and extra risk involved. In addition, pillion passengers will not informed of the purpose of the study and, therefore, issues regarding data privacy could arise.

Riders will be informed that they should ride as they normally do; the only restrictions that should be imposed should be that the participant cannot use the PTW when it would be illegal for him/her to do so (e.g. when severely fatigued or under the influence of alcohol). This should also be included in the forms signed by the participant. In specific cases, it might be the case that specific restrictions will also be applied (e.g. in the Greek study the PTW should not be used on motorways).

It is best if participants use the instrumented PTW provided for all trips that they would normally choose to undertake on their own bikes. Still, the instrumented PTW should not be ridden or otherwise transported by the participant beyond a certain distance from the partners' premises (e.g. more than 50km). The PTW must in any case remain within the country where the study is undertaken.

7.5. Methods for participant recruitment, briefing and training

7.5.1. Participant(s) recruitment procedures

Participant recruitment is a significant element of a study observing driving/riding behaviour. However, as this is considered to be an experimental study, which does not investigate specific predefined behaviours or patterns of specific rider groups, the recruitment procedure is not as important. For example, bias in participant selection is not an issue in this study considering the small sample size used. In the different studies, participants will be recruited in different ways.

In France, participants will be recruited through dealers and clubs with which the partner undertaking the study has good relations. For the experiment that takes place in Greece the motoriders club of Volos (MOTOLEV) will be contacted to seek appropriate candidates. In Italy, participants will be recruited among the University personnel; they will be contacted through a mail and then selected according to their profile.

The pre-screening process for participant recruitment aims at selecting suitable participants. In terms of suitable participants the participant characteristics, as well as other specific elements that would minimise the drop-out possibility are involved. Hence, the pre-screening process will take place to ensure that the participants have the characteristics defined in section 4.2.2 of the deliverable. At the very minimum, participants will need to demonstrate that they currently own and ride a motorcycle of similar engine capacity and performance to the instrumented PTWs and that they have a valid motorcycle licence. To minimise the possibility of drop-outs, participants that have successfully completed similar studies and have the necessary characteristics can be sought.

Further, several of the studies will apply recruitment criteria considering rider age (not young or elderly riders), rider gender (males are sought), riding experience (2-3 years of experience, experienced riders), annual mileage (at least 15000km per year or above than average exposure) accident history (at least one accident, but overall not serious / severe» accident history) and type of trips (aim, network type etc) performed with their PTW.

A briefing procedure will take place explaining the aim of the experiment, the study procedures, the do's and don'ts for the participant while using the PTW, participant rights and obligations and all aspects that the participant should be aware of prior to the start of the study. All necessary information will be provided in written form as part of the participant agreement. A verbal briefing will also be given, duplicating the written materials allowing the participant to express any questions or concerns related to the study.

7.5.2. Participant(s) training

Naturalistic studies usually involve participants driving their own vehicles. However, this is not the case in this study as the instrumented PTW will be provided to the participants from each responsible partner. Hence, it might be the case that rider training is required.

In order to maximise the «naturalistic» element of the PTW ridden by the participant, the recruitment process will have ensured that the participant is licensed to ride the bike in question and has adequate experience (both in the form of time and exposure) on a similar type of PTW. Hence, this minimises the need for participant(s) training in riding the PTW. In addition, the instrumentation that has been added to the bike is not expected to have a significant impact on handling and riding the bike, however the rider will still need to familiarise himself/herself with it. Although extensive training will not be required, some training will be. This requirement is set to ensure the participant's riding ability and ensure that he/she is appropriate for the trial.

An additional reason for rider «training» is to provide a record of competency, that might be required if the rider has an accident during the study period. Documentation of competency, however, might not be desirable for all participating partners.

For the aforementioned reasons, riders will be trained prior to the study. Hence, a one-time training session of a few hours duration will take place. The training session will take place in the partners' premises and will provide an opportunity for the riders to familiarise themselves with the bike in a controlled environment. The riders will be instructed to report any difficulties or peculiarities they experience while riding. During the aforementioned training rider performance and competence will also be recorded.

As a supplementary measure to the proposed training session TRL will employ a riding assessor to follow the participant during a test run to check for any noticeable bad habits. In addition to the proposed training session that will take place for all studies, the riders at the UoT study will have experience in riding the particular bike, as they will have been riding it for two months prior to the start of the study.

8. Implementation Strategies

This chapter serves as a kind of checklist for planning and running the Naturalistic Riding Study (NRS). The activities which should be undertaken to ensure successful completion of the study are detailed, as well as the critical issues which have an influence on the outcome of the NRS. The rationale and key elements addressed in this section are based on the FESTA Handbook (FESTA Consortium, 2008). This information should be considered in order to avoid any incidents during the execution of the NRS and to keep its shortcomings minimal.

8.1. Activity plan

The activity plan describes *what* has to be done by *whom*. At the end of the activity plan, an approximate time scheduling of the activities is given. Each sub-chapter represents an activity which has to be supported by several tasks (see tables). Indications for the successful completion of the tasks are provided for each activity and the person or team responsible for the completion of the task is defined.

8.1.1. NRS teams

Before starting the NRS, a meeting of scientific and administrative staff should be convened. Apart from the multi-disciplinary national teams, a general manager should be appointed, who has to be informed of all activities and be aware of the current status of the NRS at any time. The general manager needs to have good research, management and communication skills. However, the knowledge should never be restricted to one person. It is important make sure that people can be replaced without considerable time or quality loss. These possible changes in the NRS staff can be facilitated by a proper documentation of the study (planning, history and status). Moreover, the existence of standby staff for the key research and management positions is recommendable, though it implies considerable cost in terms of human resources.

The day-to-day management team should include persons responsible for dealing with participant issues as well as technical staff responsible for solving data recording or instrumentation issues.

Regular meetings or conference calls between the main actors are necessary in order to allow for good communication and appropriate coordination of the different parts of the study. These meetings should be scheduled in addition to the 2 Be Safe plenary meetings and take place at least once a month. This way, potential administrative, technical or other problems can be resolved in an efficient and timely manner. In addition, the meetings give the chance to constantly monitor the progress of the NRS and the corresponding timelines. The frequency and timing of the meetings should be decided at an early stage of the NRS.

Appoint NRS Manager	**TRL** (M.Chattington)
Appoint persons for technical support	**F**: Stéphane Espié, Clément Val **G**: D.Karaberopoulos **I**: N.Baldanzini & B.Chavez **UK**: M.Chattington, A.Weare
Appoint persons for administrative support	**F**: Clément Val, Reakka Krishnakumar **G**: E.Eliou **I**: B. Baldi **UK**: D.Basacik
Appoint a team for day-to-day management	

8.1.2. Definition of objectives, research questions and hypotheses

The definition of objectives, research questions and hypotheses is detailed in chapter 3. Meeting the objectives will depend on the associated costs, available support infrastructure, restricted time and resources and possible failures during the execution of the NRS. It is of crucial importance to define and prioritis the research questions before running the NRS . The research questions should always be in the focus of the NRS, in order to ensure the desired insights and to make the expenses and efforts of the study worthwhile.

Tasks

- Define objectives of the NRS
- Identify situations of interest
- Define research questions and prioritize them
- Derive hypotheses to be tested from the research questions
- Define possible constraints for meeting the objectives
- All partners involved sign off on aims

8.1.3. NRS management plan

The NRS management plan is to be developed at the beginning of the project. It serves as a guideline in terms of tasks, budget and timelines.

A GANTT chart should be created, which shows the existent dependencies of the different activities and tasks. The budget should consider unforeseen activities (such as additional meetings), and the need for consulting external experts whose knowledge and skills are not covered by the project partners (e.g. lawyers, software specialists). Since these aspects are already determined to an extent in the DoW, the planning of the NRS should be adapted to the given frame. Regarding the time schedule and the budget, it is important to keep in mind that the time and efforts required for the whole NRS are usually under-estimated. The results of the meetings should be well-documented (decisions, lessons learnt, etc.), serving as justifications for possible changes, especially regarding timelines.

Tasks

- Determine activities, tasks and sub-tasks
- Decide on responsible persons for their completion
- Check and adapt GANTT chart from DoW and establish corresponding timelines
- Check available budget in DoW
- Plan monitoring of activities, timelines, budgets and resources according to DoW

- Assess risks for the NRS and plan contingencies
- Determine sign off procedures (meetings, documents) for critical decisions within the consortium
- Define confidentiality
- Write a manual containing the procedure for conducting the NRS (Del. D5)
- All partners involved sign off on management plan

8.1.4. NRS design

The design of the NRS should be clearly defined and documented in an understandable and unambiguous way (especially research questions and hypotheses – in line with the requirements defined in chapter 3). This will ensure that all partners understand the NRS design and, accordingly, are able to which consequences any changes they may suggest would have on the study. On the other hand, it will help to understand and interpret the results of the study and allow comparing them with future NRS.

The study design should not only consider the elements defined in chapter 3 (research questions, hypotheses, etc.), but also take into account the requirements resulting from chapter 4 (especially regarding the parameters to be recorded).

The study should be designed in a way that makes it possible to directly compare between riding data and subjective measures (questionnaires, reports).

The sensors for the collection of objective data are described in chapter 5. The implementation of those data collection tools has been carried out by WP4.1.

When designing the questionnaires and travel diaries, it should be considered to keep them as short as possible in order to increase the likelihood of regular completion by the participants. Regular questionnaire sessions should not exceed two hours, since a long duration is likely to increase the riders' feeling of being part of a scientific study.

When defining the experimental procedures, an adequate time slot between vehicle allocations (rider change) should be calculated in order to carry out equipment verification and maintenance or repairs.

Besides, influences on riding performance at the beginning of the study, resulting from the low level of familiarity of the riders with the test bike, should be taken into account.

Finally, it is recommended to include a contingency plan into the design of the NRS, taking into account that unexpected events or requirements affect the scope of the study (e.g. due to the need to save money or time).

Tasks

- Identify performance indicators for testing the hypotheses
- Determine necessary subjective and objective measures
- Identify corresponding sensors and data collection tools
- Define experimental method, tools and

procedures for testing

- Establish protocols for data acquisition, storage, transfer, de-coding, reduction, filtering, back up and verification
- Determine data analysis methods
- Determine necessary sample size
- All partners involved sign off on study design and procedures

8.1.5. Legal and ethical issues

Chapter 7.1 explains the legal and ethical issues related to the NRS and specifies how to deal with them. Legal issues do not only refer to privacy issues of the participant but also data ownership, theft, insurance, duty of care, etc.

Tasks

- Identify relevant legal and ethical issues
- Resolve them in advance
- Create the necessary contracts and confidentiality agreements
- Obtain ethics approval to conduct the study
- Obtain participant consent on relevant issues before running the NRS
- All partners involved sign off on legal and ethical matters.

8.1.6. Test vehicles and systems

The test vehicles have to be prepared and the data collection and transfer systems, as well as the support systems have to be installed. Chapter 5.1.2 specifies the instrumentation of the test PTWs.

When choosing the test bikes, it is important to keep in mind that the vehicle type can influence riding behaviour (see also 5.2.2.). Further criteria for the choice of the test bikes result from chapter 4.1.1..

Moreover, maintenance requirements of the bikes should be considered and a local point for vehicle support should be provided to the test riders. For the 2 Be Safe NRS, it was defined that assistance regarding technical problems (sensors) will be made by the research institutes. Maintenance should be carried out by the local support team, which is in charge of necessary interaction with a dealer or garage. Although it would be desirable to have an extra bike, which could replace a test vehicle as a consequence of a technical failure or accident, at disposal, this will not be expected for the 2 Be Safe NRS due to limited resources. If possible, a stock of spare parts should be prepared, especially including those parts which are difficult to obtain on a short term.

Data logging systems have to be unobtrusive, safe and secure, and an easy access to the systems is recommended to enable routine repairs and maintenance. In order to guarantee high accuracy of measurements, re-calibration procedures should be implemented. Furthermore, it can be of advantage to be able to track the test vehicles. No communication from the vehicle has been foreseen (transfer of GPS coordinates) for 2 Be Safe NRS though.

Rider involvement in data download should be minimized, as well as the boot-up time of the systems. The latter is especially important, in order to prevent data loss at beginning of journeys.

Data collection could either start automatically or following confirmation by the person in charge of the study. A common time stamp for all recorded data sources is needed and the specification of the parameters to be logged should be strictly guided by the data analysis requirements. If the storage capacity and performance of the data logging system are not too low, it is advisable to record more parameters. Moreover, it is important to check that missing data can be unambiguously identified in order to avoid biased findings (e.g. missing values cannot be marked with a zero, if this is a valid value for the parameter logged). Processing delays should be avoided by employing systems with sufficient computing power.

The specification of the data to be logged should be compatible with the objective parameters defined in 4.2.1.1.

Finally, the different test bikes and systems should be comparable. The specifications of test bikes and instrumentations are developed by WP 4.1.

Tasks

- Specify requirements for test bikes
- Specify data to be logged (measures and sampling rate)
- Specify requirements for systems to collect and transfer data
- Define support systems needed and their requirements
- Equip test bikes with systems for data collection/transfer and with support systems
- All partners involved sign off on system integration activities

8.1.7. Rider feedback and reporting systems

Rider feedback and reporting systems have to be well-designed and implemented, as they represent an important part of data collection. Subjective data is needed to characterize the participants' profile and, on the other hand, to guide the interpretation of the recorded riding data (travel diaries, event diaries). The travel diaries help to confirm the rider identity and provide interesting details of the journey. Questionnaires and diaries (normal travel ones or just incident ones) should be kept as short and simple as possible (see activity 8.1.5). The subjective data that should be gathered is defined in chapter 4.2.1.2., and chapter 6.4.2. gives more details on the subjective riding log, the debriefing of the participants at the end of the study and the questionnaires to be used in the study.

The collection of subjective data should be regulated by means of a timetable, and periodic reminders should be sent in order to minimize missing data. Therefore, it is helpful to determine a contact person from each national project team. Although it may not be feasible to establish a hotline which ensures support on a 24/7 basis, the riders should be provided with a contact number they can call whenever they need support. All occurring problems or incidents should be documented.

Tasks

- Design and implement questionnaires and diaries
- Develop procedures to allow riders to report technical or other problems in a timely manner
- Implement procedures that allow the researchers to monitor the progress of the participants (compliance with study and duties)
- All partners involved sign off on driver feedback and reporting systems and procedures

8.1.8. Database

A database which stores the recorded data has to be built. In case that local databases are implemented (separate ones for each country), it is preferable that they use a common architecture. Appropriate backup procedures have to be defined, guaranteeing that copies of raw data, reduced raw data and processed data files are stored separately from the primary database. Access to the database has to be restricted and unauthorized access avoided (e.g. by not giving the database host an IP number). The architecture of the database has to meet the requirements for data analysis; preferably it should be able to feed directly into statistical packages for further processing and analysis. Post-project data issues, such as data ownership, data access and storage costs, should also be considered. Further details on data issues are described in chapter 6 (information on data storage see 6.5).

Tasks

- Design and implement a database for storage riding data logged from the bike
- Design and implement a database for storage of subjective data
- Define procedures for data storage
- All partners involved sign off on database

8.1.9. Test against functional requirements and performance specifications

All technologies have to be tested against functional requirements and performance specifications. The test vehicles are to be safe, roadworthy and their equipment has to comply with the law.

Implemented systems should not use battery when the engine is turned off. GPS time can be used to correct possible system clock errors. Sensors should be installed with a protection level that allows them to be used with all weather conditions. Procedures for the calibration of sensors have to be implemented (see also activity 8.1.7). Some further specifications for testing of the instrumentation are given in the chapters 5.2.3 to 5.2.5. Although the study period is relatively short in the 2 Be Safe NRS, it should be at least verified a posteriori how the continuous use may have affected some system components (e.g. flash memory cards may have become corrupted). The essential bike modification procedures should be documented in a short manual, in order to facilitate possible changes of study team members. It is recommended to provide the test riders with a written form, which confirms their participation in the study as well as the vehicle modifications and can be shown to authorities if needed.

Tasks

- Test bike instrumentation: develop specifications for tests and carry them out
- Assess bikes against relevant certification procedures and have modifications of the bike signed off by an engineer or testing authority

8.1.10. Participant recruitment

Participant recruitment procedures have to be developed and carried out. Since very few riders will participate in the NRS, representativeness of the relevant riding population will not be achieved. However, participant requirements should carefully be defined, taking into account that this choice will have a considerable influence on the interpretation of the results and the generalisability of the study outcomes. Criteria which should be set for the recruitment of riders are gender, age, riding experience and mileage. Herein, it has to be considered in terms of time and effort that participants with less frequently represented characteristics, such as female riders, will be more difficult to recruit. Regarding safety and risk, extreme riders should be excluded from the sample. At the same time, the bias due to the screening procedure should be minimized. The chapters 3.5. and 4.2.2. also deal with relevant criteria for participant recruitment, and some additional information can be found in 7.1.2..

The recruitment procedures must take into account ethical and legal issues, since personal data is needed from the potential test riders.

During the data collection phase, the riders' behaviour should be monitored, and in case of repeated risky behaviour or highway-code violations, the test rider should be replaced.

Tasks

- Define test rider requirements and develop recruitment strategy
- Carry out recruitment

8.1.11. Rider training and briefing material

Rider training material and instructions should give the rider a clear overview of the NRS, including the aims of the study and the rider's role within the study. Although the briefing and training material should stress the importance of a safe riding style, the instructions should avoid biasing the riding behaviour. Moreover, it is of crucial importance to make sure that the participants understand the procedures - especially those regarding questionnaires and reports -, as well as the data download protocols and timetables. Since riders will not ride their own motorcycle, it is advisable to include a training session which allows the rider becoming familiar with the test bike.

Tasks

- Indentify training and information needs
- Design rider instructions and training material
- All involved partners sign off on briefing and training material

8.1.12. Pilot testing of equipments and procedures

Pilot testing is one of the most important steps to ensure a successful study. It should therefore not be understated. Pilot testing gives the opportunity to avoid many types of failures and incidents during the real test. It should comprise testing of subjective data collection tools and procedures as well as riding data log equipment and procedures.

The pilot testing will also allow adjusting the timelines in a realistic way, since it helps to estimate how much time is required to carry out the different steps (especially subjective records and data download procedures). It is recommended that the routes ridden in the pilot tests are likely to provoke relevant (critical) situations. Additionally, an independent monitoring system can be used in order to check the validity of the data recorded by the sensors. Data acquisition, quality check of recorded data, data download and storage are part of the pilot testing. Data analysis procedures as well as event triggers should be pilot tested by analysing samples of pilot data. Thus, the data set that will be collected can be checked for appropriateness and necessary modifications can be undertaken before running the NRS. Any feedback from the pilot test riders is valuable and should be used to optimize the procedures and instruments for the NRS.

Tasks

- Establish a protocol for pilot testing
- Recruit, brief and train pilot riders
- Determine the necessary modifications after pilot testing
- All involved partners sign off on pilot testing

8.1.13. Running the NRS

The chance to successfully run the NRS will mainly depend on the proper completion of the activities previously described and on the adherence to the established protocols.

A critical issue when running the NRS is the response provided in case of technical failures or other problems the participants could have to face. It is therefore strongly recommended to implement a support service (e.g. a hotline) which guarantees timely responses to these issues and mitigates their consequences. This will also help to minimize the probability of drop-outs due to technical problems or similar annoyances.

Moreover, it is necessary to follow the quality control protocols and maintenance procedures, in order to ensure proper data recording, download and storage. Hereby, it is advisable to check logged data immediately after download and to verify its accuracy and completeness. If data is manually downloaded, storage devices have to be replaced by empty ones. In the same way, the required calibration procedures should be followed. Calibration should also include the cumulative distance travelled, in case the kilometres ridden are controlled for. Functioning of the systems should not be assumed, but checked regularly - even though results of pilot testing were positive. In a similar manner, participants' contribution (reports, vehicle maintenance, etc.) should not be taken for granted; periodic reminders and a close follow-up are strongly recommended. The test riders should also be encouraged to contact the test leader or technical support as soon as a problem occurs. Generally speaking, a good communication with the test riders and even small incentives improve the participants' compliance. Since the NRS requires a long-term involvement, the attitude of the test leaders towards the test riders (treat them as actors of the study, not simply participants) is of special importance.

All potential factors of influence (such as weather or police enforcement) should be recorded and documented to serve as a control variable in the analysis. In case of legal obligation to report recorded events of dangerous riding to the responsible authority, it is important not to forget to do so.

Sufficient time should be calculated for the different steps of the NRS. Manual data entry (paper and pencil questionnaires or reports), in particular, is a time-consuming task which should not be understated. It is convenient not to leave this kind of task to the end and to carry it out regularly during data collection.

The chapters 3.5. and 4.2.2. also deal with relevant criteria for participant recruitment, and some additional information can be found in 7.1.2..

Tasks

- Check that all previous activities are signed off.
- Management: monitor activities, timelines and budget; write progress reports; organize regular meetings of involved partners; ensure sufficient communication
- Confirm recruited participants
- Brief and train test riders
- Administer background questionnaires
- Get test bikes ready and deploy them
- Monitor riders progress (check km ridden)
- Administer subjective data collection methods
- Enter subjective data into corresponding database
- Download and store recorded riding data
- Document technical problems or rider support needs
- Initiate preliminary data evaluation
- Repair vehicles/systems if necessary
- Regularly ensure vehicle and system maintenance (special attention to legal requirements)
- Conduct final interviews
- All involved partners sign off on completion of NRS running

8.1.14. NRS data analysis

Intermediate analysis should be included into the analysis plan, in order to be able to deliver preliminary findings as part of status reports to the stakeholders and the funding organisation (EC). Conducting ongoing analysis will not only serve to identify early trends in the data, but also to detect dangerous riders at time.

The required synchronization of data tyoes and the tools to be used for the analysis are described in chapter 6.6..

Quality checks of the data are essential to be carried out before using it for the analysis. A closer look at the data will prevent generating results that do not correspond to reality. Therefore, the analysts need to understand how data was collected and know the test bikes and sensors used. Furthermore, the analysts should be informed appropriately about data privacy and the related procedures which are required.

Dealing with missing data and filtering the data in an optimal way are issues that should be carefully considered (for more details see 6.2.3 and 6.3.). Whenever data is aggregated, a copy of the original dataset should be kept in the database. Non-significant findings should not be left out, since they are also part of the results. Not being able to refute a hypothesis is a valuable outcome, assuming the study has sufficient power.

Tasks

- Establish a data analysis plan
- Analyse recorded riding data
- Analyse subjective data
- Conclude from results according to the hypotheses generated before running the NRS
- All involved partners sign off on completed data analysis

8.1.15. Minutes and reports

Considering that the duration of the NRS is relatively long, meeting minutes and progress reports help to make sure that no important information is forgotten. Herein, the problems encountered as well as the solutions found during the study are to be recorded. These lessons learnt as well as the implementation plan of the NRS have to be documented in the final report. Conclusions from the findings, further research needs and recommendations for future studies must not be missing in the report.

The review process should avoid delaying the delivery of the report, however be extensive enough to ensure good quality of the deliverable. The recommended time for review is six to eight weeks.

Tasks

- Write minutes of meetings
- Write progress reports
- Write draft of report
- Ask reviewers for feedback
- Integrate feedback and finalise report

8.1.16. Dissemination of the findings

The dissemination of the findings of the 2 Be Safe NRS is covered by WP7. Within the given dissemination plan, the level of confidentiality of the information from the NRS has to be checked before starting with the study. It specifies which parts will not be disseminated and where necessary permissions for the desired publications have to be obtained.

The full final report may not always be the appropriate document to distribute, since it might be long to read. Often, it is more recommendable to provide a concise synopsis of the NRS. Besides, conference presentation or publications in scientific journals can play an important role in achieving a wide dissemination of the study findings.

A responsible person should be designated who regulates and supervises the release of project results.

Tasks

- Inform the project sponsor (EC) whenever requested about progress of the NRS
- Appoint a dissemination manager
- Presentation of preliminary findings at conferences or similar events
- Make the intermediate and final reports public for stakeholders

8.1.17. Decommissioning of the NRS

All relevant material has to be given back to the institutes conducting the study by the participant riders at the end of the study. This includes the test bikes, related systems, storage devices and any other tool which has been at their disposal for the purpose of the NRS. The bikes should maintained instrumented until the data analysis is entirely completed and for further demonstration purposes.

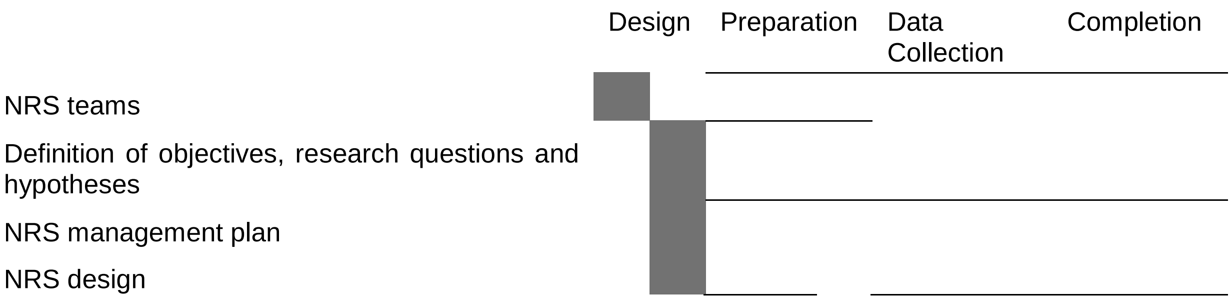
Since conducting a NRS requires considerable effort, time and budget, databases might be made accessible to research teams after the end of the project. In doing so, one should not forget to carefully explore data privacy issues and undertake the necessary steps for guaranteeing anonymity.

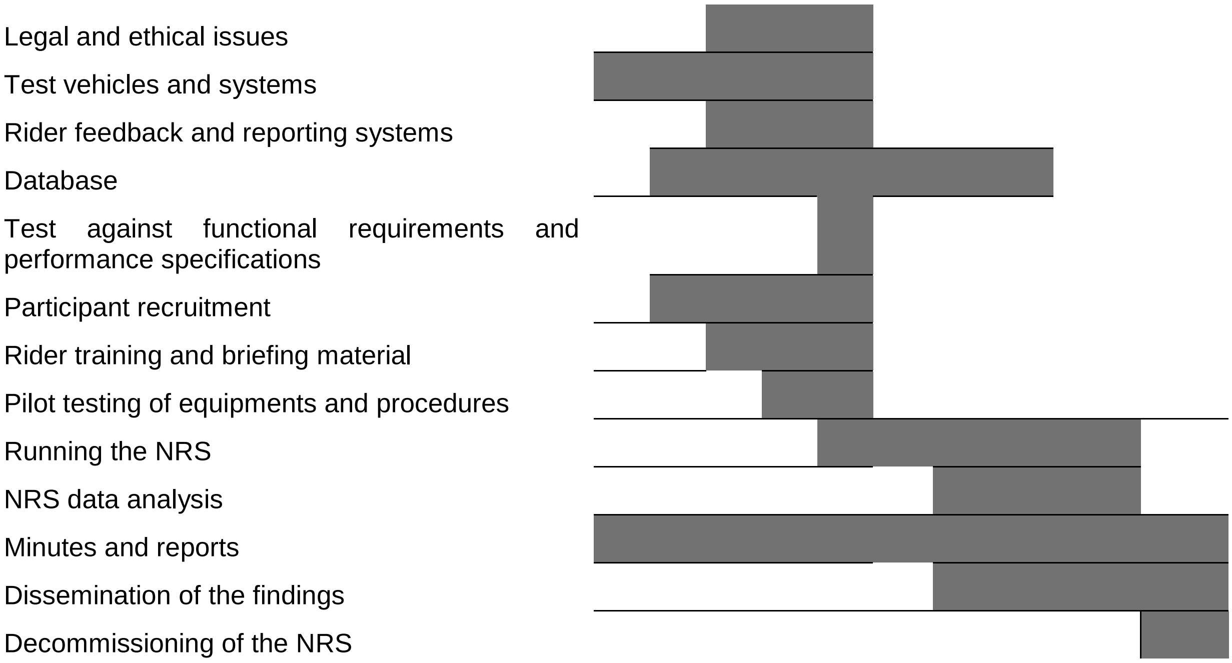
Tasks

- Conduct de-briefing sessions with the participants
- Receive test bikes and materials

8.1.18. Time-Table

The following time-table shows the sequence and relative durations of the different steps for carrying out the NRS. It is therefore an approximation and does not define exact starting dates or months of duration. Based on this template and taking into account the actual status of the related WPs, an exact schedule has yet to be defined. Although time restraints may require duration modifications of several steps, it is essential not to shorten the data acquisition period, which is already relatively short for a naturalistic study.





8.2. *Quality control*

8.2.1. Associated risks and contingencies

In order to ensure proper quality control, the risks associated with the different activities of the NRS have to be defined. In a next step, the corresponding contingency should be determined, consisting of a solution to eliminate the risk or at least mitigate it. The following table lists possible risks and suggests contingencies. Nevertheless it is probably not comprehensive and many risks will be detected when planning the NRS more in detail.

Risk	Contingency
• participant drop out	• standby participant sample
• missing subjective data	• set reminders
• failure during data collection, data loss, poor data quality	• verification test before running the NRS • support during the NRS • additional check during data download • check correct storage of data in database before deleting locally • regular backup of data base • check appropriateness of data format • establish minimum data set for all sites
• technical failure (data recorder or test bike)	• check technical equipment before starting the NRS • protocol for contact in case of technical

	failure • support by NRS local team
• accident	• try to avoid by instructions to participants • possibility to repair or equip new motorbike • replace participant if needed (e.g. injure or demonstrating risky behaviour that is not desired)
• third-parties dependencies	• contract including responsibilities of each party
• damages to the test bikes caused by the personnel during testing	• establish insurance policy
• Loss of GPS data, e.g. in tunnels	• Automatic signal recovery
• No proper addressing of all potential implications in case of incident beforehand	• sign user agreement before the start of the tests

In general terms, the test leaders should make sure that the theoretical background, the procedures and the study history are well-documented. This ensures the access to the knowledge necessary to progress successfully with the study and provides the chance to find additional information or explanation which can facilitate the interpretation of data and results.

8.2.2. Responsibilities for quality control

A central quality manager should be designated, who manages and supervises the quality control procedures across sites. Additionally, each test site should appoint a person responsible for quality controls. This can be either the test leader or any other person on the project. There should also be a person responsible for the database.

For the present NRS, responsibilities regarding quality control are as follows:

- Central quality manager: WP leader (TRL)
- Local responsible UK: Mark Chattington Basacik (TRL)
- Local responsible Greece: Nikos Eliou (UoT)
- Local responsible Italy: Bernardo Chavez (UNIFI)
- Local responsible France: Clément Val (CEESAR)
- Database responsible: Mark Chattington (TRL), (local responsible Italy: Niccolò Baldanzini, Greece: Nikos Eliou)

8.3. Other issues

8.3.1. Modification of the equipment during the trials

Modification of the systems during the trial should be avoided as they would require a considerable amount of effort and resources and thus are likely to provoke changes in timelines and budget. Initial verification tests should ensure that data collection and transfer works according to the requirements that have been set up. Regular maintenance and checks should confirm this throughout the data collection period.

In case of unexpected data recording incidents due to technical failure, the systems should be fixed in a timely manner. Therefore, it is important to establish procedures which help the rider to report technical failures or other problems (see activity 8.1.8).

If the rider has an accident, the test bike should be repaired as soon as possible. Otherwise another bike will need to be equipped; having an extra bike at immediate disposal is desirable in this situation (see also 8.1.7).

8.3.2. Drop-outs

In order to handle possible participant drop-outs, a standby database of additional participants, who are willing and able to participate on short notice, should be prepared. Appropriate documentation of drop-outs is recommended, including the reasons the participant indicated for leaving the study. There is the possibility of minimising drop-out rates through careful recruitment process.

9. Conclusions

This report defines the experimental methodology and implementation plan for the conduct of a naturalistic riding study within the 2BESAFE project. The starting point is identification of relevant questions and hypotheses that the study should be able to answer. The experimental scenarios (including participant and environment characteristics), the required variables and hence necessary equipment for instrumenting the PTWs, were decided taking into account several other constraints. In addition, issues regarding data recording, storage and analysis, equipment installation, maintenance and testing, legal and ethical issues, participant recruitment and training were also decided leading to an implementation plan that is anticipated to ensure the performance of a successful study.

As this is one of the first NRS to be conducted, the development of the methodology and implementation plan took into account ‘best practice’ experiences and relevant learning from previous naturalistic driving studies involving four wheeled vehicles. The objective of a naturalistic driving/riding study is to reveal the underlying behaviours/factors that contribute to drivers/riders being involved accidents. However, as there is currently only limited knowledge on PTW movement characteristics/riding behaviour (at a microscopic level and in a continuous manner) this study also has several more objectives of a basic nature which are highly significant. These include: validating the proposed methodology, providing a definition of PTW conflicts through quantitative measures and identifying different riding patterns.

The described procedures will be implemented in four countries – namely, France, Greece, Italy and the United Kingdom. The design takes into account the individual conditions and needs of each of the aforementioned countries, including different legislation and relevant procedures, and different types of PTW riding behaviour and accident characteristics. The core of the study is common between the countries; however, several elements were selected to cater to specific conditions, and hence will differ among the sites. Due to the limited resources (time and budget) the implemented study will be of a small scale nature. Hence, its total duration will be six months. In most cases, one instrumented bike will be used (in France two bikes are available), and the number of participants will range from 2 to 12 depending on the site.

Objective and subjective data will be collected. Objective data will be recorded via appropriate equipment installed on the PTWs and subjective data will be collected through the completion of questionnaires by the participant. PTW’s will be equipped with GPS, video cameras and sensors that collect variables including vehicle position and speed, brake activation, throttle position, steering wheel angle . Questionnaires (of different nature) will be completed prior to the beginning of the study to yield information on participant demographic characteristics, accident involvement record, riding style and patterns, character/mentality elements. In addition, during the study, data regarding participant trips will also be recorded by the participant.

The conduct of a naturalistic riding study, especially as there is no such previous experience supporting it, is a rather difficult task but at the same time a challenging one. The next step of this workpackage is to implement the methodology described in this report. Any difficulties and variations from the proposed methodology will be recorded to improve the present report, which could, in the future, form a handbook for the implementation of naturalistic riding studies.

10. References

[1] Doerzaph, A. (2008). Motorcycle rider naturalistic driving study, Presentation, Virginia Tech Transportation Institute.

[2] Brenac T. (1997). L’analyse séquentielle de l’accident de la route (Méthode INRETS), comment la mettre en pratique dans les diagnostics de sécurité routière. Rapport INRETS, Outils et Méthodes n°3. Arcueil: INRETS. 7 9 p.

[3] Phan, V. et al., 2010. Rider/Driver behaviours and road safety of PTW. Deliverable 1 of Wheeler Behaviour and Safety Project, (WP 1.1), European Commission: Brussels, Belgium.

[4] Regan, M.A., Lintern, G., Hutchinson, R., and Turetschek, C., 2010. Using Cognitive Work analysis to derive recommendations for improving motorcycle and scooter rider safety. Deliverable 21 of 2-Wheeler Behaviour and Safety Project, (WP 5.5). European Commission: Brussels, Belgium

[5] Van Elslande, P., Fouquet, K. (2007). Analyzing « human functional failures" in road accidents. Deliverable 5.1 of the EU FP6 project TRACE.

[6] Van Elslande, P., Fouquet, K. (2007). Which factors and situations for human functional failures? Developing a grid for accident causation analysis. Deliverable 5.2 of the EU FP6 project TRACE.

[7] Warner, H., Ljung Aust, M., Sandin, J., Johansson, E., & Bjorklund, G (2008). Manual for DREAM 3.0, Driving reliability and error ananlysis method. Deliverable 5.6 of the EU FP6 project SafetyNet, TREN -04-FP6TR-S12.395465/506723

[8] Baldanzini, N. et al., 2010. Literature review of naturalistic driving studies. Deliverable 4 of Wheeler Behaviour and Safety Project, (WP 2.1), European Commission: Brussels, Belgium.

[9] Winkelbauer, M. et al., 2009. Interaction between weather conditions and Powered Two Wheeler accidents. Deliverable 3 of Wheeler Behaviour and Safety Project, (WP 1.3), European Commission: Brussels, Belgium.

[10] Espie, S. et al., 2010. Instrumented Powered Two Wheelers. Deliverable 10 of Wheeler Behaviour and Safety Project, (WP 4.1), European Commission: Brussels, Belgium.

[11] FESTA Consortium (2008), *Field opErational teSt supporT Action (FESTA) Handbook Deliverable no. D6.4*, Belgium: European Commission, 2008, FESTA project.

11. Annex

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Rider	❑ 25 - 50 years old ❑ 3 years of driving experience ❑ 50% drivers fully equiped	❑ 25 - 50 years old ❑ 3 years of driving experience ❑ 5,000 km per year ❑ Mode of transport ❑ 17% of riders fully equipped	❑18 – 25 years old ❑ 3 years of driving experience ❑ 5,000 km per year ❑ 26% of riders fully equipped	❑18 – 25 and over 50 years old ❑ 2 years of driving experience ❑ 15,000 km per year ❑ PTW used for transport and leisure ❑ 60% of riders fully equipped	❑ 25 – 50 years old ❑ 3 years of driving experience ❑ 10,000 km per year ❑ PTW used for transport and leisure ❑ 26% of riders fully equipped	❑18 – 25 years old ❑ 2 years of driving experience ❑ 10,000 km per year ❑ PTW used for transport ❑ 28% of riders fully equipped	❑ 25 – 50 years old ❑ 3 years of driving experience ❑ 10,000 km per year ❑ PTW used for transport ❑ 24% of riders fully equipped
PTW	❑ Sport motorcycles ❑ 600cc ❑ Good state	❑ Conventional street PTW ❑ 600c ❑ Good State	❑ Conventional street PTW ❑ Sport PTW ❑ 600 cc ❑ Good State	❑ Conventional street PTW ❑ Sport PTW ❑ 600 cc ❑ Good State	❑ Conventional street PTW ❑ Sport PTW ❑ 600 cc ❑ Good State	❑ Conventional street PTW ❑ Sport PTW ❑ 600 cc ❑ Good State	❑ Conventional street PTW ❑ Sport PTW ❑ 600 cc ❑ Good State
Environment	❑ Good weather conditions ❑ Dry surface ❑ Day ❑ In curve	❑ Good weather conditions ❑ Dry surface ❑ Night ❑ Straight road	❑ Good weather conditions ❑ Dry surface ❑ Night ❑ Straight road	❑ Good weather conditions ❑ Dry surface ❑ Day ❑ Straight road	❑ Good weather conditions ❑ Dry surface ❑ Day/Night ❑ Straight road	❑ Good weather conditions ❑ Dry surface ❑ Day/Night ❑ Straight road	❑ Good weather conditions ❑ Dry surface ❑ Day/Night ❑ Straight road

Table 1: Results of the DVE description for motorcycle scenarios

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Rider	Time since departure manoeuvre	❑ 49 mn after departure ❑ Going ahead on a bend ❑ Going ahead on a staight road	❑ 20 mn after departure ❑ Going ahead on a bend ❑ Going ahead on a staight road	❑ 15 mn after departure ❑ Crossing the intersection to go ahead ❑ Travelling on a roundabout	❑ 30 mn after departure ❑ Going ahead on a staight road ❑ Splitting lane	❑ 15 mn after departure ❑ Going ahead on a staight road	❑ 20 mn after departure ❑ Crossing the intersection to go ahead ❑ Approch of the intersection (has a right of way status)	❑ 20 mn after departure ❑ Crossing the intersection to go ahead ❑ Approch of the intersection (has a right of way status)
	Conflict	❑ No conflict with other vehicles ❑ 25% of conflict with other users but no colission	❑ No conflict	❑ No conflict	❑ Oncomming vehicle in correct lane ❑ Vehicle in a lateral lane in the same direction	❑ A vehicle moving ahead ❑ A stationary vehicle ahead	❑ Passenger car comming from a side road	❑ Passenger car comming from a side road
	Precipitating event	❑ Excessive speed ❑ Misinterpreted the driving situation ❑ Incorrect driving manoeuver	❑ Poor evoluation or anticipation ❑ Weather conditions ❑ Alcohol: Drugs	❑ Inappropraite reaction ❑ Incorrect driving manoeuvre	❑ Incorrect driving manoeuvre ❑ Misinterpreted the driving situation	❑ Incorrect driving manoeuvre ❑ Misinterpreted the driving situation	❑ Misinterpreted the driving situation ❑ Poor evaluation or anticipation of the evolution of the situation	❑ Misinterpreted the driving situation ❑ Poor evaluation or anticipation of the evolution of the situation
	Emergency manoeuver	❑ Braking ❑ No reaction	❑ Braking ❑ No reaction	❑ Braking ❑ No reaction	❑ Braking ❑ No reaction	❑ Braking ❑ Try to control his PTW	❑ Braking ❑ Breaking and turning	❑ Braking ❑ No reaction
	Crash	❑ Under 75 km/h	❑ Under 45 km/h	❑ Under 35 km/h	❑ Frontal ❑ Under 55 km/h	❑ Frontal ❑ Under 45 km/h	❑ Frontal ❑ Under 35 km/h	❑Frontal ❑ Under 45 km/h

Table 2 Results of the description of the DVE evolution for motorcycle accidents scenarios

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Rider	HFF	❑ Guidance problem ❑ Poor control of an external disruption	❑ Guidance problem ❑ Poor control of an external disruption	❑ Poor control of an external disruption ❑ Erroneous evaluation of a passing road diificulty	❑ Expecting another user not to perform a manouevre ❑ Neglecting the need to search for information	❑ Neglecting the need to search for information ❑ Incorrect understanding of manoeuvre undertaken by another road user	❑ Expecting another user not to perform a manouevre ❑ Incorrect understanding of manoeuvre undertaken by another road user	❑ Expecting another user not to perform a manouevre
	Explanatory elements	❑ Excessive speed ❑ Intentional risk taking ❑ New PTW ❑ New rider	❑ Inadapted speed ❑ High experience of the road ❑ Bad road surface ❑ New rider	❑ Excessive speed ❑ In a hurry ❑ Inadapted speed	❑ Risk taking – lateral positioning ❑ Identification of potential risk about only part of the situation ❑ Atypical manoeuvre from other road user	❑ Excessive speed or speed over the legal limit ❑ Non adapted speed for the driving situation (not over the legal limit) ❑ Other road user: absence of clues to manoeuvre	❑Rigid attachment to the right of way status ❑Atypical manoeuvre from other road user ❑Other road user: absence of clues to manoeuvre ❑The rider has a high experience of the route. His attention level is low	

Table 3 Results of the HFF analysis for motorcycle accidents scenarios

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Rider	Phenotype	❑Too high spped ❑No action	❑Surplus force ❑Too late action	❑Surplus force ❑Too late action	❑Too late action ❑Surplus force	❑Too late action ❑Surplus force	❑Too late action ❑Surplus force	❑Too late action ❑Surplus force
	Genotypes	❑Lack of practical skills or theoretical knowledge ❑Late observation ❑Expectance of certain bhaviours ❑Inattention ❑Inadequate road maintenance	❑Reduced friction ❑Late false observation ❑Priority error ❑Overestimation of riders' skills	❑Reduced friction ❑Priority error ❑Expectance of certain behaviours ❑Late false observation ❑Overestimation of riders' skills	❑Expectance of certain behaviours ❑Missed information ❑False information ❑Inattention ❑Priority error	❑Late false observation ❑Inattention ❑Priority error ❑Overestimation of riders' skills ❑Expectance of certain behaviours	❑Expectance of certain behaviours ❑Late false observation ❑Inattention ❑Visibiliyi mask ❑Priority error	❑Expectance of certain behaviours ❑Priority error ❑Missed observation ❑Late false observation

Table 4 Results of the DREAM analysis for motorcycle accidents scenario